Copyright Statement

The digital copy of this thesis is protected by the Copyright Act 1994 (New Zealand).

This thesis may be consulted by you, provided you comply with the provisions of the Act and the following conditions of use:

- you will use the copy only for the purposes of research or private study
- you will recognise the author's right to be identified as the author of the thesis and due acknowledgement will be made to the author where appropriate
- you will obtain the author's permission before publishing any material from the thesis.
PREDICTING FARM LEVEL RESPONSE TO
GOVERNMENT POLICY:
A SIMULATION APPROACH WITH SPECIAL
REFERENCE TO HILL COUNTRY FARMING
IN NEW ZEALAND

A thesis
submitted in fulfilment of
the requirements for the degree
of
Doctor of Philosophy
in the
University of Canterbury
by
A.C. Beck

Lincoln College
1984
Abstract of a thesis submitted in fulfilment of the requirements of the
Degree of Ph.D.

PREDICTING FARM LEVEL RESPONSE TO GOVERNMENT
POLICY: A SIMULATION APPROACH WITH SPECIAL
REFERENCE TO HILL COUNTRY FARMING IN NEW ZEALAND

The main objective of the study was to develop a simulation model
of the New Zealand North Island hill country farming system to assist
planners and analysts in their assessment and evaluation of government
policy measures. A secondary but associated objective was to analyse
and describe several important aspects of financial decision making
behaviour; in particular behaviour related to consumption, investment
and the use of credit. An examination of each of these aspects of
decision making was carried out and contributed to the subsequent
development of the simulation model.

The model was designed to simulate, over a number of years, the
physical and financial operation of a representative North Island hill
country pastoral farm. The model includes flock and herd sub-models
which simulate annual livestock production under the influence of
stochastic seasonal production parameters. The value of this
production is determined by specified or randomly generated product
prices. Various functions and algorithms then operate to estimate
operating expenditure and taxation payments, and to simulate borrowing,
consumption, and investment or disinvestment behaviour. Investment
expenditure generates farm growth through land development and the associated increase in stock carrying capacity. Alternatively, under adverse economic (and/or climatic) conditions, disinvestment in the form of reduced farm maintenance and fertiliser expenditure, may lead to reduced stock carrying capacity. By manipulating model parameters and data related to prices, costs, taxation and credit, a range of policy types can be represented and their effects simulated.

The model was subjected to validation testing and sensitivity analysis before being used to simulate the effects of a number of farm support and stabilisation policies. It was concluded that the model, as developed, is effective as a policy analysis tool and could well form the basis for modelling other classes of sheep and beef farm. With respect to the secondary objective of the study some insight is provided into aspects of financial decision making, particularly in relation to consumption and borrowing behaviour and the role of liquid financial reserves in the financial operation of the farming system.

KEYWORDS: Policy Analysis; Simulation; Model; Farm Level; Farm Growth; Consumption Function; Credit; Investment.
ACKNOWLEDGEMENTS

I would like to thank Prof. Barry Dent for his supervision of this study; his friendly advice, encouragement and criticism are sincerely appreciated. I would also like to thank Dr Brian Hardaker for his useful comments and criticisms while at Lincoln on sabbatical leave from the University of New England.

An important contribution was made to the study by the New Zealand Meat and Wool Boards' Economic Service (and their Chief Economist, Rob Davison), who provided unpublished data for the consumption and credit analyses. In this respect a special acknowledgement is also due to Mrs Janet Gough for the preparation of this data and for the preliminary estimation of some consumption functions described in Chapter 5 of this thesis.

I am also grateful to several people, especially Tony Bishop, Richard McCurran and John Rathbun, who assisted with programming parts of the simulation model, and to Gillian McNicol for her careful word processing.

The financial assistance of the N.Z. Ministry of Agriculture and Fisheries (who commissioned the study) and the Agricultural Economics Research Unit at Lincoln College is gratefully acknowledged.

Last but not least, I would like to acknowledge the support and patience of my wife Rosalie, and my children Nadeena, Anita and Brendan; without their understanding and forebearance the completion of this thesis would not have been possible.
## Abstract

## Acknowledgements

## Contents

<table>
<thead>
<tr>
<th>Contents</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSTRACT</td>
<td>i</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>iii</td>
</tr>
<tr>
<td>CONTENTS</td>
<td>iv</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>xi</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>xiii</td>
</tr>
</tbody>
</table>

## Part I - Introduction and Review

### Chapter 1 Introduction

1.1 Policy Analysis

1.2 North Island Hill Country Farming

1.3 Modelling Philosophy

1.4 Outline of Study

#### 1.4.1 Part I - Introduction and Review

#### 1.4.2 Part II - System Analysis

#### 1.4.3 Part III - System Synthesis and Model Evaluation

#### 1.4.4 Part IV - Model Application and Study Conclusions

### Chapter 2 Farm Policy Review

2.1 Introduction

2.2 Causes of Income Instability

2.3 Effects of Income Instability

#### 2.3.1 Farm level

#### 2.3.2 National level

2.4 Recent Stabilisation Policies

#### 2.4.1 The Farm Income Equalisation Scheme

#### 2.4.2 Producer Boards' Stabilisation Schemes
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.4.3 Supplementary Minimum Prices (S.M.P.s)</td>
<td>23</td>
</tr>
<tr>
<td>2.5 Alternative Support Policies</td>
<td>26</td>
</tr>
<tr>
<td>2.6 Conclusion</td>
<td>28</td>
</tr>
<tr>
<td>CHAPTER 3 REVIEW OF METHODOLOGY</td>
<td>30</td>
</tr>
<tr>
<td>3.1 Historical Perspective</td>
<td>30</td>
</tr>
<tr>
<td>3.2 Selecting an Appropriate Model Type</td>
<td>33</td>
</tr>
<tr>
<td>3.3 A Review of Selected Farm Growth Models</td>
<td>36</td>
</tr>
<tr>
<td>3.3.1 Overview of selected models</td>
<td>36</td>
</tr>
<tr>
<td>3.3.2 Investment decision algorithms</td>
<td>38</td>
</tr>
<tr>
<td>3.4 Conclusion</td>
<td>44</td>
</tr>
<tr>
<td>PART II - SYSTEM ANALYSIS</td>
<td>46</td>
</tr>
<tr>
<td>CHAPTER 4 A GENERAL INTRODUCTION TO NORTH ISLAND HILL COUNTRY</td>
<td>48</td>
</tr>
<tr>
<td>4.1 Introduction</td>
<td>48</td>
</tr>
<tr>
<td>4.2 Hill Country Defined</td>
<td>48</td>
</tr>
<tr>
<td>4.3 General Background</td>
<td>50</td>
</tr>
<tr>
<td>4.4 Hill Country Production Systems</td>
<td>53</td>
</tr>
<tr>
<td>4.4.1 Physical and production features</td>
<td>53</td>
</tr>
<tr>
<td>4.4.2 Capital structure</td>
<td>54</td>
</tr>
<tr>
<td>4.4.3 Expenditure and income</td>
<td>56</td>
</tr>
<tr>
<td>4.4.4 Disposition of net income</td>
<td>59</td>
</tr>
<tr>
<td>4.5 Economics of Hill Country Development</td>
<td>60</td>
</tr>
<tr>
<td>4.5.1 National level analysis</td>
<td>61</td>
</tr>
<tr>
<td>4.5.2 Farm level analysis</td>
<td>63</td>
</tr>
<tr>
<td>4.6 Conclusion</td>
<td>64</td>
</tr>
<tr>
<td>CHAPTER 5 CONSUMPTION ANALYSIS</td>
<td>67</td>
</tr>
<tr>
<td>5.1 Introduction</td>
<td>67</td>
</tr>
<tr>
<td>5.2 General Theories of Consumption Behaviour</td>
<td>68</td>
</tr>
<tr>
<td>Section</td>
<td>Page</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>5.2.1 The absolute income hypothesis</td>
<td>69</td>
</tr>
<tr>
<td>5.2.2 The relative income hypothesis</td>
<td>70</td>
</tr>
<tr>
<td>5.2.3 The permanent income hypothesis</td>
<td>73</td>
</tr>
<tr>
<td>5.2.4 Influence of variables other than income</td>
<td>74</td>
</tr>
<tr>
<td>5.3 Application to Agriculture and New Zealand</td>
<td>75</td>
</tr>
<tr>
<td>5.3.1 Review of studies</td>
<td>75</td>
</tr>
<tr>
<td>5.3.2 New Zealand data</td>
<td>78</td>
</tr>
<tr>
<td>5.3.3 Models selected</td>
<td>82</td>
</tr>
<tr>
<td>5.3.4 Estimation</td>
<td>83</td>
</tr>
<tr>
<td>5.4 Discussion of Results</td>
<td>85</td>
</tr>
<tr>
<td>5.5 Conclusions</td>
<td>95</td>
</tr>
<tr>
<td>CHAPTER 6 ANALYSIS OF THE USE OF CREDIT</td>
<td>98</td>
</tr>
<tr>
<td>6.1 Introduction</td>
<td>98</td>
</tr>
<tr>
<td>6.1.1 Sources of data</td>
<td>99</td>
</tr>
<tr>
<td>6.2 Aspects of Credit Using Behaviour</td>
<td>100</td>
</tr>
<tr>
<td>6.2.1 Reasons for borrowing</td>
<td>100</td>
</tr>
<tr>
<td>6.2.2 Debt levels</td>
<td>102</td>
</tr>
<tr>
<td>6.2.3 Borrowing frequency</td>
<td>106</td>
</tr>
<tr>
<td>6.2.4 Attitude to use of credit</td>
<td>107</td>
</tr>
<tr>
<td>6.3 Analysis of Factors Affecting Long-Term Borrowing</td>
<td>112</td>
</tr>
<tr>
<td>6.3.1 Hypothesised factors</td>
<td>112</td>
</tr>
<tr>
<td>6.3.2 Regression analysis</td>
<td>115</td>
</tr>
<tr>
<td>6.3.3 Results of estimation</td>
<td>117</td>
</tr>
<tr>
<td>6.3.4 Discussion</td>
<td>121</td>
</tr>
<tr>
<td>6.4 Analysis of Factors Affecting Short-Term Borrowing</td>
<td>123</td>
</tr>
<tr>
<td>6.4.1 Hypothesised factors</td>
<td>123</td>
</tr>
<tr>
<td>6.4.2 Graphical observation and regression analysis</td>
<td>124</td>
</tr>
<tr>
<td>6.5 Conclusions</td>
<td>132</td>
</tr>
<tr>
<td>CHAPTER 7 ECONOMIC AND ENVIRONMENTAL FACTORS AFFECTING PASTORAL SUPPLY RESPONSE</td>
<td>134</td>
</tr>
<tr>
<td>7.1 Introduction</td>
<td>134</td>
</tr>
<tr>
<td>7.2 A Review of Pastoral Sector Studies</td>
<td>134</td>
</tr>
</tbody>
</table>
7.2.1 Pre-1970 models
7.2.2 More recent studies

7.3 An Analysis of Factors Affecting North Island Hill Country Stock Numbers

7.4 Conclusions with Respect to Investment Behaviour

7.5 Modelling Investment and Disinvestment in a North Island Hill Country Farm Growth Model

7.5.1 Funds available for investment
7.5.2 The need for disinvestment
7.5.3 Specification of investment and disinvestment alternatives
7.5.4 Selecting between investment alternatives

PART III - SYSTEM SYNTHESIS AND MODEL EVALUATION

CHAPTER 8 MODEL DESCRIPTION

8.1 Introduction
8.2 Model Overview

8.2.1 Production, income and costs
8.2.2 Adjusting stock numbers
8.2.3 Model operation

8.3 Production Components of the Model

8.3.1 Flock and herd sub-models
8.3.2 Production parameters

8.4 Financial Components of the Model

8.4.1 Valuing production - gross revenue
8.4.2 Cost accounting
8.4.3 Taxation
8.4.4 Consumption function
8.4.5 Borrowing decision rules for long-term loans
8.4.6 Use of reserve funds
8.4.7 Deferring repairs, maintenance and fertiliser applications
8.4.8 Overdraft provisions
8.4.9 Investment
8.4.10 Capital monitoring

8.5 Model Programming and Verification
CHAPTER 9 VALIDATION

9.1 Introduction

9.2 Validation Tests

9.2.1 Purpose of the model
9.2.2 Available data
9.2.3 Nature of model output
9.2.4 Tests applied

9.3 Data Used for Validation

9.3.1 Reserve limit
9.3.2 Proportion of reserve funds invested
9.3.3 Investment profile
9.3.4 Debt servicing allowance
9.3.5 Minimum equity limit
9.3.6 Proportion of borrowed funds used for investment
9.3.7 Prices
9.3.8 Working expenses function
9.3.9 Culling rate adjustments
9.3.10 Production and consumption parameters

9.4 Validation Results

9.4.1 Selected key parameters
9.4.2 Gross income estimates
9.4.3 Total expenditure
9.4.4 After-tax cash surplus
9.4.5 Tax paid
9.4.6 Consumption
9.4.7 Long-term debt
9.4.8 Reserves
9.4.9 Total assets
9.4.10 Equity ratio
9.4.11 Total stock units

9.5 Conclusion

CHAPTER 10 SENSITIVITY ANALYSIS

10.1 Introduction

10.2 Approach to Sensitivity Analysis

10.2.1 Performance variables
10.2.2 Accounting intervals
10.2.3 Sensitivity measures
10.2.4 Parameters tested

10.3 Sensitivity Analysis Results
11.7.3 Stabilisation policies

CHAPTER 12 CONCLUSIONS

12.1 Value of the Study

12.2 Model Implementation

12.2.1 Policy analysis

12.2.2 Other farm situations

12.3 Further Model Development

12.3.1 Investment and production options

12.3.2 Adapting the model for different farm classes

12.4 Further Research

12.4.1 Farm expenditure and investment

12.4.2 The role of reserves in the pastoral farming system

REFERENCES

APPENDICES

APPENDIX 1 Credit Related Questions in the 1981/82 Farmer Opinion Survey

APPENDIX 2 Tabulated Results of Sensitivity Analysis

APPENDIX 3 Model Performance under Extreme Price Conditions

APPENDIX 4 Model Program Listing
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>Capital Structure of Average North Island Hill Country (Class 4) Farm - 1980/81</td>
<td>55</td>
</tr>
<tr>
<td>4.2</td>
<td>Farm Expenditure for Average North Island Hill Country (Class 4) Farm - 1980/81</td>
<td>57</td>
</tr>
<tr>
<td>4.3</td>
<td>Farm Income for Average North Island Hill Country (Class 4) Farm - 1980/81</td>
<td>58</td>
</tr>
<tr>
<td>5.1</td>
<td>Definitions of Meat and Wool Boards' Economic Service Variables Used to Estimate Consumption Functions</td>
<td>81</td>
</tr>
<tr>
<td>5.2</td>
<td>Estimated Coefficients for Consumption Functions Based on Absolute Income and Relative Income Hypotheses</td>
<td>86</td>
</tr>
<tr>
<td>5.3</td>
<td>Estimated Coefficients for Consumption Functions Based on the Permanent Income Hypothesis</td>
<td>94</td>
</tr>
<tr>
<td>5.4</td>
<td>Estimated Marginal Propensities to Consume</td>
<td>96</td>
</tr>
<tr>
<td>6.1</td>
<td>Reasons for New Long-term Borrowing - 1979/80</td>
<td>101</td>
</tr>
<tr>
<td>6.2</td>
<td>Equity Levels, and Interest Payments as a Proportion of Total Expenditure, for North Island Hill Country Farms, 1965/66 to 1980/81</td>
<td>103</td>
</tr>
<tr>
<td>6.3</td>
<td>Respondents' Ability to Borrow All the Money Required During 1981/82 Season</td>
<td>103</td>
</tr>
<tr>
<td>6.4</td>
<td>Respondents' Attitude to Borrowing</td>
<td>110</td>
</tr>
<tr>
<td>6.5</td>
<td>Why Respondents Did Not Borrow More in 1981/82</td>
<td>110</td>
</tr>
<tr>
<td>6.6</td>
<td>Results of Regressions Related to Fixed Liabilities</td>
<td>118</td>
</tr>
<tr>
<td>6.7</td>
<td>Results of Regressions Related to Current Liabilities</td>
<td>127</td>
</tr>
<tr>
<td>7.1</td>
<td>Soil Moisture Deficit Indices for North Island Districts and North Island Hill Country</td>
<td>152</td>
</tr>
<tr>
<td>8.1</td>
<td>The Stock Carrying Capacity Effect of Reduced Fertiliser Maintenance</td>
<td>191</td>
</tr>
<tr>
<td>9.1</td>
<td>Model Variables and Corresponding Survey Items Compared in Validation Tests</td>
<td>214</td>
</tr>
<tr>
<td>9.2</td>
<td>Results of Validation Tests</td>
<td>215</td>
</tr>
<tr>
<td>11.1</td>
<td>Statistical Summary of Annual Price Series</td>
<td>264</td>
</tr>
</tbody>
</table>
11.2 Correlation Matrix for Livestock and Wool Prices

11.3 Statistical Summary of Production Parameter Series - 1961/62 to 1980/81

11.4 Five Year Annual Averages for Model Responses, and Associated Standard Deviations, for Simulated Years 1986/87 to 1990/91 - Various Price and S.M.P. Scenarios

11.5 Average Annual Model Responses, and Associated Standard Deviations, for Simulated Year 1990/91 - Various Price and S.M.P. Scenarios

11.6 Estimated Distribution of Extra Revenue from Supplementary Minimum Prices between Alternative Uses

11.7 Price Elasticities for Model Responses Based on a Twenty Percent Reduction in the Product Price Probability Distributions

11.8 Five Year Annual Averages for Model Responses, and Associated Standard Deviations, for Simulated Years 1986/87 to 1990/91 - Various Farm Support Policies

11.9 Average Model Responses, and Associated Deviations for Simulated Year 1990/91 - Various Farm Support Policies

11.10 Five Year Annual Averages for Model Responses, and Associated Standard Deviations, for Simulated Years 1986/87 to 1990/91 - Various Price and Income Stabilisation Policies

11.11 Average Model Responses, and Associated Standard Deviations, for Simulated Year 1990/91 - Various Price and Income Stabilisation Policies
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1</td>
<td>Percentage Change in Nominal Fixed Liabilities between 1969/70 and 1978/79</td>
<td>105</td>
</tr>
<tr>
<td>6.2</td>
<td>Percentage Change in Real Fixed Liabilities between 1969/70 and 1978/79</td>
<td>105</td>
</tr>
<tr>
<td>6.3</td>
<td>Change in Equity Percentage between 1969/70 and 1978/79</td>
<td>108</td>
</tr>
<tr>
<td>6.4</td>
<td>Frequency of Borrowing over Period 1969/70 to 1978/79</td>
<td>108</td>
</tr>
<tr>
<td>6.5</td>
<td>Nominal Net Income and Current Liabilities for Years 1961/62 to 1980/81</td>
<td>125</td>
</tr>
<tr>
<td>6.6</td>
<td>Real Net Income and Current Liabilities for Years 1961/62 to 1980/81</td>
<td>125</td>
</tr>
<tr>
<td>6.7</td>
<td>Reserves, Working Expenses and Current Liabilities for Years 1961/62 to 1980/81</td>
<td>129</td>
</tr>
<tr>
<td>7.1</td>
<td>Changes in Class 4 Stock Units per Hectare - Actual and Predicted</td>
<td>154</td>
</tr>
<tr>
<td>7.2</td>
<td>Class 4 Stock Units per Hectare - Actual and Predicted</td>
<td>154</td>
</tr>
<tr>
<td>8.1</td>
<td>Schematic Diagram of Model Structure</td>
<td>169</td>
</tr>
<tr>
<td>8.2</td>
<td>Linkages between Income and Investment</td>
<td>187</td>
</tr>
<tr>
<td>9.1</td>
<td>Actual and Simulated Gross Revenue from Sheep</td>
<td>216</td>
</tr>
<tr>
<td>9.2</td>
<td>Actual and Simulated Gross Revenue from Wool</td>
<td>216</td>
</tr>
<tr>
<td>9.3</td>
<td>Actual and Simulated Gross Revenue from Cattle</td>
<td>218</td>
</tr>
<tr>
<td>9.4</td>
<td>Actual and Simulated Total Expenditure Levels</td>
<td>218</td>
</tr>
<tr>
<td>9.5</td>
<td>Actual and Simulated After-tax Cash Surplus</td>
<td>221</td>
</tr>
<tr>
<td>9.6</td>
<td>Actual and Simulated Tax Payments</td>
<td>221</td>
</tr>
<tr>
<td>9.7</td>
<td>Actual and Simulated Consumption</td>
<td>223</td>
</tr>
<tr>
<td>9.8</td>
<td>Actual and Simulated Long-term Debt Levels</td>
<td>223</td>
</tr>
<tr>
<td>9.9</td>
<td>Actual and Simulated Reserve Levels</td>
<td>226</td>
</tr>
<tr>
<td>9.10</td>
<td>Land Value per Stock Unit Carried - Class 4 - 1971/72 to 1980/81</td>
<td>229</td>
</tr>
</tbody>
</table>
9.11 Actual and Simulated Total Asset Values .......................... 229
9.12 Actual and Simulated Equity Ratios .............................. 231
9.13 Actual and Simulated Stock Unit Numbers .................... 231
11.1 Gross Revenue Projections With and Without S.M.P.s ........ 273
11.2 Consumption Projections With and Without S.M.P.s .......... 274
11.3 Deferred Maintenance Projections With and Without S.M.P.s 276
11.4 Annual Investment Levels With and Without S.M.P.s ......... 276
11.5 Potential Stock Unit Projections With and Without S.M.P.s 278
11.6 Gross Revenue Projections Under Different Price and S.M.P. Scenarios ........................................ 284
11.7 Consumption Projections Under Different Price and S.M.P. Scenarios ........................................ 285
11.8 Deferred Maintenance Projections Under Different Price and S.M.P. Scenarios ........................................ 286
11.9 Annual Investment Projections Under Different Price and S.M.P. Scenarios ........................................ 286
11.10 Potential Stock Unit Projections Under Different Price and S.M.P. Scenarios ........................................ 287
11.11 Gross Revenue Projections Under Different Farm Support Policies ...................................................... 295
11.12 Consumption Projections Under Different Farm Support Policies ...................................................... 296
11.13 Deferred Maintenance Projections Under Different Farm Support Policies ...................................................... 297
11.14 Annual Investment Projections Under Different Farm Support Policies ...................................................... 297
11.15 Potential Stock Unit Projections Under Different Farm Support Policies ...................................................... 298
11.16 Triangular Price Distributions With Floor and Ceiling Prices ...................................................... 305
11.17 Gross Revenue Projection Under Different Stabilisation Policies ...................................................... 307
<table>
<thead>
<tr>
<th>Page</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.18</td>
<td>Consumption Projections Under Different Stabilisation Policies</td>
<td>308</td>
</tr>
<tr>
<td>11.19</td>
<td>Deferred Maintenance Projections Under Different Stabilisation Policies</td>
<td>309</td>
</tr>
<tr>
<td>11.20</td>
<td>Annual Investment Projections Under Different Stabilisation Policies</td>
<td>309</td>
</tr>
<tr>
<td>11.21</td>
<td>Potential Stock Unit Projections Under Different Stabilisation Policies</td>
<td>310</td>
</tr>
</tbody>
</table>
PART I
INTRODUCTION AND REVIEW

CHAPTER 1 INTRODUCTION
1.1 Policy Analysis
1.2 North Island Hill Country Farming
1.3 Modelling Philosophy
1.4 Outline of Study

CHAPTER 2 FARM POLICY REVIEW
2.1 Introduction
2.2 Causes of Income Instability
2.3 Effects of Income Instability
2.4 Recent Stabilisation Policies
2.5 Alternative Support Policies
2.6 Conclusion

CHAPTER 3 REVIEW OF METHODOLOGY
3.1 Historical Perspective
3.2 Selecting an Appropriate Model Type
3.3 Review of Selected Farm Growth Models
3.4 Conclusion
1.1 Policy Analysis

Taken in its broadest context, it is the objective of this study to provide an aid to the formulation of effective agricultural policy in New Zealand. For the purposes of the study "effective agricultural policy" is defined as policy which efficiently achieves the government's stated objectives.

The design and implementation of effective agricultural policy is not a trivial problem given the nature of agricultural production and the characteristics of the agricultural sector. Agricultural production is characterised by uncertainty associated with climatic and economic factors which makes the outcome of any policy difficult to predict. Also, the agricultural sector is inherently complex as a result of the range of climatic conditions, soil types, enterprises, farm resources, farmer objectives and farmer capabilities involved. Given that all these features will affect a farmer's response to policy it makes the design of a policy to achieve a specific goal difficult. This difficulty is further exacerbated by the interaction of the agricultural sector with other sectors in the economy.

The difficulty of policy planning serves to strengthen the case for a systematic and rational approach to the problem. In this respect, it seems clear that no one analytical methodology is theoretically and/or practically suitable to assess all the
implications of policy measures at all levels in the economy. The alternative would appear to be the development of a suite of relatively small manageable models, available to be used to assess different policies in different ways. The Bureau of Agricultural Economics (BAE) in Australia, for example, have three classes of models which, taken together, "provide a range of methods capable of addressing a spectrum of questions ranging from issues in structural adjustment at the farm level, or supply response for one or several enterprises, to the impact on the rural sector as a whole, of changes in either macroeconomic policies or the structure of other sectors in the economy" (Kingma, Longmire and Stoeckel, 1980).

Kingma et al. classify these models as: production models, in which whole farms or regional aggregates of farms are modelled using mathematical programming and system simulation techniques; econometric commodity models which are used for projection work and for policy evaluation, and; general equilibrium models, which subsume much of the detail of the production and commodity models.

This study is concerned with the development and application of a "production model"; more specifically, a farm-level production model of a pastoral farming system. Within the context of a suite of policy evaluation models, such farm-level models are justified on the grounds that they can be used to simulate, explicitly and in detail, the physical and financial operation of farming systems in order to indicate farm-level response to changes in various aspects of the farm's physical, financial and socio-economic environment. Some of these aspects, such as input and output price levels, price stability,
tax rates, and credit conditions may be influenced by government policy. It is at this level of modelling and analysis that insight can be gained into the actual process by which a policy influences a farmer and his farming system. Analysis at the farm level also allows an understanding of how different farm situations and farmer circumstances can affect the nature and extent of policy response.

Farming systems are inherently dynamic and complex, and are governed by the unique decision making behaviour of the farmer and the family involved. Accordingly, it is a premise of this research that the effectiveness of farm policy measures can be improved by a better understanding of the operation of the family farming system - its dynamic structure, its decision makers and the environment within which decisions are made. A secondary objective, therefore, in addition to the development of the model, is to gain a better understanding of the behaviour of farmers with respect to financial decision making in farming.

1.2 North Island Hill Country Farming

Ultimately it would seem the ideal situation if policy makers and analysts had available to them farm-level production models for all major production systems. The development of such a range of models is clearly a long-term objective; this study takes the first step toward that ultimate objective by modelling an important component of the pastoral sector. The specific focus of this study is the (New Zealand) North Island hill country pastoral farming system, although the resulting model could well form the basis of other pastoral sector
models.

The focus on the North Island hill country farming system can be justified because of the importance of this type of farming to the New Zealand export economy, and the potential for further development that exists in this farm class. In general terms hill country is defined as non-ploughable land excluding South Island high country. In 1982 hill country land supported approximately 42 per cent of New Zealand's total stock units and generated around $1,000 million in overseas earnings (Rattray, 1982). These earnings represented approximately 17 per cent of total export receipts (New Zealand Dept. of Statistics, 1982).

While substantial production is already obtained from hill country, it is the development potential of the area, particularly North Island hill country, that makes it of particular interest to agricultural policy makers. A number of authors (Brougham, 1973; Yeoman, 1973; Hight, 1976; Mauger, 1977; Parker et al., 1977 and the National Research Advisory Council, 1978) have estimated that potential production increases of 50 to 200 per cent are possible, based on further land development and increased stocking rates. The National Research Advisory Council working party on hill country research (NRAC, 1978), for example, considered that the hill country sector of New Zealand agriculture had the potential to at least double its output. They went on to state that "... this potential represents an additional 40 million stock units. With the nation facing a serious shortage of overseas funds, the $18.4 per stock unit at f.o.b. at current (1978) prices could yield $736 million annually. This figure shows the real economic significance of at least approaching hill
1.3 Modelling Philosophy

With any research involving modelling it is important to be cognisant of the model's ultimate purpose. While traditional validation tests, such as those described in Chapter 9 of this report, can help to establish the "credentials" of a model as a representation of the real system, they do not ensure that the model will be useful and acceptable to decision makers as a decision support tool. The ultimate test of such a model is that it is used, and is regarded as being useful, in the process of formulating and evaluating farm policies.

When emphasis given to the "utility" of a model, as opposed to the more limited "validity" of a model, there are important implications for model design and application; the model must be designed in such a way as to foster user confidence and encourage use of the model. Highly complex model structures, aimed at improving the technical validity of the model, may be inappropriate under these circumstances if they make the operation of the model more difficult to understand and/or difficult to operate.

This issue of model complexity can be looked at from another point of view. A model developed to assist in policy evaluation provides a medium for experimentation - a means of making predictions about the likely outcome of particular policy options. Rarely, if ever, will the model represent the only basis for policy decision making; rather it
will provide one of a number of inputs into the decision making process. Similarly, it would be unusual, particularly in the policy making process, if the decision makers did not have some prior expectations or beliefs about the likely impact of a policy on certain key responses. The use of a model to provide response predictions should serve to modify and/or strengthen the decision maker's convictions about the likely impact of the policy. Consequently, it is the confidence that the decision maker has in the predictions from the model that determines the extent of the influence and value of the model as an aid to decision making.

In a decision theoretic or Bayesian framework the decision makers can be thought of as perceiving some prior probability distribution for the possibly policy responses. Also, the model predictions will have some likelihood probabilities associated with them, i.e. given that a particular response occurred, what is the probability that the model would predict it. The model predictions, together with the decision maker's prior and likelihood probabilities form the basis for determining the decision maker's posterior probabilities. These posteriors may be used directly in making the decision or may form the priors for further revision before the decision is made.

Clearly, it is the likelihood probabilities that the decision maker places on the model predictions that reflect the value of the model in his decision making process. These likelihoods will be affected by a number of different factors, but particularly by the inherent accuracy or validity of the model as a representation of the actual system, and the decision maker's understanding of the model.
While increasing complexity in a model may be justified on the grounds that it improves the validity of the model, it may mitigate against user understanding. To the extent that a model represents a "black box" to a decision maker, it would be expected that his confidence in its predictions would decline. A balance must therefore be struck between validity, complexity, transparency and simplicity in the model if it is to prove effective. Accordingly, in this study an effort was made to develop a model which had sufficient validity to be of value for its intended purpose, but which was still transparent and "serviceable" for the model user.

1.4 Outline of Study

1.4.1 Part I - Introduction and Review.

The study is divided into four parts. Part I comprising Chapters 1, 2 and 3, provides a statement of study objectives (Chapter 1), a review of recent farm policy in New Zealand (Chapter 2) and a review of modelling methodology (Chapter 3). In Chapter 3 the choice of simulation modelling is justified as the most appropriate methodology given the objectives of the study and the nature of the farming system involved. Procedures for the analysis of a system to determine its essential features, the development of a suitable model, and the subsequent testing of, and experimentation with, the model, are well documented (Anderson, 1974; Dent and Blackie, 1979) and form a basis for the analytical stages of the study (Parts II, III and IV).
1.4.2 Part II - System Analysis.

This is the initial analytical stage of the modelling process where the system is studied to determine the nature and behaviour of its components and sub-systems. In particular, the interaction between components is considered. The system analysis stage of this study is described in Chapters 4 to 7 and involves the use of literature reviews, data analysis and subjective observation and assessment.

In Chapter 4 an overview of North Island hill country and the associated farming system is compiled, together with discussion of the physical and financial aspects of hill country farming. The subsequent three chapters analyse in detail the key financial components of the farming system; consumption (Chapter 5), borrowing (Chapter 6) and investment and supply response (Chapter 7). This latter chapter also deals with the effects of climate on hill country production.

1.4.3 Part III - System Synthesis and Model Evaluation.

System synthesis involves the process of synthesising the results of systems analysis into a coherent and logical conceptual framework, and the implementation of the framework into a working computer model. The process of synthesis also involves the explicit consideration of stochastic aspects of the system and the development of appropriate procedures for representing these aspects.

In this study the procedures of model verification are regarded as part of the system synthesis process. Verification involves the
testing and observation of the operation of the model computer program to ensure that it performs in accordance with modeller's intentions.

Inevitably there is some feedback looping between analysis and synthesis; however, for purposes of reporting this project they are presented as sequential stages. The synthesised and verified model of the hill country farming system is described in Chapter 8.

Model evaluation is concerned with assessing the usefulness of the model for its intended purpose. An important part of model evaluation is validation testing which involves the testing of the verified model's ability to mimic the operation of the real world system. Validation procedures are described in Chapter 9 and include a range of statistical and graphical comparisons between actual and simulated time-series.

Model evaluation is also concerned with learning about the behaviour of the validated model. Sensitivity analysis is a useful procedure for this purpose. It involves testing the sensitivity of important model responses to changes in various model parameters, particularly those about which there is some uncertainty. Recognition of the structural soundness of various aspects of the model afforded by sensitivity analysis is important if the model is to be used appropriately with due regard to its strengths and limitations. Sensitivity analysis with the model developed in this study is described in Chapter 10.
1.4.4 Part IV - Model Application and Study Conclusions.

The model was put to its intended purpose with a series of experiments aimed at examining the impact of a range of farm support and stabilisation policies based on those reviewed in Chapter 2. Presentation and discussion of the results of these experiments together with implications for policy making occurs in Chapter 11.

In a final Chapter conclusions are drawn as to the overall value of the study and consideration is given to the implementation of the model for the assessment of different policies under a range of farming conditions. The scope for further model development is then examined, including the possible adaptation of the model to other farm classes. Finally, areas where further research would appear to be worthwhile are discussed.
CHAPTER 2

FARM POLICY REVIEW

2.1 Introduction

The relatively detailed representation of production, expenditure, borrowing, investment and consumption processes, which typifies farm-level production models, can provide considerable flexibility with which to represent policy scenarios. Such a model should, therefore, be capable of making some contribution to the assessment of a wide range of farm policies. The model developed in this study was designed with such flexibility in mind; however, for illustrative purposes, and because of the importance of the policy to New Zealand pastoral farming in the 1980's, special attention is given to an assessment of the Supplementary Minimum Price (S.M.P.) scheme, its impact on farm production and finances, and its effectiveness in comparison with other stabilisation and support policies.

Supplementary Minimum Prices (S.M.P.s), which are government financed floor prices, were introduced for export grades of sheep, beef, wool and dairy products in 1978/79 and, since the 1981/82 season, have provided a significant supplement to pastoral sector incomes. The S.M.P. scheme is the latest of many government policies which have been introduced over the years with the objective of stabilising and supporting farm incomes (Zanetti et al., 1975). While the stated objective of such policies has usually been to achieve medium to
long-run stability, they have often been introduced in response to particular short-term problems and have often involved a significant element of subsidy (Deane and Nicholl, 1979). The adoption of "stabilisation" schemes involving a heavy element of subsidisation, in particular the Supplementary Minimum Price scheme, has become the subject of increasing criticism both within New Zealand, and from New Zealand's trading partners, and the need for alternative policies is being recognised.

In this Chapter the recent history of stabilisation policy is reviewed, together with a review of literature describing and evaluating various aspects of the schemes involved. Some consideration is also given to alternative types of farm support policy. The alternative policy types discussed in this Chapter form the basis for an analytical comparison of stabilisation and support policies presented in Chapter 11 of this study.

2.2 Causes of Income Instability

Price and income instability has always been a feature of pastoral farming in New Zealand. In general terms, the instability of pastoral product prices can be attributed to influences on both the supply of and demand for such products on the world markets. Pastoral products tend to have a low short-run elasticity of supply, thus short-run imbalances between supply and demand are generally accommodated in the market by price rather than output adjustments. Accentuating this effect is the problem of export demand volatility, resulting from the residual nature of the international market for many pastoral products
The other major factor contributing to income instability is the variability of production caused by climatic conditions. Unlike prices, the destabilising effect of adverse climatic conditions tends to be localised in its impact. Consequently, Chudleigh and Filan (1976), in a study of the sources of variance in sheep farm incomes, found that fluctuations in wool production and lamb turnoff assumed increasing significance as a source of instability as consideration was moved from the national aggregate to the individual farm. Nevertheless, they found that these factors only appeared to be of moderate significance as sources of income variance compared with price variability, particularly wool price variability.

2.3 Effects of Income Instability

A range of adverse effects have been attributed to income instability and these have prompted the implementation of stabilisation policies. These effects can broadly be classified into farm level and national level effects.

2.3.1 Farm level.

Zanetti et al. (1975) undertook a detailed examination of issues related to instability in the New Zealand rural sector, and outlined the major (alleged) farm-level effects on the pastoral sector. They stressed the impact of income instability on investment:
"Characteristically farm incomes fluctuate widely and hence the investible surplus also. This in itself, leads to a "stop-go" type of investment with its attendant inefficiencies". Stewart (1967) described some such inefficiencies in relation to land development. For example, scrub land may be cleared but may not be able to be fertilised at adequate levels, or at a later stage, grassing may be completed but there may be insufficient capital available for the purchase of associated livestock.

While there would appear to be some investment inefficiencies that can occur as a result of income instability, it is debatable whether instability leads to a net reduction in the level of investment over time. Proponents of the "permanent income" hypothesis would suggest that there are two components of income — permanent (or assured) income, and transitory income. Consumption decisions are based on the permanent component while savings, and therefore investment, come out of the transitory component. Under these conditions income stabilisation, which would reduce the transitory income component, would tend to lead to reduced investment.

Apart from the validity in the "permanent income" hypothesis (which is examined analytically in Chapter 5) the above argument appears to ignore the relationship between income instability, risk and decision making behaviour. It is well established that typically risk averse farmers will tend to trade-off some income to reduce risk in their farming operations (Anderson, Dillon and Hardaker, 1977). With respect to the pastoral sector of New Zealand this behaviour is likely to lead to conservative management practices and reduced investment in
the more risky forms of farm development (Dent and Beck, 1983).

Another farm level effect of instability, and another justification for stabilisation policies, is the misdirection of resources and investment in response to price changes which may turn out to be only short term. While it is difficult for pastoral farmers to change quickly in response to price movements, once changes are made it may be even more difficult and costly to reverse them. Zanetti et al. (1975) summed up the difficulty by pointing out that "The major problem is that of isolating short-term price fluctuations from longer term trends. The latter are of course the true signals to respond to, but frequently to a farmer the former may be the most obvious and in the final event, most costly".

2.3.2 National level.

The effects of income instability extend beyond the farm gate to affect the demand for goods and services and labour requirements in the servicing and processing sectors. Through this and other linkages farm income fluctuations can destabilise the economy as a whole. Deane and Nicholl (1979) summarise the operation of these linkages for an increase in farm export earnings:

(a) the farm income multiplier; an increase in farm incomes is transferred to the rest of the economy through an income-expenditure process, and the resultant increase in total expenditure is a multiplied amount of the initial increase in farm incomes.

(b) the liquidity effect; an increase in farm incomes will also lead to an increase in trading bank deposits ... and an increase in the
reserve assets of the trading banks. Consequently, the lending capacity of the banking system is increased.

(c) government policy; a government may take advantage of higher export receipts to raise its own expenditure so as to enhance social objectives and expand demand to protect employment.

(d) the business expectations effect; an increase in export receipts could lead to improved business expectations, with a resultant growth in overall demand.

The combined impact of these effects can be large. For example, Deane and Nicholl (1979) suggested that "The farm income boom and associated liquidity build-up in 1972 and 1973 contributed to the strong expenditure and inflation surge in 1973-74 which made adjustment to New Zealand's changed economic circumstances that much more difficult."

2.4 Recent Stabilisation Policies

There continues to be considerable debate about the economic justification for stabilisation schemes in agriculture (see Stoeckel (1984), for example). Nevertheless, in New Zealand the effects of instability in farm prices and incomes outlined above, have provided enough justification for a wide range of price support and stabilisation policies to be introduced in the past. A complete history of these policies is provided by Zanetti et al. (1975). For this current study, however, the review of stabilisation policies concentrates on those policies which have been most directly aimed at pastoral sector price and/or income stabilisation in the last 15 years. The selected policies comprise the Farm Income Equalisation Scheme, the Producer Boards' Stabilisation Schemes for meat and wool, and the Supplementary Minimum Price schemes for meat and wool. (For a more
detailed description of these policies see Ministry of Agriculture and Fisheries (MAF), 1980).

2.4.1 The Farm Income Equalisation Scheme.

This scheme was introduced in 1965 with the aim of reducing fluctuations in aggregate farm income and expenditure levels, and to assist in the planned development of farms. A secondary purpose was to reduce the tax inequity whereby the progressive tax rates lead to more tax being paid on a fluctuating income than on a stable income of similar average level. Under the scheme procedures, funds can be deposited and are tax deductible in the year of deposit. Withdrawals can be spread over the succeeding five years, and are assessable for tax in the year of withdrawal. At first the maximum deposit allowable in any year was 25 per cent of the assessable farm income of that year, but in 1974 this was raised to 100 per cent of assessable farm income. Until 1977 no interest was paid on deposits but since that time an interest rate of 3 per cent has been paid.

A number of studies have been undertaken of the relative merits of the Income Equalisation Scheme (I.E.S.). See for example, Hinkley and Taplin (1966), McArthur (1969, 1971), Charlton (1975), and Chudleigh, Blackie and Dent (1976). McArthur (1971) compared the tax savings from using the Scheme with the opportunity cost of tying up money in an account bearing no interest. He concluded that the tax disadvantage of variable incomes can only be partially overcome by using the I.E.S., and that the Scheme was not worth using unless incomes were highly variable.
McArthur's study was made at a time when the deposits were limited to 25 per cent of assessable income. Subsequent studies, however, have confirmed McArthur's conclusions; Charlton (1975), in a guide to tax planning procedures, suggested that only limited deposits should be made in the I.E.S., and then only on a short-term basis. Similarly, Chudleigh, Blackie and Dent (1976), in a study of methods for stabilising the post-tax incomes of New Zealand sheep farms, concluded that while the I.E.S. had been shown to be very effective in reducing the variability of post-tax incomes, it was not well utilised by farmers. They suggested that the reason for this was that the tax equity and post-tax income stability advantages were often more than outweighed by the opportunity cost of deposits held at zero interest rate. They recommended that "an appropriate interest rate should be paid on deposits in the scheme in order to assist income stabilisation in the farm sector".

As noted above, since 1977 interest has been paid on deposits, at the rate of 3 per cent. The payment of interest at this rate, however, has coincided with a period of high interest rates in the rest of the economy. Consequently, the Scheme would appear to be no more attractive to farmers and its potential for stabilising income has probably not been fully realised. More market competitive interest rates are now being advocated (Deane and Smith, 1980).

2.4.2 Producer Boards' Stabilisation Schemes.

Another type of stabilisation policy that will be examined in this study is exemplified by the buffer fund and buffer stock schemes
operated by the New Zealand Meat and Wool Boards. In these schemes the burden of price stabilisation is borne primarily by the industry as a whole, with both government and the individual farmer having little direct involvement. The history of the current schemes dates back to mid-1970s when the issue of farm income instability became pressing, and ideas for industry based stabilisation schemes were canvassed. The Farm Incomes Advisory Committee (Zanetti et al., 1975), which was convened to investigate the issues, recommended:

"(i) the setting of a basic price at the beginning of the season based on a moving average of recent net market returns. The difference between the basic and market price is to be paid as a deficiency payment, or collected as a levy, as a debit or credit to a buffer account. The scheme being, in essence, self-funding.

(ii) the establishment of criteria for deciding when Government-funded supplementary payments are necessary to maintain an adequate income level".

While a moving average price scheme was advocated, the Meat and Wool Boards and the then Minister for Agriculture, favoured price stabilisation schemes based on the concept of floor and trigger prices, and administered by the Producer Boards. Consequently, after negotiations between the Government and Producer Boards, legislation was enacted late in the 1975/76 season to establish the Schemes. An outline of the Schemes is presented below. Their operations are reviewed in more detail by Sheppard and Biggs (1982).
(a) Meat Income Stabilisation Arrangements

A Meat Export Prices Committee establishes minimum and trigger prices for benchmark grades of export meat - lamb, mutton, manufacturing beef and prime beef - before the start of each meat production season. If the schedule price for any benchmark grade is below the minimum level, the Meat Producers Board must also establish minimum prices for other grades of that type of meat. It then ensures that producers receive no less than the minimum prices by making supplementary payments from the Meat Income Stabilisation Account held at the Reserve Bank and/or by purchasing the meat.

When the schedule price of a benchmark grade exceeds its trigger price, a levy is imposed at a rate equivalent to 50 per cent of the excess. This percentage levy is also applied to the schedule prices of all grades of that type of meat, and deductions made from producers' return accordingly. The levy is paid into the Meat Income Stabilisation Account (MAF, 1980).

(b) Wool Income Stabilisation Arrangements

The Wool Board Scheme differs from that operated by the Meat Producers Board. In addition to setting minimum and trigger prices, the Board operates a flexible market intervention policy as part of its price smoothing operations.

Under its Minimum Prices Scheme the Wool Board sets a table of minimum prices for the season for all types of shorn wool and dead wool
produced in New Zealand. When the sale price for any wool falls below its appraised minimum price, the Board will supplement that price up to its minimum level through a payment from the Minimum Wool Prices Funding Account held at the Reserve Bank. The Board may also provide minimum price support by purchasing the wool using its own funds or borrowing for that purpose. To finance the Minimum Price Scheme, a levy is imposed on all shorn wool and dead wool produced in New Zealand. The levy is paid into the Minimum Wool Prices Funding Account.

In association with the Minimum Price Scheme, the Board also operates the Grower Income Retention Scheme to skim funds when prices are high. When the average price of wool at auction, after deduction of the minimum prices funding levy, exceeds the trigger price set at the beginning of the season, a further levy operates on all wool sold. The rate of levy is equivalent to 50 per cent of the amount by which the average price at that auction exceeds the trigger price. The levy is credited to individual grower accounts within the Grower Incomes Retention Account at the Reserve Bank. Deposits are returned to producers after five years, or at the discretion of the Minister of Agriculture and Fisheries.

Buffer fund and buffer stock schemes such as those operated by the New Zealand Meat and Wool Boards are intuitively attractive because they can be self-financing. In practice, however, such schemes are notoriously difficult to administer effectively. If the price band (between the minimum and trigger prices) is too narrow, then there are likely to be problems of excessive skimming or supplementation. On the
other hand, if the band is too wide then the scheme will rarely operate and will have little stabilising effect. Also, long-term balancing of levies and supplementary payments largely depends on accurate forecasting of price trends which is difficult.

The operation of the Schemes between 1975/76 and 1977/78 generally involved the use of relatively conservative minimum prices which resulted in infrequent intervention in the market and relatively little effect on price instability. Sheppard and Biggs (1982) suggest that the operation of the Schemes over that period was viewed with concern by the Government. They contend that "... It had been anticipated (by Government) that the schemes would provide for the stabilisation of farm product prices as well as the achievement of an adequate level of farm income based on market returns. In the opinion of the Government, neither of these objectives had been met over the three years of stabilisation scheme operation and it was therefore decided that a new scheme should be introduced with the objectives of improved stabilisation and farm income adequacy". Consequently, the Supplementary Minimum Price Schemes for meat and wool (and dairy products) were introduced in 1978/79.

2.4.3 Supplementary Minimum Prices (S.M.P.s).

Supplementary Minimum Prices were introduced as an adjunct to the stabilisation schemes operated by the New Zealand Wool Board and the New Zealand Meat Producers' Board, in order to maintain an adequate income level and improve price stability and confidence. It was expected that the Schemes would be an interim measure (Muldoon, 1978);
however, they have continued to operate and from 1981/82 have provided a significant supplement to farm incomes.

With respect to meat, the Government underwrites meat export schedule prices to producers, supplementing those set under the Meat Producer Board's stabilisation arrangements. The S.M.P.s are related to the benchmark grades of meat used for the Board's stabilisation scheme. They apply only to export carcass meat from sheep and cattle, excluding bobby calves. If the schedule price for any benchmark grade of meat (including any supplement paid by the Meat Producers' Board under its Meat Income Stabilisation arrangements) is below the specified S.M.P. for that grade, the Board establishes S.M.P.s for other grades of that type of meat. The Board then further supplements prices up to the S.M.P. levels by making supplementary payments from the Government-financed S.M.P. Account maintained by the Board at the Reserve Bank.

For wool, S.M.P.s apply only to shorn wool and dead wool. The rate of supplement payable by the Government through the Wool Board is based on the amount by which the average price of wool at auction, is below the specified S.M.P. This rate of supplement is applied to the gross proceeds from the sale of qualifying wools and paid to growers through brokers or directly by the Wool Board. The Board makes these supplementary payments from the Government-finance S.M.P. Account at the Reserve Bank (MAF, 1980).

The value and effectiveness of S.M.P.s have been topical issues, particularly since the 1981/82 season, when they began to play a
significant price supporting role. Sheppard and Biggs (1982), for example, reviewed the operation of S.M.P.s up to the 1982/83 season and concluded that S.M.P.s had not been very effective in either stabilising incomes, or maintaining income adequacy.

In a more analytical study, Laing and Zwart (1983a) used an econometric model of the New Zealand pastoral sector to evaluate the short and long-run impacts of S.M.P.s. They concluded that, in the short-term, while S.M.P.s help maintain farm incomes, they do not have a major influence on the productive capacity of the pastoral farming sector. "Thus, even as a short term measure, the payment of subsidies to farmers under the S.M.P. scheme cannot be justified on the ground that without them export receipts would fall dramatically". Similarly, for the longer term, they concluded that the level of capital and livestock numbers would largely be maintained in the absence of an S.M.P. policy, making it possible to respond to any upturn in market returns.

The Laing and Zwart study had two major limitations which justify a further study of the impact of S.M.P.s. Firstly, given the nature of their analysis, it was necessary to assume that there would be a constant and permanent difference between market and farm-gate prices. In reality, the difference between market and farm-gate prices, and thus the extent of S.M.P. payments, fluctuates widely depending on market prices. This dynamic aspect of S.M.P.'s will affect their impact at the farm level. Secondly, Laing and Zwart were not able to make any conclusive statement regarding the viability of farming without S.M.P.s. While the productive capacity of the farm may largely
be maintained without S.M.P.s, the profitability of farms may be severely affected, perhaps to the extent that debt servicing and family consumption commitments would lead to serious adjustment problems. As a result, the disruption to the productivity of the sector in the absence of S.M.P.s may be greater than was indicated by the Laing and Zwart study (Dent and Stewart, 1983).

2.5 Alternative Support Policies

In addition to its stabilising role, the S.M.P. scheme has become a major source of assistance for the agricultural sector and represents a significant item of Government expenditure. Chudleigh, Greer and Sheppard (1983), estimated that the gross value of Government assistance to the agriculture in the year ended 30 June 1982 was approximately $819 million. Of this, price-subsidisation through the S.M.P. scheme accounted for about $220 million. For the 1982/83 and 1983/84 seasons the cost of S.M.P.s has been estimated at $351 million and $295 million respectively (MAF, 1984).

Issues related to taxpayer support for the agricultural sector are discussed elsewhere, (see for example, Balderstone et al., 1982; Bushnell et al., 1982 and Chudleigh et al., 1983) and are beyond the scope of this study; however, if a government believes that financial support is justified a number of alternative policies are possible. Perhaps the most direct form of support would be an output subsidy paid on an ad valorem basis. Such a policy would have the advantage (over S.M.P.s) of allowing the direct transmission of price signals; in particular, distortions caused by interference in livestock price
relativities would not occur. However, such direct subsidisation of output may not be acceptable to some trading partners (or New Zealand taxpayers).

The other major class of direct support policies (apart from output/price subsidies) can be classified under the general heading of input subsidies. Input subsidies can take a wide range of forms and have been commonly used in New Zealand in the past. Input subsidies can range from simple direct subsidies on such inputs as fertiliser and herbicide (e.g. the Fertiliser Price Subsidy, the Fertiliser and Lime Transport Subsidy and the Noxious Plants Control Scheme), to relatively complex development-linked assistance "packages" involving special credit and taxation concessions. Typical of this latter form of input subsidisation were the Livestock Incentive Scheme and the Land Development Encouragement Loans (MAF, 1980).

The Livestock Incentive Scheme was operative between 1976 and 1982 and was introduced to achieve a permanent increase in the number of livestock carried. In essence the scheme provided a grant of $12 or a tax deduction of $24 for each extra (qualifying) stock unit carried for two years. A certain minimum increase in stock units carried had to be achieved before the incentive could be claimed.

The Land Development Encouragement Loans scheme operated between 1978 and 1981 to encourage the development of unimproved or reverted land by ensuring that initial capital and, where necessary, working capital, was available. Given that certain conditions were fulfilled, all interest on the special development loan was deferred and
accumulated interested was (will be) written off at the end of the fifth, tenth and fifteenth years, after the commencement of the approved development program. Of the principal, half is written off after 10 years and the remainder is repayable by equal amounts spread over 10 years commencing at the end of the fifth year.

If increases in production are an objective for support policies then investment-linked input subsidising schemes such as the L.I.S. and the L.D.E.L. scheme are likely to achieve this (see assessments by Scott and Sorrenson (1979) and McIntosh (1981)). They remain, however, direct forms of subsidisation and are likely to be criticised strongly by trading partners.

The only form of assistance that may escape such criticism is assistance provided indirectly through such channels as agricultural research and development, or through general economic restructuring policies which reduce the cost of agricultural inputs. Such assistance would ultimately be reflected at the farm level as an improvement in the terms of trade or as increased productivity.

2.6 Conclusion

This brief review of recent stabilisation and support policies highlights a number of policy types which could provide alternatives to the Supplementary Minimum Price scheme. For stabilisation purposes, the existing Income Equalisation Scheme and the Meat and Wool Boards' "buffer price" schemes could be developed to play a more important role. Alternatively, a moving average price scheme of the type
suggested by Zanetti et al. (1975) could be adopted.

If continued significant levels of assistance can be justified then alternatives range from direct price subsidies, through various forms of input subsidisation, to indirect research funding and economic restructuring. The use of the model developed in this study is illustrated in Chapter 11 by comparing the physical and financial effects of these alternative policy types with those projected for the Supplementary Minimum Price scheme.
3.1 Historical Perspective

The need to predict farmer response to changes in the financial, institutional and technological environment of farming has long been recognised. Traditionally, predictive models have taken the form of econometrically estimated supply response models and production functions. Up until recently these models, in line with neo-classical theory, have implied the existence of, or at least the rationality of, profit maximising behaviour. For example, on the question of allocative efficiency there has been a continuing debate about the extent to which farmers allocate their resources to maximise profits. In the sixties and early seventies a number of studies based on Cobb-Douglas production functions fitted to time-series data generally concluded that farmers tend to behave as profit maximisers within their technological and institutional constraints (Chenareddy, 1967; Hopper, 1965; Lau and Yotopoulos, 1971; Welsch, 1965). Econometric models of industry supply response therefore have tended to concentrate on the response to price and price expectations.

During the seventies, however, the developing interest in decision theory with its emphasis on decision makers' expectations and preferences led to increasing recognition of the role of attitudes and other factors in decision making. The thrust of decision theory to date has been toward normative theories and models to determine the
perceived risk involved in farming and to indicate how farmers should react to risk. The implications of risk and other "non-economic" factors for positive response studies has only recently begun to be examined. With respect to risk, for example, Just (1974, 1975) empirically tested risk-response models which appear to better explain aggregated farmer supply response under conditions of changing risk levels. Risk response occurs when farmers who are averse to risk experience a significant change in the riskiness of their decision making environment, perhaps due to government policy, new technology etc. If risk is reduced then output of the previously risky product is likely to increase even if the expected return remains unchanged. As might be expected the existence of risk response has raised questions about the design and likely impact of public stabilisation schemes (Just, 1974; Anderson, Hazell and Scandizzo, 1977; Quiggin and Anderson, 1979).

Econometric models of the type described above, while sometimes useful for ex-post policy analysis, are of limited value in the evaluation of new policy measures. A more disaggregated farm-level approach is required. At this level, an apparent paradox has arisen between observations that farmers are rarely risk-neutral profit maximisers and yet, according to the production function studies cited above, they supposedly behaved as if they were. Evidence against the validity of the profit maximisation hypothesis in behavioural studies has continued to mount up. For example, Lin, Dean and Moore (1974) concluded that "...empirical studies explicitly employing the profit maximisation hypothesis (e.g. in linear programming studies of individual farms and aggregate supply response) have generally provided
results inconsistent with observed or plausible behaviour."

Other problems, particularly related to the use of linear programming in this context, have also been shown. Lins (1969) provided empirical evidence that a "mathematically optimal" solution generated by a linear programming model of farm growth may not be a "logical optimum" due to problems associated with the indivisibility of factors. Also the simultaneous solution of a linear programming model usually implies the assumption of perfect knowledge. The true optimal solution under the inherently uncertain conditions of the real system may differ significantly from the LP "optimum". These problems may be exacerbated when individual farm LP models are combined into large aggregative linear programming models (Wicks, Mueller and Crellin, 1978).

These observations have led to a critical re-evaluation of production function research (e.g. Dillon and Anderson, 1971) and moves to find more realistic and useful behavioural theories and methodologies. With respect to behavioural theories, Lin, Dean and Moore (1974) tested the hypothesis that Bernoullian and lexicographic utility maximisation are more accurate predictors of farmer behaviour than profit maximisation. After an intensive study of six large scale commercial mixed cropping farms in California they concluded "that Bernoullian utility maximisation explains actual farmer behaviour more accurately than profit maximisation...the lexicographic utility function, although apparently related more closely to the actual decision processes of farmers, performed poorly - only slightly better than profit maximisation - in predicting actual and planned decisions".
They noted, however, that none of the models predicted actual behaviour well, with a strong tendency for all models especially profit maximisation, to predict more risky behaviour than was in fact observed.

Also Hardaker (1979) reported that O'Mara (1971), Wolgin (1975) and Herath (1979) had found some empirical support for the view that the SEU (subjective expected utility) model predicts small farmer behaviour better than does the expected profit maximisation model.

On the methodological side considerable effort has been put into overcoming both the normative and predictive shortcomings of linear programming particularly with respect to the handling of risk. (See for example Anderson et al, 1977, Chapter 7; Rae, 1971; Webster and Kennedy, 1974; Wicks and Guise, 1978). While the predominance of effort has been on the normative side it is likely that the predictive potential of programming models is also being improved (Lin, Dean and Moore, 1974; Officer and Halter, 1968). However, with pure programming models many of the problems of handling the dynamic and stochastic aspects of farming systems remains; in this respect simulation based models have been found to provide an effective means of representing these important aspects of farming systems (Dent and Anderson, 1971; Anderson, 1974; Dent and Blackie, 1979).

3.2 Selecting an Appropriate Model Type

While some form of utility maximising function may improve the power of predictive models in some circumstances, the incorporation of
such a function in a model may not necessarily be justified for several reasons. Firstly, a proportion of farmer response will inevitably remain unexplained. Humans tend to be inconsistent in their behaviour, may display bias in subjective probability judgements, or fail to revise subjective probabilities in a rational (Bayesian) way (Slovic, Fischoff and Lichtenstein, 1977; Officer and Halter, 1968; Binswanger, 1978).

Secondly, and perhaps more importantly, the theoretical improvement in a model's predictive accuracy, resulting from the use of a utility maximising objective function, may be minimal compared with the potential errors involved in modelling other aspects of the farming system. This would be particularly so where there is little difference between the riskiness of alternative farm activities and/or where the range of activities is strongly constrained by the nature of the farming system and associated physical, environmental and financial factors. Under these circumstances the modelling emphasis should be on adequately representing the influence and interaction of these factors.

Such would appear to be the case with the North Island hill country farming system; geographic and climatic factors tend to limit enterprise options to sheep and cattle breeding activities, both of which are subject to similar sources of environmental and economic uncertainty. There is little scope for short-term changes in the farming system; such change that does take place is likely to occur in the medium to long-term as a result of investment or disinvestment. The level of funds available for investment will depend on the interaction of a number of factors including production, prices, consumption,
borrowing, expenditure and taxation. Under these circumstances the observations of Campbell (1958) with respect to agricultural investment appear relevant:

"The profit maximisation or marginal theories of investment, even in their more sophisticated farm involving risk, uncertainty and expectations, seem to have their chief value in providing a basis for setting up ideal goals for agricultural investment rather than an explanation of, or guide to, entrepreneurial action." Rather he suggested that..."The most plausible formulation [of the investment process] would treat investment as a residual, defined as the net income realised from current operations less tax commitments and some conventional allowance for farm family living expenses."

A detailed analysis of the farming system is presented in subsequent chapters but it seems clear that a model is required which is capable of representing the various physical, financial and behavioural components of the farming system in a dynamic and stochastic framework. Sufficient detail is required to allow a range of policy instruments, and their impact on various components of the farming operation, to be represented. An appropriate methodology in this context involves the use of simulation based models, possibly with programming sub-models included. Examples include pure simulation models (Patrick and Eisgruber, 1968; Charlton, 1972), models combining simulation and single-period LP components (recursive programming) (Kingma, 1973; Kingma and Kerridge, 1977) and combined multi-period LP and simulation (Chien and Bradford, 1976). Such models, often referred to as farm growth models, can represent a dynamic and stochastic
farming system involving divisible and indivisible factors, and non-linear production and financial relationships. They can also provide the necessary flexibility to allow a range of behavioural decision rules to be incorporated into the dynamic and stochastic structure (Dent and Blackie, 1979).

3.3 A Review of Selected Farm Growth Models

Given that a dynamic simulation based model is appropriate in this context, a selective review of three such models was made to observe some of the approaches taken by others to the modelling of investment and other aspects of the farm system. The three models reviewed were developed by Heidues (1966), Patrick and Eisgruber (1968), and Kingma and Kerridge (1977). These three were selected because they provide good examples showing the range approaches taken to farm growth modelling. A brief overview of each model is provided before considering model structures in more detail.

3.3.1 Overview of selected models.

Heidues (1966) used a deterministic recursive LP model of farm growth to analyse the effects of four EEC policy alternatives on different types of farms in Northern Germany. Recursive programming (RP) is a sequence of mathematical programming problems in which the parameters of a given problem are functionally related to the optimal variables of preceding problems in the sequence (Day, 1963). Unlike dynamic programming or multi-period LP, RP involves sequential optimising to explain behaviour (positive) and is not used to devise
optimal decision rules which lead to optimal policies over the time period considered (normative). This work has provided an important reference point for most of the subsequent applications of RP to modelling farm growth.

Patrick and Eisgruber (1968) used a pure simulation approach to farm growth modelling. They attempted to account for the relationships between multiple goals, expectations and other stochastic and dynamic aspects of the farming system. The purpose of their work was to study the impact of managerial ability and capital structure on farm growth, and they were able to draw some conclusions about the effect of credit policy.

The approach taken by Kingma and Kerridge (1977) falls between the recursive programming of Heidues and the simulation of Patrick and Eisgruber, and has been called a recursive optimising and simulation approach. They modelled the complex financial aspects of the farm in a simulation framework which encompasses detailed taxation calculations, consumption decisions and future investment. Once these major decisions are made for each year, a risk constrained linear programming model is used to allocate resources of land, labour and capital to the various productive enterprises. The result is a recursive programming type model with enhanced positive elements based on financial sub-models, expectations, stochastic elements of the environment and risk aversion on the part of the farmer. The model has been used in various Australian Bureau of Agricultural Economics (BAE) policy analysis studies to explore the value of price stabilisation schemes; to investigate the farm-level impact of various land, capital and debt
scenarios; to examine the ability of various types of farms to cope with economic pressures over time; and to assess the impact of constraints on the expansion of a sheep meat enterprise (Kingma, et al., 1980).

3.3.2 Investment decision algorithms.

Of particular interest for this study was the way investment decisions were handled. Accordingly, the models are reviewed from this point of view. For descriptive purposes, the investment decision making algorithms used in the three models are broken down into three components:

(i) determining what funds are available for investment;
(ii) specifying investment alternatives;
(iii) selecting between investment alternatives.

Each of these aspects is considered in detail in the following sections.

(a) Allocating Funds for Investment

In all three models, funds for investment are generated from internal and external sources. In each case internally generated funds are assumed to be the residual after paying operating costs and fixed commitments such as loan repayments, tax (except Heidues), and satisfying consumption requirements.
The question of consumption requirements is a critical issue in modelling the flow of internal funds for reinvestment. Heidues took the simplest approach and specified a fixed requirement for consumption based on an historical average which was incremented by an annual growth factor to represent an increasing real standard of living. Patrick and Eisgruber estimated a more complex consumption function based on USDA survey data. Consumption was represented as a function of a weighted average of farm income (after tax and debt payments) in the current and previous two periods, family size and the age of the farm operator. A minimum consumption level was also imposed. The weighted average farm income variable implied that consumption expenditure was likely to remain relatively constant and would adjust with a lag to changes in farm income.

Kingma and Kerridge in the BAE model assumed that the farm family makes allowances for consumption based on a modified Keynesian consumption function in which, assuming a positive cash surplus after all expenses, consumption in period \( t \), \( C_t \), is expressed as:

\[
C_t = a_0 + a_1 \left( \frac{CS_{t-1} + CS_t}{2} \right)
\]

where \( a_0 \) is the basic wage, 
\( a_1 \) is the marginal propensity to consume, and 
\( CS_t \) is the cash surplus in period \( t \).

The approach taken in these models, either implicitly or explicitly, is in line with the residual funds hypothesis for investment (Campbell, 1958) i.e. investment outlay is a residual, defined as the net income realised from current operations less tax.
commitments and some allowance for farm family living expenses.

The other source of investment funds is borrowing. In Heidues' model and Kingma and Kerridge's model, leverage constraints were imposed i.e. the farmer could only borrow up to some specified proportion of total farm assets. This type of constraint allows for farmers' observed aversion to excess borrowing and also gives expression to the fact that there may be external credit rationing imposed. Such constraints can also be interpreted as representing a farmer's preference for some level of credit reserves as a response to uncertainty (Barry and Baker, 1971).

Patrick and Eisgruber took a more flexible approach to the borrowing decision. No absolute constraint is placed on borrowing or asset/debt ratio. Rather, the credit requirement of each alternative investment option is determined as one of its attributes. Investments are then selected on the basis of a multi-attributed utility function so that borrowing with its associated costs and risks is accepted to the extent necessary to achieve other goals.

The ability-to-repay constraint on borrowing was handled in a straight-forward manner in the models which included programming. Basically, the borrowing activity in the LP will only come into the optimal solution to the extent that is possible without violating the constraints that require that other cost and consumption requirements are met.
(b) Specification of Investment Alternatives

The range of alternative production and investment alternatives specified in these models obviously depends on the type of farming system being modelled. Heidues dealt with an intensive mixed cropping and livestock farm. Investment alternatives included purchase of durable assets (mainly machinery and buildings) and the purchase and rental of land. Production activities used some level of asset capacity which could be added to by investment in new assets or reduced through depreciation or, possibly, disinvestment. The formulation of investment and disinvestment activities was based on the theory of asset fixity. An asset was fixed for the firm if its productive value was smaller than the acquisition costs and larger than its salvage value. Depending upon the assets' mobility, price and technological change, a difference could arise between its productive value and its salvage value thus making disinvestment worthwhile.

The Kingma and Kerridge model involved a range of sheep and cattle activities as well as a range of broadacre crops. The investment alternatives for land development are of particular interest here. Pasture land resources were specified at various levels of development, and improvement through land clearing and/or the application of superphosphate allowed land to be converted from one level to another. For land involving superphosphate application, pasture reversion activities were included. These activities facilitated a response to superphosphate price by allowing land to revert to lower levels of development, accompanied by lower application rates of superphosphate. Flexibility constraints between years restricted movement between
land-use categories in order to account for the gradual decline in residual superphosphate in the soil.

Patrick and Eisgruber modelled a mixed cropping system with some livestock activity. They allowed new land to be bought or rented and provided a choice of seven crop rotations of different intensities, as well as providing the potential to expand the livestock activity. Alternatively, the farmer could work off the farm and operate as a part-time farmer, or sell the farm. Rather than being represented as activities in an LP matrix, these alternatives were discrete and were described in terms of their expected contribution to current income, net worth and risk, and their requirements for labour, time and credit.

(c) Selecting Between Alternatives

In developing behavioural decision-rules to select between the specified investment alternatives, the structure of all three models implied the premise that farmers are goal oriented i.e. they are reasonably systematic in their efforts to maximise something. Just what it is that they maximise, how they go about it, and how the procedure can be modelled are questions that were answered in different ways by the different modellers. All models, by their nature, depart significantly from neo-classical theory; however, the model that comes closest to assuming profit maximising behaviour is Heidues' German model. Prices and yields were assumed to be known with certainty and the objective was to maximise annual net farm income. The major constraints were related to resource capacities for such factors as machinery, farm buildings, and soil quality, as well as accepted crop
rotational practices. Also, behavioural constraints were included to limit the rate and total amount of borrowing, and to maintain consumption and liquidity.

Kingma and Kerridge in their BAE model used LP as only a component of a larger simulation model and thus were able to allow for more behavioural and stochastic aspects of the farming system. They used simulation to handle most of the financial aspects of the firm such as taxation, concepts of utility relating to the farm-household, and decision-theoretical concepts concerning consumption and future investment. In the simulation component of the model, actual and expected price and production yields were determined.

Prices and yields were determined stochastically based on variation and correlations found historically. Price expectations were estimated using an adaptive lag model while production yield expectations were based on expected values estimated from historical and research response data. Once these major decisions were made and the associated parameters are fixed for the year, the linear program was used to allocate resources of land, labour and capital to the various productive enterprises. Also, the LP model accounted for risk using the techniques of mean absolute deviation developed by Hazell (1971), thus allowing for the fact that risk averse farmers will trade off expected income to reduce risk. In the resulting model, production and investment alternatives are selected on the basis of a neo-classical response circumscribed or dampered by:
(a) sub-optimal household decisions related to, amongst other things, use of the annual cash surplus,
(b) expression, through use of adaptive expectations, of the fact that farmers are generally unwilling to rapidly adjust their enterprise mix to what might be only short-term price phenomena, and
(c) the effect of risk aversion or the unwillingness to borrow funds.

The approach to selecting between production and investment alternatives used by Patrick and Eisgruber was the most strongly influenced by behavioural theory, as opposed to neo-classical economic theory. Each available alternative activity was budgeted to determine its likely contribution to the four family goals i.e. current income, net worth, labour/leisure and credit/risk. In this budgeting process price and yield expectations were used based on a weighted average of the previous three years experience. A desired norm or expected level was assumed for each goal and each budgeted alternative was assigned a level of satisfaction or utility reflecting the degree to which the plan was expected to attain the desired norm. The plan promising the highest level of overall satisfaction - that is, the one which best attained the multiple goals of the decision maker - was selected and implemented.

3.4 Conclusion

This review of methodology and farm growth models indicates the range of structures and algorithms possible in this type of modelling. The appropriate structure for a model will depend on the nature of the system being modelled and the purpose of the model. A detailed
examination of the North Island hill country farming system was undertaken and is described in Part II of this study.
PART II

SYSTEM ANALYSIS

CHAPTER 4 A GENERAL INTRODUCTION TO NORTH ISLAND HILL COUNTRY

4.1 Introduction
4.2 Hill Country Defined
4.3 General Background
4.4 Hill Country Production Systems
4.5 Economics of Hill Country Development
4.6 Conclusion

CHAPTER 5 CONSUMPTION ANALYSIS

5.1 Introduction
5.2 General Theories of Consumption Behaviour
5.3 Application to Agriculture and New Zealand
5.4 Discussion of Results
5.5 Conclusions

CHAPTER 6 ANALYSIS OF THE USE OF CREDIT

6.1 Introduction
6.2 Aspects of Credit Using Behaviour
6.3 Analysis of Factors Affecting Long-Term Borrowing
6.4 Analysis of Factors Affecting Short-Term Borrowing
6.5 Conclusions
CHAPTER 7 ECONOMIC AND ENVIRONMENTAL FACTORS AFFECTING PASTORAL SUPPLY RESPONSE

7.1 Introduction

7.2 A Review of Pastoral Sector Studies

7.3 An Analysis of Factors Affecting North Island Hill Country Stock Numbers

7.4 Conclusions with Respect to Investment Behaviour

7.5 Modelling Investment and Disinvestment in a North Island Hill Country Farm Growth Model
CHAPTER 4

A GENERAL INTRODUCTION TO NORTH ISLAND HILL COUNTRY

4.1 Introduction

As the first step in the systems analysis process, a general review of New Zealand hill country and associated farming systems was undertaken. This review starts with a physical definition and description of "hill country". Particular attention is then given to the physical and financial features of North Island hill country farming systems as revealed by the Meat and Wool Boards' Economic Service (MWBES) Sheep and Beef Farm Survey. The economics of hill country development is also discussed.

4.2 Hill Country Defined

Although the term "hill country" is often used in discussions and studies of the New Zealand pastoral sector (see, for example, Brougham, 1973; Hight, 1976, 1979; Mauger, 1977, 1981; Parker, 1981; Rattray, 1982b) the definition of the term remains arbitrary. For many purposes hill country can be simply defined as "predominantly non-ploughable land, excluding South Island high country". This is the definition adopted by the National Research Advisory Council in a study of hill country research requirements (NRAC, 1978). For other purposes more specific classification and definitions are necessary to account for the diversity which is inherent in "hill country". This diversity is associated with differences in geographical location, slope, rainfall,
soil type and farming system. For example, the Meat and Wool Boards' Economic Service (MWBES) in their Survey of Sheep and Beef Farms define three hill country farm classes based on a combination of farming system and geographical factors. These are:

(i) Hill Country, South Island (Class 2): farms running mainly fine wool sheep and with a carrying capacity of approaching three stock units per hectare. Wool and sales of cast-for-age ewes are a major source of income. These farms are mainly in Canterbury.

(ii) Hard Hill Country, North Island (Class 3): farms running mainly Romney sheep and carrying around eight stock units per hectare (with approximately one cattle beast to ten sheep). Cattle provide approximately one quarter of the revenue, the balance being derived from the sale of store sheep and lambs, plus wool income. These farms are mainly located on the east and west coasts and central plateau of the North Island.

(iii) Hill Country, North Island (Class 4): farms located on easier hill country and tending to be smaller holdings than Class 3. Mainly Romney sheep are stocked at over ten stock units per hectare (with approximately one cattle beast to 12 sheep). A high proportion of sale stock are sold in forward store or prime condition. These farms are located throughout the North Island.

In other cases, hill country has been classified into wet and dry (Brougham, 1973), on the basis of geographical location (Fitzharris and Wright, 1980), and on the basis of soil type, vegetation and slope (Scott, 1981). Classification and definition can be pursued further on the basis of a number of criteria such as geological history, soil types, vegetation, altitude etc. (see DSIR, (1980) for example).

Notwithstanding the diversity inherent in "hill country", it would appear that this class of land has sufficient unique and common features to justify the use of a broad definition in many studies. The National Research Advisory Council (1978) describe these features:

"Principal of these (features) is its steeply sloping nature which restricts land use to grazing pasture and forestry; limits management flexibility because the area suitable for growing
supplementary crops or conserving grass is often little or nothing; and dramatically increases the costs and difficulty of fertiliser spreading, fencing, weed control, pasture renovation and other operations. In addition social problems (such as inadequate access, schooling, cultural and recreational facilities) resulting from the remoteness of much hill country, increase the difficulties of maintaining a farming population and labour force."

Given these common features and the purpose of this study, which is concerned with the effect of external factors on the operation of hill country farms, a broad definition has been adopted here. Thus, in the first instance this introductory discussion will relate to hill country defined as "predominantly non-ploughable land, excluding South Island hill country". Attention will then be focussed on "North Island hill country" (Class 4 as defined by the MWBES) which is an important sub-set of all hill country, and which represents the main area of interest in this study.

4.3 General Background

New Zealand has about 13 million hectares of pastoral land of which approximately 4.5 million hectares is hill country. Despite the physical and socio-economic difficulties of hill country farming, hill country land supports about 40 per cent of New Zealand's total stock units (NRAC, 1978; Hight, 1979), representing about 34 million stock units in 1982 (MWBES, 1982). In 1978 the NRAC reported that pastoral

---

1 Based on MWBES classification and comprising approximately 1.8m hectares South Island hill country (Class 2), 1.0m hectares North Island hard hill country (Class 3) and 1.7m hectares North Island hill country (Class 4) (NRAC, 1978). Environment associated with South Island hill country also results
farming on all hill country earned "... more than $600 million a year in foreign exchange which is about 50 per cent greater than the value of receipts from "manufacturing exports". They went on to point out that "if allowance is made for the relatively low import content of hill country farming (9 per cent against manufacturing's 27 per cent), its net foreign exchange contribution compared with manufacturing is higher still".

There are about 8,000 hill country farms which provide direct employment for more than 15,000 people as well as having a significant effect on employment opportunities in other sectors. In addition, hill country farms are a major source of breeding ewes, and store lambs and cattle for lowland farms (NRAC, 1978; Hight, 1979).

The average carrying capacity of hill country farms is about 7 stock units per hectare (s.u./ha), with about 3 s.u./ha being supported on South Island hill country and about 10 s.u./ha on easier wetter land in the North Island (MWBES, 1982).

These figures indicate the superior productivity of North Island hill country which tends to be less affected by the temperature and rainfall constraints that limit South Island hill country production. As a result of this difference in productivity and the relative areas involved (1.8 million hectares in South Island and 2.7 million hectares in North Island), North Island hill country is of greater economic importance than the South. Approximately 85 per cent of hill country stock carrying capacity is in the North Island. The harsher in farming systems which tend to differ markedly from North Island hill
country systems. As indicated by MWBES description of Class 2 farms, emphasis in the South Island is on fine wool production while in the North Island meat and coarse wool production predominate (see MWBES Class 3 and 4 farms).

The MWBES defines two hill country farm classes (3 and 4) within the North Island which differ mainly on the basis of the difficulty of the physical environment involved. There are approximately 1 million hectares of "hard North Island hill country" (Class 3) carrying about 8.6 stock units per hectare on average, and there are approximately 1.7 million hectares of (easier) "North Island hill country" (Class 4) carrying about 10.8 stock units per hectare on average.

While there seems little doubt that the potential for increasing hill country production is substantial, surprisingly little research has been done in the past to establish more objectively the extent of the potential or to determine optimal hill country management systems. This fact has been highlighted by a number of authors (see, for example, Hight, 1976, 1979; NRAC, 1978; Gillingham, 1980; and Scott, 1981). Hight (1976) for example, stated that "Few self-contained management trials have been conducted in New Zealand hill country to define the effects of class and genetic merit of stock, aspect (shady or sunny), grazing method, grazing intensity (continuous/infrequent and lax/hard), fertiliser requirements, or of supplementary feed on pasture and animal production..." ² More hill country research seems

---

² Some relevant biological and management research includes Inglis, 1965; Kissock, 1966; Hight and Wright, 1972; Suckling, 1975; Smith et al., 1976.
likely in the future, following a review of research priorities undertaken by a Hill/High Country Research Committee of the DSIR in 1981.

4.4 Hill Country Production Systems

4.4.1 Physical and production features.

A sketch of the typical or average easier North Island hill country farm can be gained by reviewing the results of the MWBES Sheep and Beef Farm Survey for Class 4 farms. Based on survey results for the period 1976/77 to 1980/81 the following picture emerges:

The average size of Class 4 farms is between 370 and 400 hectares of which approximately 90 per cent is effective. Average carrying capacity is 10.5 stock units per effective hectare, of which 30 to 35 per cent are cattle. Hill country farming is still strongly based on family farming units with the average labour used being about 1.7 labour units per farm.

The lack of ploughable land and difficulties with pasture production and utilisation in much of the North Island hill country mean that extensive stock breeding and rearing are the main activities. The predominance of stock breeding activities is illustrated by data from the MWBES Survey of Sheep and Beef Farms (1982) which show that, on average, for Class 4 farms, purchases as a percentage of stock wintered was only 3.5 per cent for sheep and 11 per cent for cattle. Average lambing percentages typically vary between 90 and 100 per cent,
with average calving percentages varying between 80 and 85 per cent. On a kilogram per hectare basis, average annual meat production is typically between 110 and 130. Average wool sales per sheep stock unit vary between 5 and 6 kilograms. On a kilogram per hectare basis, this represents average annual production of between 40 and 50 kilograms per hectare.

In comparison with other farm classes, Class 4 farms tend to be the most productive (and smallest) of the more extensive classes of pastoral farm in New Zealand. On the other hand they tend to be larger and less productive than farms on flatter country.

4.4.2 Capital structure.

The average capital structure of Class 4 farm is most conveniently described using the MWBES Survey results for 1980/81, reproduced in Table 4.1. A number of features are worthy of note. Firstly, the combined value of land, buildings and improvements (separate valuations are not available) dominate the asset structure, accounting for nearly 70 per cent of total assets. The next most significant category of assets is livestock representing 18 per cent of total assets. Other items are relatively insignificant.

Secondly, the value of non-farm assets appears very low; probably less than 4 per cent of total assets if the homestead and car are not counted, and some allowance is made for liquid reserves. While the value of off-farm assets is underestimated in the survey (because investments outside the farm are valued at book value and not at
# TABLE 4.1

**Capital Structure of Average North Island Hill Country (Class 4) Farm 1980/81**

<table>
<thead>
<tr>
<th>ASSETS</th>
<th>$</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Value (land, buildings and improvements, excluding homestead)</td>
<td>516,721</td>
<td>68.8</td>
</tr>
<tr>
<td>Truck and Tractor</td>
<td>8,519</td>
<td>1.1</td>
</tr>
<tr>
<td>Other Plant and Machinery</td>
<td>3,646</td>
<td>0.5</td>
</tr>
<tr>
<td>Livestock: Sheep</td>
<td>72,738</td>
<td>9.7</td>
</tr>
<tr>
<td>Cattle</td>
<td>62,217</td>
<td>8.3</td>
</tr>
<tr>
<td>Other</td>
<td>441</td>
<td>0.1</td>
</tr>
<tr>
<td>FARM CAPITAL</td>
<td>664,282</td>
<td>88.4</td>
</tr>
<tr>
<td>Cash at Bank or Firm</td>
<td>7,209</td>
<td>1.0</td>
</tr>
<tr>
<td>Income Equalisation Balance</td>
<td>4,488</td>
<td>0.6</td>
</tr>
<tr>
<td>Homestead</td>
<td>37,419</td>
<td>5.0</td>
</tr>
<tr>
<td>Other Assets (including car)</td>
<td>16,138</td>
<td>2.1</td>
</tr>
<tr>
<td>Investments and Deposits</td>
<td>21,561</td>
<td>2.9</td>
</tr>
<tr>
<td>TOTAL</td>
<td>751,097</td>
<td>100.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LIABILITIES</th>
<th>$</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed Liabilities</td>
<td>74,766</td>
<td>10.0</td>
</tr>
<tr>
<td>Current Liabilities</td>
<td>18,208</td>
<td>2.4</td>
</tr>
<tr>
<td>Sub-Total Liabilities</td>
<td>92,974</td>
<td>12.4</td>
</tr>
<tr>
<td>Specific Reserves</td>
<td>4,048</td>
<td>0.5</td>
</tr>
<tr>
<td>CAPITAL (NET WORTH)</td>
<td>654,075</td>
<td>87.1</td>
</tr>
<tr>
<td>TOTAL</td>
<td>751,097</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Source: MWBES Sheep and Beef Farm Survey, 1980/81
current market value) the MWBES, in their discussion of survey results, confirm that, in most farms surveyed, non-farm investments are few (MWBES, 1982). This fact has important implications for modelling the farm business system; it means that the investment options that must be handled by the model can be restricted to on-farm investments.

A detailed analysis of farmer use of credit is provided in Chapter 6. At this stage, therefore, it suffices to note that average level of fixed and current liabilities for Class 4 farms in 1980/81 was equivalent to 10 and 2.4 per cent of total assets, respectively. The average farmer equity ratio, therefore, is high at about 87 per cent.

4.4.3 Expenditure and income.

A summary of average Class 4 farm expenditure for 1980/81 is presented in Table 4.2. Major items of cash expenditure are fertiliser, lime and seeds, interest, repairs and maintenance, and shearing expenses. With minor variations, the pattern of expenditure shown in Table 4.2 has remained similar in recent years. It should be noted that the MWBES Survey does not differentiate between operating (and maintenance) expenditure, and development expenditure. This is because expenditure data in the Survey are based on farm accounts, and most development expenditure, being tax deductible, is rarely noted in farm accounts as a separate expenditure item. This makes the important issue of investment behaviour difficult to investigate. A review of studies of investment and supply response behaviour is presented in Chapter 7.
### TABLE 4.2
Farm Expenditure for Average North Island Hill Country (Class 4) Farm - 1980/81

<table>
<thead>
<tr>
<th>Category</th>
<th>$</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WORKING EXPENSES</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wages</td>
<td>5,633</td>
<td>9.5</td>
</tr>
<tr>
<td>Animal Health, Weed and Pest Control</td>
<td>2,533</td>
<td>4.3</td>
</tr>
<tr>
<td>Shearing Expenses</td>
<td>6,129</td>
<td>10.3</td>
</tr>
<tr>
<td>Fertiliser, Lime and Seeds</td>
<td>9,305</td>
<td>15.7</td>
</tr>
<tr>
<td>Vehicles, Fuel and Power</td>
<td>5,439</td>
<td>9.2</td>
</tr>
<tr>
<td>Feed and Grazing</td>
<td>867</td>
<td>1.5</td>
</tr>
<tr>
<td>Contract</td>
<td>3,731</td>
<td>6.3</td>
</tr>
<tr>
<td>Repairs and Maintenance</td>
<td>6,742</td>
<td>11.3</td>
</tr>
<tr>
<td>Railage and Cartage</td>
<td>1,435</td>
<td>2.4</td>
</tr>
<tr>
<td>Administration Expenses</td>
<td>2,002</td>
<td>3.4</td>
</tr>
<tr>
<td><strong>SUB-TOTAL WORKING EXPENSES</strong></td>
<td>43,816</td>
<td>73.8</td>
</tr>
<tr>
<td><strong>STANDING CHARGES</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insurance</td>
<td>1,127</td>
<td>1.9</td>
</tr>
<tr>
<td>Rates</td>
<td>1,861</td>
<td>3.1</td>
</tr>
<tr>
<td>Managerial Salaries</td>
<td>597</td>
<td>1.0</td>
</tr>
<tr>
<td>Interest</td>
<td>7,383</td>
<td>12.4</td>
</tr>
<tr>
<td>Rent</td>
<td>552</td>
<td>0.9</td>
</tr>
<tr>
<td><strong>SUB-TOTAL STANDING CHARGES</strong></td>
<td>11,520</td>
<td>19.4</td>
</tr>
<tr>
<td><strong>TOTAL CASH EXPENDITURE</strong></td>
<td>55,336</td>
<td>93.1</td>
</tr>
<tr>
<td>Book Depreciation</td>
<td>4,075</td>
<td>6.9</td>
</tr>
<tr>
<td><strong>TOTAL CASH EXPENDITURE PLUS DEPRECIATION</strong></td>
<td>59,411</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Source: MWBES Sheep and Beef Farm Survey, 1980/81

The sources and disposition of farm income in 1980/81 is shown in Table 4.3. The proportion of income shown from each source is typical of the pattern that has occurred in recent years. Over the period 1976/77 to 1980/81 gross income from wool has varied between 41 and 48 per cent of total gross farm income; gross income from sheep between 30 and 33 per cent; and cattle between 19 and 24 per cent. Income from other farm sources is typically low at about 1 per cent.
TABLE 4.3

Farm Income for Average North Island Hill Country (Class 4) Farm - 1980/81

<table>
<thead>
<tr>
<th>Gross Farm Income:</th>
<th>$</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wool A/c</td>
<td>35,831</td>
<td>42.3</td>
</tr>
<tr>
<td>Sheep A/c</td>
<td>27,473</td>
<td>32.4</td>
</tr>
<tr>
<td>Cattle A/c</td>
<td>20,670</td>
<td>24.0</td>
</tr>
<tr>
<td>Other A/cs</td>
<td>729</td>
<td>0.9</td>
</tr>
<tr>
<td>TOTAL GROSS FARM INCOME</td>
<td>84,703</td>
<td>100.0</td>
</tr>
<tr>
<td>Less Total Expenditure and Depreciation</td>
<td>59,411</td>
<td>70.1</td>
</tr>
<tr>
<td>NET FARM INCOME</td>
<td>25,292</td>
<td>29.9</td>
</tr>
<tr>
<td>Income Equalisation Account Deposit</td>
<td>789</td>
<td>0.9</td>
</tr>
<tr>
<td>AVAILABLE NET FARM INCOME</td>
<td>24,503</td>
<td>29.0</td>
</tr>
</tbody>
</table>

DISPOSITION OF AVAILABLE NET FARM INCOME

<table>
<thead>
<tr>
<th></th>
<th>$</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drawings</td>
<td>13,768</td>
<td>56.2</td>
</tr>
<tr>
<td>Taxation</td>
<td>10,088</td>
<td>41.2</td>
</tr>
<tr>
<td>Savings</td>
<td>647</td>
<td>2.6</td>
</tr>
<tr>
<td></td>
<td>24,503</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Source: MBES Sheep and Beef Farm Survey, 1980/81

Expenditure and depreciation as a proportion of total gross farm income has fluctuated widely over the period 1976/77 to 1980/81, from 54 per cent to 70 per cent, with a generally upward trend reflecting the deteriorating terms of trade suffered by the pastoral sector as a whole. The proportions tended to be highest in low income years and vice versa reflecting the fact that expenditure levels in absolute terms remain relatively stable compared with the fluctuations in gross income.
4.4.4 Disposition of net income.

The relative disposition of available net income between drawings, taxation and savings also fluctuates widely. Drawings, for example, varied between 42 and 64 per cent over the period 1976/77 to 1980/81. As with farm expenditure, drawings, which reflect farmers' consumption levels, remain relatively stable in absolute terms. This results in drawings accounting for a high proportion of available net income in low income years, and vice versa. A detailed analysis of farmers' consumption behaviour is presented in Chapter 5.

Taxation payments are primarily related to income and current tax scales but the relationship is not simple. The figure shown for taxation in Table 4.3 is the amount of tax paid in the financial year. This consists of both terminal and provisional tax payments thus the previous years' income is a major influence on current year's tax payment. The estimated relationship, based on MWBES Survey data for the period 1961/62 to 1980/81, is as follows:

\[
\text{TAX}_t = -643 + 0.164 \text{ANFY}_t + 0.229 \text{ANFY}_{t-1}
\]

\[R^2 = 0.98 \quad D.W. = 1.96\]

where \(\text{TAX}_t\) is tax paid in Year \(t\)

and \(\text{ANFY}_t\) is net income adjusted for income equalisation deposits and wool income retention deposits.

(Figures in parentheses are standard errors of the coefficients.)

This estimated relationship shows that both current and lagged "adjusted net farm income" are significant determinants of tax paid,
accounting for 98 per cent of the variation in tax paid.

Savings as recorded in the Survey represent, theoretically, the amount of money left after meeting current farm expenses including depreciation, personal living expenses and taxation commitments. (In some years savings may be negative if reserves are liquidated to meet these commitments). In notes on aspects of the Survey the MWBES (1982) point out that, while few farmers actually run a depreciation reserve fund, replacement of existing capital equipment will generally be met out of the depreciation allowance figure shown in the accounts. Amounts required over and above the depreciation allowance, as well as any repayment of borrowed capital, will be met out of savings. As might be expected for a residual item, the level of average annual savings tends to be volatile, varying significantly as incomes fluctuate. Over the period 1976/77 to 1980/81 for example, savings varied from 31.5 per cent of available net farm income (1978/79) to dis savings equivalent to 11.2 per cent of available net farm income (1977/78).

4.5 Economics of Hill Country Development

As well as a lack of biological research relevant to hill country, there has also been a dearth of research on the economics of hill country development, particularly from the national point of view. This situation is probably partly due to the lack of biological data. It may also be a result of the widely held belief that increased export earnings resulting from increased hill country development must be beneficial to New Zealand. The NRAC (1978) for example concluded that hill country potential for increased stock carrying "... represents an
additional 40 million stock units. With the nation facing a serious shortage of overseas funds, the $18.4 per stock unit at f.o.b. at current prices could yield an additional $736 million annually. This figure shows the real economic significance of at least approaching hill country potential".

4.5.1 National level analysis.

In an attempt to quantify and evaluate North Island hill country potential more objectively, Scott (1981) undertook a systematic assessment of the potential stock unit increases attainable and the possible costs and benefits of achieving those increases. The study used the National Water and Soil Conservation Authority's Land Resource Inventory to divide North Island hill country into nearly 24,000 land units. Each unit was described by five physical factors i.e. rock type, soil type, vegetation, slope and erodability. With the assistance of MAF Farm Advisory Officers, each land unit was assessed in terms of its capacity for sustained productive use, expressed in terms of stock carrying capacities (stock units per hectare). Three levels of utilisation were defined. The first was the current actual stocking rate, which allowed for land not in pasture; the second was the current average stocking rate if a unit of land was completely in pasture; and the third was the carrying capacity currently being achieved by the "top farmer" on a particular type of land. Potential stock unit increases were obtained by calculating the differences in total stock units between these three levels.
Results from Scott's study indicated that if undeveloped hill country was developed and stocked at the current average rates then total stock carried would increase by 82 per cent or approximately 22 million stock units. If, in addition to this, carrying capacity was increased to top farmer levels then a further increase of 46 per cent of the base level (or 12 million stock units) would be achieved.

In analysing the economic consequences of achieving these increases in stock carrying capacity Scott divided the development process into two stages:

(1) Development of scrub or bush to pasture - a relatively high cost step involved in moving from current actual to current average stocking rate.

(2) Intensification - a relatively low cost step usually involving such techniques as oversowing, subdivision and improved water supply. This is the step assumed to be involved in moving from current average to "top farmer" stocking rates.

A standard cost-benefit evaluation technique was used in which all transfer payments such as taxes, subsidies and interest were ignored. Hence the investment in hill country development was evaluated from the national, rather than the individual's, point of view. Using 1981 costs and prices Scott found that only about 12 per cent of the total undeveloped North Island hill country area would have an IRR for development of greater than 10 per cent if developed to current average stocking rate levels. However, if further intensification were to
occur and stocking rates could be raised from existing levels to top farmer levels then about 65 per cent of the area would have an IRR greater than 10 per cent. On a regional basis, Eastern Bay of Plenty, Wellington and Gisborne-East Coast were found to be relatively "unprofitable" regions, while other regions, particularly Northland, were found to have good economic potential for development. Sensitivity analysis indicated that profitability was sensitive to costs and prices used in the study. Scott also investigated the erosion problem that could result from development and found erosion to be potentially a major problem in Gisborne - East Coast and Eastern Bay of Plenty.

4.5.2 Farm level analysis.

A study of the economics of hill country development from the farmer's point of view was published by Parker (1981). He assessed the profitability of development, both with and without assistance from the Livestock Incentive Scheme (L.I.S.) and the Land Development Encouragement Loan Scheme (L.D.E.L.) (see Chapter 2 for a description of these schemes). He also assessed the effect of marginal tax rate. As did Scott (1981), Parker evaluated the two main forms of development: expansion, where new land is bought into production, and intensification, where production is increased on existing grassland. Cash flow budgeting was used in the analysis which was carried out under 1980/81 price levels assuming a constant relationship between output and input prices.
For the evaluation of expansion development, Parker assumed that, because development in the past has occurred on relatively easy land, future development would occur on comparatively steeper country with a heavier scrub cover. He concluded that development of such "store" hill country from scrub, without recourse to grants and incentives, was likely to be unprofitable. With L.D.E.L. and L.I.S. assistance he found that profitability improved but remained marginal if tax savings were not possible on development deficits. If, however, the farmer had a marginal tax rate of 60 per cent, then development became attractive with an IRR of 28 per cent and a payback period of only 5 years.

With respect to the evaluation of intensification, Parker assumed that it would take the form of extra subdivision, some capital and maintenance fertilising and oversowing, leading to a stocking rate increase of 2.5 stock units per hectare. This form of development was found likely to be profitable, with or without assistance from the Livestock Incentive Scheme grant. Measures of profitability ranged from 12.1 per cent IRR and 9 years payback period with zero marginal tax rate and no L.I.S. grant, to 21 per cent IRR and 5 years payback period with 60 per cent marginal tax rate, and L.I.S. grant.

4.6 Conclusion

North Island hill country is an area which accounts for a significant proportion of New Zealand's pastoral production and which has considerable physical potential for further development. As such it has attracted the particular attention from politicians and farming interests and, more recently, researchers and economists. Although
"North Island hill country" involves some diversity of characteristics, it would appear to be sufficiently unique to justify being regarded, for analytical purposes, as a relatively homogeneous sub-sector of the pastoral sector.

A number of features of North Island hill country farms are revealed which have implications for the modelling process. Firstly, the topographical features of hill country impose severe constraints on both the range of production activities possible and the nature of farm investment. There is an almost complete predominance of livestock production activities, especially sheep and beef breeding, in the area. Wool sales contribute most to gross revenue, followed by sheep sales, then cattle sales. The relative proportion of gross revenue contributed by each has remained relatively stable over recent years. Secondly, the capital assets of the average farm tends to involve mainly land and improvements, and livestock; off-farm assets appear to be minimal compared with the value of farm assets. Average equity levels are high (around 87 per cent). With regard to other aspects of the system, expenditure and consumption levels appear to remain relatively stable compared with the fluctuations in gross income levels while taxation payments are largely determined by current and lagged net income levels.

With respect to hill country development, two general categories tend to be recognised; pasture establishment from scrub, and intensification of existing established pasture. Based on published analyses undertaken in 1981, considerable scope for profitable development appeared to exist; however, the profitability of such
investment will vary from farm to farm and appears sensitive to the costs and prices involved.

Following the general overview of the hill country and associated farming system, a number of aspects of the system were selected as being of key importance in modelling the decision framework of the system. Farmers' decisions relating to the allocation of farm income between farm expenditure, consumption and investment, and their attitude to borrowing, determine the level of investment or disinvestment in the industry and consequently the future production and growth of the sector. Similarly, farmers' response to government policy is likely to involve changes in consumption, investment and borrowing behaviour, yet very little is known about the nature of this behaviour. The following three Chapters of System Analysis analyse behaviour related to consumption, borrowing and investment.
CHAPTER 5

CONSUMPTION ANALYSIS

5.1 Introduction

The objective of this analysis was to investigate factors affecting the consumption behaviour of New Zealand farm households, with special reference to North Island hill country farms, and to derive a consumption function suitable for incorporation in the hill country farm simulation model. The approach taken was to examine the general theory of consumption behaviour, review some studies that have specifically considered farm household consumption behaviour, and then estimate consumption functions for the New Zealand hill country situation.

Consumption is a major element in farm household decision making, and is of particular interest in farm production and growth studies in as far as it affects funds available for investment. A relationship between consumption and investment in farming is recognised in the Residual Funds hypothesis suggested by Campbell (1958) and others.

Most research into factors affecting consumption has involved groups whose main source of income is from wages and salaries. While there are likely to be important differences in the consumption behaviour of wage and salary earners and farmers, the traditional consumption function theories can still provide a useful basis for
farmer consumption studies. The most widely accepted hypothesis regarding the consumption function is that its main determinant is the level of disposable income. Other hypothesised influences are generally more difficult to interpret and predict, and include price and income expectations, holdings of liquid assets, availability of credit, demographic and life cycle factors (Keiser, 1970).

5.2 General Theories of Consumption Behaviour

Three general theories have been postulated to explain household consumption behaviour: the absolute income hypothesis suggested by Keynes, the relative income hypothesis expounded by Duesenberry and others, and the permanent income hypothesis favoured by Friedman. Although significantly different in their implications they nevertheless have important properties in common. Each postulates a relationship between consumption and income, although the concepts underlying these terms may differ. Other possibly relevant factors such as age, family status, education, etc., are generally assumed constant.

Also, all theories are supposedly of general relevance; each has been used on time-series as well as cross-section data and to derive macro as well as micro-relationships. Each was advanced originally in terms of individual behaviour and then generalised to aggregate behaviour. It should be noted that none of the theories has found unqualified support despite extensive empirical research — each is subject to wide controversy receiving support from some empirical studies but not from others. Even proponents of the same theory often
disagree with each other on appropriate definitions and approaches (Ferber, 1970).

5.2.1 The absolute income hypothesis.

Keynes (1936) observed that... "Men are disposed, as a rule and on the average, to increase their consumption as their income increases, but not by as much as the increase in their income." In its simplest form, the absolute income hypothesis usually takes the form:

\[ C_t = a + bY_t \]

where \( C_t \) represents consumption expenditure in period \( t \), and \( Y \) is income in period \( t \). Under this formulation 'a' is a minimum required level of consumption and 'b' is the "marginal propensity to consume (m.p.c.)".

This Keynesian consumption function in its simplest form implies that consumption in period 't' depends only on income in that period; however, adjustment of consumption to new levels of income is not likely to be instantaneous so that previous income also seems likely to have an effect on current consumption. This suggests a model of the form:

\[ C_t = a + bY_t + bY_{t-1} + ... + bY_{t-n} \]

where \( b = b_0 + b_1 + ... + b_n \) becomes the long-term marginal propensity to consume, and 'b' must be greater than 'b_0' (the short-term m.p.c.). A slightly different formulation which proposes that current
consumption is not only dependent on current income but also on habits of consumption (which, in turn, were influenced by previous levels of income) is:

\[ C_t = a + bY_t + cC_{t-1} + cC_{t-2} + \ldots + cC_{t-n} \]

which can be reduced to:

\[ C = a + bY_t + cC_{t-1} \]

In this case the short-term m.p.c. is 'b' and the long-term m.p.c. is \( b/1-c \) i.e. the increase in consumption \( C \) which follows a unit increase in all previous income \( Y_t, Y_{t-1}, \ldots \) (Malinvaud, 1970). This latter formulation is often preferred for estimation purposes because it accounts for the important "inertia" effect of previous consumption. An alternative interpretation of this specification is that the \( C_{t-1} \) term acts as a suitable proxy to account for changes in wealth and income distribution. If these factors affect consumption levels for a given income, then it would be expected that different levels of consumption would be associated with different levels of lagged consumption, even when current disposable income is constant between periods.

5.2.2 The relative income hypothesis.

Empirical work undertaken in the 1940's by Kuznets and others to test the Keynesian hypothesis found that it conformed with the evidence from cross-section household data, and from short-term periods of
aggregate data, but that the long-term implication of a decline in the average propensity to consume as a community became richer was not upheld.

To explain this, Duesenberry (1952) and others propounded the Relative Income Hypothesis. They suggested that the consumption rate depends, not on the level of income, but on the relative position of the individual on the income scale. Duesenberry supplied the psychological support for this hypothesis, noting that a strong tendency exists in our social system for people to emulate their neighbours and, at the same time, to strive for a higher standard of living. Given this basis for the long-term proportionality of consumption and income, Duesenberry then proceeded to explain the short-term non-proportionality in terms consistent with it. He suggested that once a new, higher standard of living is achieved, say, as a cyclic peak, people are reluctant to return to a lower level when incomes go down. This hypothesis, incorporating the notion of habit persistence, thus suggests that people seek to maintain at least the highest standard of living attained in the past (Ferber, 1970).

On the basis of this reasoning Duesenberry argued that the relative income hypothesis could be transformed into one expressing consumption as a function of the ratio of current income to the highest level previously achieved:

\[
\frac{C_t}{Y_t} = a + b\frac{Y_t}{Y^0}
\]
where \( Y^0 \) is the previous highest recorded income. This can be estimated as:

\[
C_t = aY_t + bY_t^2 / Y^0
\]

An alternative specification suggested by Guise and used by Mullen, Powell and Reece (1980) is:

\[
C_t = a + bY_t + c(Y_t - Y^0)
\]

where 'b' gives the long-run m.p.c. and 'c' the short-run m.p.c.

Another formulation was suggested by Brown (1952) who modified Duesenberry's hypothesis by introducing the lagged consumption variable \( C_{t-1} \) instead of the variable for the previous highest income. (The inclusion of lagged consumption has thus been justified from both an absolute income and a relative income point of view.) Also Brown split income into wage income \( Y^W \) and non-wage income \( Y^N \) to facilitate the hypothesis that changes in these income components would have a differential effect on the m.p.c. His formulation is given by:

\[
C_t = a + bY^W_t + cY^N_t + dC_{t-1}
\]

Further development along these lines came with Zellner (1957) who allowed for the observation that, for the same level of income, consumption will vary in accordance with the liquid assets of each household. He thus proposed the following formula to explain consumption:
\[ C_t = a + bY_t + cC_{t-1} + dL_{t-1} \]

where \( L_t \) denotes liquid assets at the start of period \( t \).

The relative income hypothesis would appear to have particular relevance to agriculture where consumption, and therefore investment behaviour, under conditions of fluctuating income, is of particular interest.

5.2.3 The permanent income hypothesis.

A more recent hypothesis on consumer behaviour grew out of the rising concern regarding the adequacy of current income as the most appropriate determinant of consumption. Particularly among non-wage-earner families, income receipts vary substantially from period to period while consumption outlay usually exhibits much greater stability. To account for this observation the permanent income hypothesis, developed by Friedman (1957), postulates that the reaction of current consumption to a change in current income depends on the individual's expectation about whether the change is likely to be permanent. Permanent changes in income are assumed to directly affect expected consumption whereas transitory changes are assumed to have no effect on expected consumption. Income and consumption in a particular period are assumed to be made up of "transitory" and "permanent" components:

\[ Y_t = Y_t^P + Y_t^T \]
where the superscripts indicate "permanent" or "transitory". The basic permanent income relationship can then be specified as:

\[ C_t = C^P_t + C^T_t \]

Also, transitory and permanent income are assumed to be uncorrelated, as are transitory and permanent consumption, and transitory consumption and transitory income.

The main problem with applying this function is to find a suitable measure for the permanent income variable since the only income series usually available is that for actual income. One possible way of linking the two concepts, given the hypothesised importance of expectations in changing an individual's evaluation of permanent income, is by way of an adaptive expectations or distributed lag formulation. For example, \( Y^P_t \) can be approximated by weighting current and lagged actual income by specific discrete weights. Alternatively, a continuous distributed lag process can be tested by estimating a function with a lagged dependent variable. This latter procedure implies the model structure: \( C_t = a + bY_t + cC_{t-1} \). As noted above this formulation can also be justified from the absolute and relative income hypotheses.

5.2.4 Influence of variables other than income.

The consumption functions described above all imply ceteris
paribus assumptions with respect to factors other than income. In recent years studies have focused on three sets of these other factors: socio-economic characteristics of the household, particularly age and life cycle; financial characteristics; and attitudes and expectations (Ferber, 1970). Of these, the life cycle factors have been found to be important in some studies and this has led to the "Life Cycle Hypothesis of Consumption and Savings" (see Ando and Modigliani, 1963). In its most general form this hypothesis suggests that age and family status of the consuming household are major factors in determining consumption behaviour.

5.3 Application to Agriculture and New Zealand

5.3.1 Review of studies.

The generalised consumption functions described above can be regarded as micro-economic relationships used to describe aggregate (macro-economic) behaviour. Malinvaud (1970) suggests that the aggregate model is only really valid if all households have the same marginal propensity to consume and if the distribution of incomes is described by a stable linear stochastic model. Although these are very restrictive conditions, studies of the specific consumption behaviour of relatively homogeneous sub-sections of the population may still be justified as it could reasonably be expected that similar households would have similar marginal propensities to consume.

With respect to agriculture Klein and Goldberger (1955) built a model of the U.S. economy in which the consumption function took
account of the differences in types of income by splitting it into three groups: disposable wage income, disposable agricultural income and other classes of disposable income. This was early recognition of the special nature of the agricultural sector. Since that time, however, there appears to have been only a few studies which have specifically analysed the consumption behaviour of farm households despite the policy implications for countries such as Australia and New Zealand where the agricultural sector forms a significant portion of the economy. These studies include Macmillan and Loyns (1969) (Canada), Girao, Tomek and Mount (1974) (U.S.A.), and Mullen et al. (1980) (Australia). Also, a simple consumption function for New Zealand pastoral farmers has been estimated by Johnson (1981).

Macmillan and Loyns (1969) in a cross-section study of Canadian farm household expenditure tested for factors affecting different types of expenditure as well as total consumption expenditure. Dependent variables included expenditure on food, household operations, clothing, health, etc. while explanatory variables included total income, age of head of household, number of persons in the household, change in net worth and the annuity value of total assets. Total consumption expenditure proved inelastic with respect to changes in each of these explanatory variables, and close to zero for changes in age of head and net worth. For total expenditure, values of 0.236 and 0.593 were estimated for marginal and average propensity to consume respectively.

Girao et al. (1974) investigated the effect of income instability on farmers' consumption and investment using two samples of Minnesota farmers with contrasting degrees of income stability. Based on their
favoured model (a life cycle model which included farmer's age as an explanatory variable) they found that for the unstable group short-run and long-run marginal propensity to consume (m.p.c.) was 0.14 and 0.46 respectively, with an a.p.c. of 0.53. For the stable group short-run and long-run m.p.c. was 0.16 and 0.48 respectively, with an a.p.c. of 0.54. Based on these and other results they concluded that income stability has little effect on consumption behaviour.

Mullen et al. (1980) in a study of the consumption behaviour of 16 farm families in New South Wales over an eight year period came to a similar conclusion. Their best estimates of short-run m.p.c. ranged from 0.13 to 0.16 while long-run m.p.c. estimates were in the range 0.19 to 0.25. (Average propensity to consume was 0.75). These low estimates suggested that, at the farm level, most of any increase in disposable income would be available for either savings or investment. Looking at it another way these results imply that consumption will remain relatively stable as incomes fluctuate.

With respect to New Zealand, Johnson (1981) in a brief appendix to a paper on the financing of agricultural investment in New Zealand, presented a consumption function calculated as:

\[ C_t = 201.1 + 0.2182 Y_t + 0.5879 C_{t-1} \]

This function was estimated using MWBES Sheep and Beef Farm Survey data for 1970/71 to 1977/78. This model specification gives a short-run a.p.c. of 0.22 and a long-run m.p.c. of 0.53. A closer investigation of this model is presented below in Section 5.4.2 of this
Finally, a study by Deane and Giles (1972) of aggregate consumption equations for New Zealand should be mentioned. In this study quarterly time-series data for the New Zealand economy were used to estimate a number of consumption equations based on a range of alternative hypotheses. Attention was centred on the behaviour of real personal disposable income in relation to expenditure on consumption goods, the latter being disaggregated into the durables and non-durables. The permanent income hypothesis was favoured as the model which best explained the consumption behaviour in the New Zealand economy during the period under study (1961 to 1970). Results from this study indicated significant differences between the marginal propensities to consume for salary/wage income and non-salary/wage income. For salary/wage income, short-run m.p.c. was estimated at 0.10 and long-run m.p.c. at 0.30, while for non-salary/wage income, short and long-run m.p.c. were estimated as 0.30 and 0.42 respectively.

5.3.2 New Zealand data.

A number of New Zealand data sources were examined in order to determine the availability of suitable data for consumption functions analysis (Greer, 1982; Stats Dept.; Shepherd and Worsop, 1980; MWBES Sheep and Beef Farm Survey). It was concluded that the MWBES Sheep and Beef Farm Survey results contained the most relevant data for the objective in hand, particularly those data related to North Island hill country (Class 4) farms.
These data were available in two forms; firstly as published annual average data based on a sample of 128 farms for the period 1958/59 to 1979/80, representing a time-series of 22 data points; and secondly, as unpublished "panel" data provided by the MWBES for 46 individual Class 4 farms for the period 1969/70 to 1978/79. The criteria for inclusion in the panel was that the farm had been continuously surveyed by the MWBES over the ten year period. Therefore, the panel data farms cannot be regarded as a random subsample of the published data sample.

From these data the best measure of consumption available was personal "drawings", a figure taken from farm accounts, which represents personal living expenses. One disadvantage of using this measure, particularly in the short-term or for any cross-sectional analysis, is that no distinction is made between consumption of "durables" and "non-durables". Another is that a certain amount of consumption will not be accounted for. Examples of this could include the purchase of consumable items which are entered elsewhere in the farm accounts, or more commonly, the use of food and fuel items produced on the farm. It may be possible to adjust for consumption of farm produce in the same way that the managerial reward calculation includes a percentage of the ruling wage; however, a straight percentage increase is not particularly satisfactory and, in the absence of better information, was not attempted in this study.

3 Approximately 85 per cent of farms remain in the sample from one year to the next. The other 15 per cent, which drop out of the survey or otherwise become ineligible, are replaced using random sampling techniques. More detail on survey procedures is given in MWBES (1982).
Net farm income was readily available, and has been used here in a form adjusted for stabilisation accounts and taxation (see Table 5.1). It was not possible to get a reliable measure for off-farm income, which could include interest from savings accounts, rental from a house on the property and possible share dividends. Although this income may not be significant, it would ideally be included.

Liquid assets were calculated as cash in bank, plus specific reserves. Specific reserves are funds specially designated as reserves in the balance sheet, of which common examples are taxation, income equalisation deposits and development reserves. Some indeterminate proportion of specific reserves may not be backed by actual liquid reserves. For example, the item includes allowance for funds spent but not all claimed for tax purposes in the current year (R. Davison, MWBES, pers. comm.).

With MWBES survey data no measure of household size nor of the number of households supported by a sample farm is available. The sampling unit for the survey is the farm, and financial data refer to that farm only. Farm ownership may be held by an individual or by multiple owners under Partnerships, Trusts, Estates or Companies or a combination of these alternative forms. While the incidence in the sample of multiple household farms (apart from those associated with paid labour) cannot be measured, the strong tradition of family farming in this area would suggest that it is low. With respect to household size Mullen et al. (1980) did conclude that household size was not a significant factor in explaining consumption, however, here the hypothesis cannot be tested.
TABLE 5.1
Definitions of Meat and Wool Boards' Economic Service Variables Used to Estimate Consumption Functions

<table>
<thead>
<tr>
<th>Variable Used</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$C_t$ Drawings</td>
<td>Personal living expenses.</td>
</tr>
<tr>
<td>$Y_t$ Income</td>
<td>Total gross farm income adjusted for deposits or withdrawals on the 'Wool Income Retention Account' and 'Income Equalisation Account' minus total cash expenditure and depreciation and minus taxation (which includes both terminal and provisional tax payments).</td>
</tr>
<tr>
<td>$Y^0$ Highest previous income</td>
<td>Highest previous value of $Y_t$.</td>
</tr>
<tr>
<td>$L_t$ Liquid assets</td>
<td>Cash in bank + specific reserves.</td>
</tr>
</tbody>
</table>
A summary of variables used in the analysis, and their description is presented in Table 5.1.

5.3.3 Models selected.

Six models were selected for testing. The absolute income hypothesis was tested with two model forms:

\[ C_t = a + bY_t \]  
(Model 1)

\[ C_t = a + bY_t + cC_{t-1} \]  
(Model 2)

where \( C_t \) and \( Y_t \) represent consumption and income respectively. (It should be noted that this Model 2 can be interpreted as an expression of the relative and permanent income hypotheses as well as the absolute income hypothesis.)

Two forms of relative income model were selected. These were:

\[ C_t = aY_t + bY_t^2 / Y_0 \]  
(Model 3)

where \( Y_0 \) is the previous highest recorded income (in real terms); and

\[ C_t = a + bY_0 + c(Y_t - Y_0) \]  
(Model 4)

which is derived from Mullen et al. (1980) and was suggested by Guise (1978, University of New England) in a personal communication to that author. In this model the long-run m.p.c. is given by 'b' and the
short-run m.p.c. by 'c'.

Zellner's model (Zellner, 1957) was also used because of the addition of liquid assets (L) to the model:

\[ C_t = a + bY_t + cC_{t-1} + dL_{t-1} \]  \hspace{1cm} (Model 5)

The final model tested was the Friedman permanent income model tested in the form:

\[ C^P_t = a + bY^P_t \]  \hspace{1cm} (Model 6)

where \( Y^P \) is an estimate of permanent income.

5.3.4 Estimation.

Despite some shortcomings outlined below, Ordinary Least Squares (OLS) regression was used to estimate all models both with the time-series and the panel data. In both cases all values were expressed in "real" terms, by adjusting to 1980/81 dollars using the consumer price index (CPI). This assumes that people perceive the "real" value of an item when considering consumption, and are not subject to "money illusions". Although this may not be a completely realistic assumption, it was accepted in the absence of any sound reasoning suggesting that the relationship is between nominal or money income and consumption.
Where lagged consumption is introduced as an exogenous variable, statistical problems arise. If the error terms are not serially correlated then OLS estimates will be biased for small samples, but will be consistent and asymptotically efficient for large samples. Also, because of the bias in the estimates the computed standard errors will also be biased. Various alternatives to OLS have been suggested for this situation but none have been shown to be "better" in small samples (Rao and Miller 1971), consequently OLS was used in this study.

With the adaptive expectations structure used in Model 6 the errors are, by definition, serially correlated and there will be non-linearities in the parameters. Under these circumstances the OLS estimates will be inconsistent, however, an alternative technique of estimation with serially dependent errors has not been perfected.

Another problem which occurs when the lagged dependent variable is included in the model is that the Durbin-Watson test for serial correlation is biased towards 2 and thus is no longer valid. A modified "h" statistic was suggested by Durbin (1970) but this test could not be used in this study because the denominator in the mathematical expression was always negative.

For the panel data (i.e. the time-series of cross-sections) the estimation procedures used followed Mullen et al. (1980) who collected data in a similar form. The panel data can be pooled and estimated using OLS regression; however, if this is done, the usual assumptions concerning the error term breakdown, and there is a strong likelihood of serial correlation of the error term and heteroscedasticity. Under
these circumstances the estimates of the variance of the coefficients and their associated 't' statistics will be biased although the estimates of the coefficients should be unbiased (Fuller and Battese, 1974). Various techniques have been used to overcome this problem whilst retaining a maximum amount of information. A simple adaptation involves the addition of a dummy variable for each farm in the cross-section. These dummy variables can be attached to the intercept in the model if it is assumed that, although the absolute level of consumption may vary from farm to farm, the marginal impact of the explanatory variables is the same for all farms.

Alternatively the dummy variables could be associated with the regression coefficients implying different marginal responses from farm to farm. This approach has the added advantage of identifying particular farms which show different characteristics over time, and which may be considered outliers. On the other hand, it is difficult to interpret the coefficients of the dummy variables. More complicated procedures include a maximum likelihood function approach discussed by Maddala (1971) and cross-error models which further investigate the composition of the error term (Fuller and Battese, 1974; Wallace and Hussain, 1969). For this analysis the first two simple techniques (OLS and OLS with dummy variables) were used.

5.4 Discussion of Results

The results of the regression analyses undertaken to test the various model specifications are presented in Table 5.2 and discussed in the following sections. With respect to the equation numbers in
<table>
<thead>
<tr>
<th>Equ. No.</th>
<th>CONST.</th>
<th>$Y_t$</th>
<th>$C_{t-1}$</th>
<th>$Y_t^2/Y_t^0$</th>
<th>$Y_t^0$</th>
<th>$Y_t - Y_t^0$</th>
<th>$L_{t-1}$</th>
<th>$R^2$</th>
<th>D.W.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>12,994</td>
<td>0.170*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.154</td>
<td>1.53</td>
</tr>
<tr>
<td>1.2</td>
<td>9,074</td>
<td>0.347**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.425</td>
<td></td>
</tr>
<tr>
<td>1.3</td>
<td>11,781</td>
<td>0.078**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.546</td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>6,228</td>
<td>0.207**</td>
<td>0.361*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.314</td>
<td>2.47</td>
</tr>
<tr>
<td>2.1a</td>
<td>3,800</td>
<td>0.237**</td>
<td>0.600**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.727</td>
<td></td>
</tr>
<tr>
<td>2.1b</td>
<td>3,017</td>
<td>0.231**</td>
<td>0.584**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.752</td>
<td></td>
</tr>
<tr>
<td>Johnson (1981)</td>
<td>201</td>
<td>0.218</td>
<td>0.588</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.948</td>
<td></td>
</tr>
<tr>
<td>2.2</td>
<td>3,821</td>
<td>0.179**</td>
<td>0.508**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.614</td>
<td></td>
</tr>
<tr>
<td>2.3</td>
<td>10,388</td>
<td>0.081**</td>
<td>0.093</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.547</td>
<td></td>
</tr>
<tr>
<td>3.1</td>
<td>15,723</td>
<td>-0.085</td>
<td></td>
<td>0.155</td>
<td></td>
<td></td>
<td></td>
<td>0.219</td>
<td>2.18</td>
</tr>
<tr>
<td>3.2</td>
<td>8,644</td>
<td>0.431**</td>
<td>-0.058**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.448</td>
<td></td>
</tr>
<tr>
<td>4.1</td>
<td>16,250</td>
<td>0.057</td>
<td></td>
<td>0.169*</td>
<td></td>
<td></td>
<td></td>
<td>0.255</td>
<td>2.26</td>
</tr>
<tr>
<td>4.2</td>
<td>6,097</td>
<td>0.379**</td>
<td>0.231**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.505</td>
<td></td>
</tr>
<tr>
<td>5.1</td>
<td>6,900</td>
<td>0.201**</td>
<td>0.240</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.069</td>
<td>0.319</td>
</tr>
<tr>
<td>5.2</td>
<td>4,740</td>
<td>0.149**</td>
<td>0.388**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.669</td>
<td></td>
</tr>
</tbody>
</table>

+ significant at the 10 per cent level; * significant at the 5 per cent level; ** significant at the 1 per cent level
this Table (for Models 1 to 5), the first number represents the model number as specified above, while the second number represents the mode of estimation as follows:

.1 estimated with published MWBES Class 4 time-series data for years 1958/59 to 1979/80, reflated to 1980/81 dollars.
.3 as for 2 above, with a dummy variable included for each farm. Only Models 1 and 2 were tested using this procedure.

5.4.1 Model 1: \( C_t = a + bY_t \)

This model generally had low explanatory power although in each equation the signs on the coefficients were as expected and all the coefficients for \( Y_t \) appear significantly different from zero at the 5 per cent level of significance or better. It must be noted however, that 't' tests applied to coefficients estimated using OLS regression with panel data are likely to be biased. The Durbin-Watson test for serial correlation proved negative at the 5 per cent significance level for the time-series estimations.

Estimates of the marginal propensity to consume (m.p.c.) based on these results varied widely - probably the most reliable estimates come from the time-series (Equation 1.1) indicating a m.p.c. of 0.17, and the panel data estimate (Equation 1.2) of approximately 0.35. (The average propensity to consume was 0.84 for the time-series sample farms, and 0.73 for the farms constituting the panel data.)
5.4.2 Model 2: $C_t = a + bY_t + cC_{t-1}$

This model was estimated by Johnson (1981) using MWBES published "All Class Average" data for the period 1970/71 to 1977/78. Johnson's definition of income differed from that used in this study in that taxation and depreciation payments were included as available income. Also, the function was estimated using undeflated data. Johnson's estimated model is included in Table 5.2 together with two additional equations, 2.1a and 2.1b which were estimated for comparison. Equation 2.1a was derived using real values on the same basis as 2.1 except that the time-series was reduced to 8 years (1970/71 to 1977/78). The basis for estimating equation 2.1b was the same as 2.1a except that depreciation was included as part of disposable income.

In comparison with Model 1, the explanatory power of Model 2 was greater. The Durbin-Watson (d) statistic is presented for Equation 2.1 rather than the more appropriate 'h' because the latter could not be calculated. In any case it is likely that a significant level of serial-correlation exists in these equations making the coefficient estimates and standard errors biased for small samples; however, in the absence of any better estimates, and because the coefficients are consistent and asymptotically unbiased, the estimates were accepted as the best available.

All coefficients showed the expected signs and the coefficients of $Y_t$ all proved to be significantly different from zero at, at least, the 5 per cent significance level. Estimates of the short-run marginal propensities to consume based on the coefficients of $Y_t$ were consistent
except for the panel data with dummies estimate (Eq. 2.3). All other equations gave a short-run m.p.c. of between 0.18 and 0.24. This is in line with Johnson's estimate of 0.22.

The coefficients of lagged consumption were also significant in most cases indicating a relationship between current and previous consumption. The coefficient values appeared to vary depending on the time period over which the equation was estimated. For Equation 2.1 estimated over the full time-series, 1958/59 to 1979/80, the coefficients of lagged consumption were relatively low, 0.36 and 0.27 respectively, leading to long-run m.p.c. estimates of 0.32 and 0.29. In contrast, the equations estimated with 1970's data only, be it time-series (Equations 2.1a, 2.1b, and Johnson's) or panel data (Eq. 2.2) gave higher lagged consumption coefficient estimates of between 0.5 and 0.6. These values lead to long-run m.p.c. estimates of 0.36 for panel data (Eq. 2.2) and between 0.53 and 0.59 for the time-series data (Eqs. 2.1a and 2.1b). These latter estimates are close to the value of 0.53 implied by Johnson's equation. These results suggest that long-run m.p.c. may have increased in the 1970's while short-run m.p.c. has remained reasonably stable.

Also of interest is the substantially improved explanatory power of this model for the 1970's compared with the longer time-series 1958/59 to 1979/80. This is evidenced by the fact that for the time-series data $R^2$ (adjusted) improves from 0.314 (Eq. 2.1) to 0.727 (Eq. 2.1a) for periods 1958/59 to 1979/80 and 1970/71 to 1977/78 respectively. The $R^2$ value achieved by Johnson's model could not be matched because of the effect of deflating the data.
5.4.3 Model 3:  \( C_t = a + bY_t^2 + cY_t/Y_0 \)

Based on \( R^2 \), significance of coefficients and sign expectations, this model performed poorly with the time-series data. This was not unexpected because, with a time-series of averages, the important link between previous highest income and current consumption for each household is lost.

For the panel data (Eq. 3.2) the results appeared more satisfactory despite the likelihood of multicollinearity between the explanatory variables. Both the coefficients of \( Y_t \) and \( Y_t^2/Y_0 \) were significant and the negative sign on \( Y_t^2/Y_0 \) was logical. This model gives a good example of the "ratchet" effect that is implied by the relative income hypothesis. This effect relates to the different behaviour of consumers when income is increasing compared with when it is decreasing, and is apparent when the marginal propensities are calculated using this model. Taking the first partial derivative (w.r.t. \( Y_t \)) of Equation 3.3 gives an equation for m.p.c. as follows:

\[
\frac{\partial C_t}{\partial Y_t} = 0.431 - 0.116 Y_t/Y_0
\]

This implies that if income is increasing, i.e. \( Y_t = Y_0 \), then m.p.c. is 0.315; however, if current income falls below the previous highest income, i.e. \( Y_0 > Y_t \), then the m.p.c. increases. For example, if previous highest income is $15,000 and current income is $10,000, m.p.c. will be 0.354.
The marginal impact of a change in the level of previous highest income can also be derived by calculating the first partial derivative w.r.t. \( Y^0 \) as follows:

\[
\frac{\partial C_t}{\partial Y^0} = 0.116 \frac{Y_t^2}{Y^0^2}
\]

This function will be positive indicating that an increase in \( Y \) will increase current consumption; however, the extent of that increase will depend on the relative size of \( Y^0 \) and \( Y_t \).

5.4.4 Model 4: 

\[ C_t = a + bY^0 + c(Y_t - Y^0) \]

This model, which is based on the relative income hypothesis, performed best for the panel data as might be expected - the time-series data are Class 4 averages so that the link between previous highest income and current consumption for each individual is lost. This problem is further evidenced by the non-significance of the \( Y_t \) coefficient in the time-series equation (4.1).

The panel data equation (4.2) gave satisfactory results; the estimated coefficients were significant at the 1 per cent level and have the expected sign and order of magnitude. With this model formulation the coefficient of \((Y_t - Y^0)\) gives the short-run m.p.c. while the coefficient of \( Y^0 \) gives the long-run m.p.c. On this basis Equation 4.2 gives a short-run m.p.c. of 0.23 and a long-run m.p.c. of 0.38.
5.4.5 Model 5: \( C_t = a + bY_t + cC_{t-1} + dL_{t-1} \)

This model is similar to Model 2 except that the lagged liquidity level is also included. In comparison with Model 2, the explanatory power of the model improved slightly in each case, however, the signs, magnitudes and significance of the estimated coefficients were more variable and lacked consistency. For the time-series equation (5.1) the coefficient on \( Y_t \) was highly significant and of similar value to the same coefficient in Model 2. The coefficients on \( C_{t-1} \) and \( L_{t-1} \), however, lacked significance.

For the panel data (Eq. 5.2) all three estimated coefficients were significant and the explanatory power of the model was reasonable (adjusted \( R^2 \) was 0.67). The coefficient of lagged liquidity, 0.06, while significant, indicates a relatively small effect. Thus while there is some indication that liquidity and consumption are related, the strength of this link is unclear. In any case, it is likely that a significant part of the liquidity effect is captured indirectly through lagged consumption.

5.4.6 Model 6: \( C_t^P = a + bY_t^P \)

Different procedures were used to test the permanent income hypothesis. The permanent income hypothesis states that the consumption \( C_t \) of a household in period 't' depends on its permanent income and not on its transitory income. To investigate this hypothesis the model was formulated in the following way:
\[ C_t = a + b Y^P_t \]

where \( C_t \) is period \( t \) consumption and \( Y^P_t \) is permanent income.

Permanent income cannot be directly observed, however, Friedman (1957) suggested an adaptive expectations formulation could be used to estimate a proxy for permanent income. In this study a range of different lag and weight structures were tested. These structures, and the equation number in which they are tested, are as follows:

6.1 \( Y^P_t = Y_t \)
6.2 \( Y^P_t = 2/3Y_t + 1/3Y_{t-1} \)
6.3 \( Y^P_t = 3/6Y_t + 2/6Y_{t-1} + 1/6Y_{t-2} \)
6.4 \( Y^P_t = 4/10Y_t + 3/10Y_{t-1} + 2/10Y_{t-2} + 1/10Y_{t-3} \)
6.5 \( Y^P_t = 5/15Y_t + 4/15Y_{t-1} + 3/15Y_{t-2} + 2/15Y_{t-3} + 1/15Y_{t-4} \)

Results are presented in Table 5.3 where the third digit in each equation number indicates the data used to estimate the equation; for example, 6.11 indicates that the model was estimated using published MWBES time-series data for Class 4 farms over the period 1958/59 to 1979/80, reflated to 1980/81 dollars. Alternatively, the same model labelled 6.12 was estimated using unpublished MWBES Class 4 panel data comprising 46 farms for years 1969/70 to 1978/79, also reflated to 1980/81 dollars.

Notwithstanding the statistical problems described above, the results appear satisfactory with the coefficient of \( Y^P_t \) proving to be significant at the 5 per cent level or better in all equations. \( R^2 \) is
TABLE 5.3

Estimated Coefficients for Consumption Functions
Based on the Permanent Income Hypothesis

<table>
<thead>
<tr>
<th>Equ. No.</th>
<th>CONST.</th>
<th>$\gamma^p_t$</th>
<th>$\hat{R}^2$</th>
<th>D.W.</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.11</td>
<td>12994</td>
<td>0.170*</td>
<td>0.15</td>
<td>1.53</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.077)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.12</td>
<td>9074</td>
<td>0.347**</td>
<td>0.43</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.019)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.21</td>
<td>9720</td>
<td>0.330**</td>
<td>0.43</td>
<td>1.55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.082)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.22</td>
<td>7435</td>
<td>0.427**</td>
<td>0.52</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.021)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.31</td>
<td>8922</td>
<td>0.366**</td>
<td>0.33</td>
<td>1.71</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.115)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.32</td>
<td>6589</td>
<td>0.487**</td>
<td>0.55</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.024)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.41</td>
<td>9946</td>
<td>0.302*</td>
<td>0.20</td>
<td>2.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.128)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.42</td>
<td>6270</td>
<td>0.519**</td>
<td>0.54</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.027)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.51</td>
<td>9132</td>
<td>0.346*</td>
<td>0.21</td>
<td>1.94</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.146)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.52</td>
<td>6136</td>
<td>0.555**</td>
<td>0.54</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.032)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* significant at 5 per cent level
** significant at 1 per cent level
greatest in Equation 6.21 (where \( Y^P_t = \frac{2}{3}Y_t + \frac{1}{3}Y_{t-1} \)) for the time-series data, and Equation 6.32 (where \( Y^P_t = \frac{3}{6}Y_t + \frac{2}{6}Y_{t-1} + \frac{1}{6}Y_{t-2} \)) for the panel data. If these equations are taken to provide estimates of long-run m.p.c., a value of 0.33 is obtained for the time-series and 0.49 for the panel data. Short-run m.p.c. estimates can also be derived by multiplying the \( Y^P \) coefficient by the weight given to \( Y \) in the \( Y^P \) formulation. Thus from Equation 6.21 a short-run m.p.c. for the time-series of 0.20 is obtained, and from Equation 6.32 a panel data estimate of 0.24 is obtained. The time-series result is consistent with that obtained from Model 2 (0.21 and 0.32 from Equation 2.10, however, the long-run m.p.c. estimate obtained with the panel data is significantly higher than that obtained from Model 2 (i.e. 0.36 from Equation 2.3).

5.5 Conclusions

Despite shortcomings in the data and some statistical problems associated with the use of panel data and OLS estimation, a reasonably consistent picture emerges of the consumption behaviour of North Island hill country farmers, at least as far as their marginal propensity to consume is concerned. Table 5.4 shows the marginal propensities to consume estimated with selected model specifications. Best estimates of short-run m.p.c., based on a range of model and data specifications, appear to be in the range of 0.18-0.24, while for long-run m.p.c. estimates tend to vary depending on the data and time base. For the full time-series of 1958/59 to 1979/80, long-run m.p.c. estimates ranged from 0.26 to 0.33. For the same time-series truncated to 1970/71 to 1977/78 long-run m.p.c. estimates increased to 0.53-0.59.
### TABLE 5.4

**Estimated Marginal Propensities to Consume**

<table>
<thead>
<tr>
<th>Model No.</th>
<th>Short-Run</th>
<th>Long-Run</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>0.17</td>
<td></td>
</tr>
<tr>
<td>1.2</td>
<td>0.35</td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>0.21</td>
<td>0.32</td>
</tr>
<tr>
<td>2.1a</td>
<td>0.24</td>
<td>0.59</td>
</tr>
<tr>
<td>2.1b</td>
<td>0.23</td>
<td>0.56</td>
</tr>
<tr>
<td>Johnson (1981)</td>
<td>0.22</td>
<td>0.53</td>
</tr>
<tr>
<td>2.2</td>
<td>0.18</td>
<td>0.36</td>
</tr>
<tr>
<td>3.2</td>
<td>0.23</td>
<td></td>
</tr>
<tr>
<td>4.2</td>
<td>0.23</td>
<td>0.38</td>
</tr>
<tr>
<td>5.1</td>
<td>0.20</td>
<td>0.26</td>
</tr>
<tr>
<td>5.2</td>
<td>0.15</td>
<td>0.24</td>
</tr>
<tr>
<td>6.21</td>
<td>0.20</td>
<td>0.33</td>
</tr>
<tr>
<td>6.32</td>
<td>0.24</td>
<td>0.49</td>
</tr>
</tbody>
</table>

Average propensity to consume:  
- time series 0.84  
- panel data 0.73
This higher long-run m.p.c. for the 1970's is confirmed to some extent by the panel data estimations (based on time period 1969/70 to 1978/79) which range from 0.36 to 0.49 for long-run m.p.c. These results indicate that there may have been a real change in consumption patterns in the 1970's. The real cost of basic consumption items appears to have dropped while at the same time farmers seem more inclined to spend once an increase in income has been found to be more than transitory.

With respect to the alternative behavioural hypotheses tested, no one hypothesis is clearly superior. The model formulation which gives the best and/or most consistent results is Model 2 (i.e. $C_t = a + bY_t + cC_{t-1}$); this formulation can be justified from any one of the three behavioural hypotheses. Looking at the models that are more specifically linked to the behavioural hypotheses the picture still remains unclear although the absolute income hypothesis in its most basic form (Model 1) generally performed poorly. The relative income hypothesis models (Models 3 and 4) both performed satisfactorily providing some evidence of the "ratchet effect" which is a feature of this behavioural hypothesis. Similarly, the permanent income model (Model 6) also performed satisfactorily and the validity of this hypothesis cannot be dismissed.
6.1 Introduction

Credit is an important source of funds for pastoral farmers and borrowed funds are used for a number of purposes ranging from the payment of day-to-day working expenses on the farm, through to the financing of long term capital development and land purchase. In order to better understand and model the role of credit in farm production and growth, an investigation of farmer borrowing behaviour was carried out. In undertaking this study it was generally assumed that observed borrowing behaviour was primarily a function of farmer attitudes, rather than of external credit rationing. This assumption would appear to be justified given some empirical observations described below, and given government policy. The Minister of Finance, acting through the Reserve Bank, has wide powers to give directions to financial institutions on the policy to be followed in relation to lending priorities. Although details of the guidelines vary from time to time agricultural export industries have always had top priority (Deane and Nicholl, 1979).

Various aspects of borrowing behaviour were explored by reviewing past credit surveys and studies, and by undertaking some statistical analyses using survey data. In addition to past surveys and analyses of credit-use, some additional primary data were sought in order to further investigate credit-use and farmer borrowing behaviour.
6.1.1 Sources of data

The first source of data used was the annual Sheep and Beef Farm Survey conducted by the Meat and Wool Boards' Economic Service (MWBES). Published data were available from the survey giving the average values for the major asset and liability categories for each farm class over the last 20 years. Also the MWBES recently published the results of a detailed survey of the composition of term liabilities on sheep and beef farms in 1979/80 (MWBES, 1984).

While these data were useful for observing and analysing various aspects of borrowing behaviour, more disaggregated data were required if a clearer understanding of the behaviour of individual farmers was to be gained. To this end the "panel" of data used for the consumption analysis was used again. This comprised individual farm data from the MWBES Survey for a sample of 46 Class 4 farms covering the ten years from 1969/70 to 1978/79. These data included all major financial and production items surveyed. The criterion for selection in the sample was that the farm had been continuously in the MWBES Survey for at least 10 years. This criterion effectively excluded farms that had undergone major changes in size or ownership structure; thus, while borrowing behaviour related to farm and land purchase could not be observed, the data provided a good basis for observing and analysing borrowing behaviour related to normal farming operations and development.

The other source of primary data used in this study was the Farmer Opinion Survey (Pryde and McCartin, 1983) conducted through the AERU at
Lincoln College. A special series of questions on capital structure, investment and borrowing were included in the survey to provide data for this study. The section of the questionnaire related to these aspects is reproduced in Appendix 1. In addition to the published results, more detailed results were tabulated for North Island hill country sheep-beef farmers (258 respondents, excluding farmers on hard hill country).

6.2 Aspects of Credit Using Behaviour

6.2.1 Reasons for borrowing

In a Rural Credit Survey conducted by the MAF (1975) it was found that in 1974/75 the largest proportion of outstanding long-term credit was used for purchase and amalgamation (55 per cent), followed by development (27 per cent), refinancing (14 per cent), and personal reasons (4 per cent). Although a more detailed breakdown of the purposes for borrowing was not available from this Survey, it is likely that a high proportion of finance in the category for "purchase and amalgamation" would constitute large mortgages taken out for the original purchase of the property.

An indication of the reasons for new borrowing was provided by the credit survey conducted by the MWBES (1984). The proportions of the value of new borrowing in 1979/80 classified by reason are shown in Table 6.1 for both Class 4 farms and the All Class average. Of interest for this study is the fact that only 35 per cent (44 per cent if farm purchase borrowing is excluded) of new borrowing on Class 4
TABLE 6.1
Reasons for New Long-Term Borrowing - 1979/80

<table>
<thead>
<tr>
<th>Reason</th>
<th>All Class Average</th>
<th>North Island</th>
<th>hill country (Class 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Farm Purchase</td>
<td>21</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>Additional Land</td>
<td>18</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>New Farm Buildings</td>
<td>11</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Additional Stock</td>
<td>2</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>New Plant and Vehicles</td>
<td>13</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Land Development</td>
<td>15</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Climatic, Other Assistance</td>
<td>&lt;1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Forestry Development</td>
<td>&lt;1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Death Duties</td>
<td>1</td>
<td>&lt;1</td>
<td></td>
</tr>
<tr>
<td>Refinancing</td>
<td>15</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Multi-purpose</td>
<td>1</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Other</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>100</td>
<td></td>
<td>100</td>
</tr>
</tbody>
</table>

Source: MWBES (1984)
farms was for on-farm investment purposes i.e. buildings, stock, plant and vehicles, and land development.

6.2.2 Debt levels

(a) Average debt levels

In nominal terms average debt levels have increased significantly over the last 20 years, and tend to be highly correlated with the value of land. For example, using MWBES Class 4 published data for the period 1961/62 to 1980/81, and regressing the level of fixed liabilities (FXLIAB) as a function of the nominal value of land and improvements (LANDVAL), the following results were obtained:

\[
FXLIAB = 15868 + 0.137 \text{LANDVAL} \quad R^2 = 0.90 \quad \text{D.W.} = 0.81
\]

\[(0.011)\]

Notwithstanding the presence of auto-correlation indicated by the Durbin-Watson statistic, the equation indicates the very high correlation that exists between the two variables.

With respect to real debt levels, Pryde and Martin (1980) observed that, for the pastoral sector in general, there appeared to be a slight downward trend in the average real level of debt, and a corresponding increase in equity levels, over the period 1971 to 1979. Using MWBES published data in Table 6.2, this trend is shown to be true also for North Island hill country, and to have continued until at least 1980/81.
### TABLE 6.2

**Equity Levels, and Interest Payments as a Proportion of Total Expenditure for North Island Hill Country Farms, 1965/66 to 1980/81**

<table>
<thead>
<tr>
<th>Year</th>
<th>Equity*</th>
<th>Interest as % of Total Expenditure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1965/66</td>
<td>70.8</td>
<td>9.7</td>
</tr>
<tr>
<td>1966/67</td>
<td>70.1</td>
<td>11.3</td>
</tr>
<tr>
<td>1967/68</td>
<td>68.6</td>
<td>13.1</td>
</tr>
<tr>
<td>1968/69</td>
<td>68.6</td>
<td>11.7</td>
</tr>
<tr>
<td>1969/70</td>
<td>74.4</td>
<td>11.8</td>
</tr>
<tr>
<td>1970/71</td>
<td>72.8</td>
<td>13.4</td>
</tr>
<tr>
<td>1971/72</td>
<td>72.3</td>
<td>13.2</td>
</tr>
<tr>
<td>1972/73</td>
<td>79.0</td>
<td>10.5</td>
</tr>
<tr>
<td>1973/74</td>
<td>80.1</td>
<td>10.0</td>
</tr>
<tr>
<td>1974/75</td>
<td>78.7</td>
<td>13.7</td>
</tr>
<tr>
<td>1975/76</td>
<td>80.3</td>
<td>12.6</td>
</tr>
<tr>
<td>1976/77</td>
<td>81.4</td>
<td>10.6</td>
</tr>
<tr>
<td>1977/78</td>
<td>80.9</td>
<td>12.4</td>
</tr>
<tr>
<td>1978/79</td>
<td>80.9</td>
<td>12.4</td>
</tr>
<tr>
<td>1979/80</td>
<td>85.4</td>
<td>13.0</td>
</tr>
<tr>
<td>1980/81</td>
<td>87.1</td>
<td>13.3</td>
</tr>
</tbody>
</table>

* Net Worth/Total Assets

### TABLE 6.3

**Respondent's Ability to Borrow All the Money Required During 1981/82 Season**

| Did not apply to borrow funds | 47 | 46 |
| Was able to borrow all funds required | 37 | 37 |
| Was not able to borrow all funds required | 10 | 11 |
| Don't know | 6 | 7 |

No. of valid observations 874 167
Using "interest payments as a percentage of gross expenditure" as a measure of debt levels, no such trend is apparent. In Table 6.2 it is shown that, between 1967/68 and 1980/81, the average percentage varied between 10.0 and 13.8 per cent without trend. It appears that increases in interest rates have maintained the interest burden despite a decline in real debt levels.

(b) Individual debt levels

With respect to individual borrowing behaviour, a number of surveys (Miller, 1965; MAF 1975; Pryde, 1978; Pryde and McCartin, 1983) have shown a very wide range of credit use, with considerable variation, not only from farm to farm, but also from district to district and from one farm type to another. To investigate borrowing trends at the individual farm level the MWBES panel data for 46 North Island hill country farms over 10 years was used. The changes in the level of fixed liabilities across the 46 farms showed a wide range. Some farms went from being debt free to having substantial long-term debt at the end of the ten year period, while others went from having substantial debt levels to being debt free. The distribution of percentage changes in nominal and real fixed liability levels over the ten year period is shown in Figures 6.1 and 6.2. Of the 45 farms that had some long-term debt 29 (or 64 per cent) showed an increase in the nominal level of debt over the period, with 16 farms (35 per cent) showing a decline in nominal debt levels. The average nominal debt level increased by 114 per cent over the ten year period.
FIGURE 6.1
Percentage Change in Nominal Fixed Liabilities between 1969/70 and 1978/79

FIGURE 6.2
Percentage Change in Real Fixed Liabilities between 1969/70 and 1978/79
When debt levels were converted to real terms by reflating to 1980 dollars using the MWBES Farm Price Index it was found that only 12 farms (26 per cent) showed an increase in real debt levels while 33 farms (74 per cent) showed a decline in real debt levels. The average real debt level decreased by 28 per cent. This decline in average real debt levels was also reflected in an analysis of the change in equity levels for the 46 farms. The distribution of equity change is shown in Figure 6.3. Thirty five farms (or 78 per cent) increased equity over the period with 10 farms (22 per cent) having reduced equity.

In summary, it is clear that there is a very wide range of borrowing behaviour amongst farmers and no clear pattern is apparent. Taking the group as a whole, however, two significant observations are possible. Firstly, the majority of farmers have significant levels of debt and are prepared to increase that level of debt in nominal terms. Secondly, while farmers tend to borrow actively, the majority do not do so to the extent of increasing their real level of debt or reducing their equity percentage. It would appear that, while inflation in asset values, particularly land, provides farmers with the capacity for increased borrowing, only part of this capacity is exploited.

6.2.3 Borrowing frequency

To determine borrowing frequency, each significant borrowing event was noted for each of the 46 farms over the 10 year period. A "significant" borrowing event was defined as an increase of $1000 or more in fixed liabilities compared with the previous year. The frequency of borrowing is shown in Figure 6.4. Only ten farmers out of
the 46 (or 20 per cent) did not borrow at any time during the ten year period. Of the 36 farmers who borrowed, 11 (31 per cent) borrowed only once, 9 (25 per cent) twice and 8 (22 per cent) three times. Eight farmers (22 per cent) borrowed between four and seven times in the ten year period. The average time between borrowing was approximately four years.

6.2.4 Attitude to use of credit

(a) Long-term credit

One of the most important financial decisions that farmers have to make relates to the extent to which they will use borrowed funds to finance farm operations and development. There is considerable evidence to indicate that, in this respect, many pastoral farmers in New Zealand are averse to borrowing in the sense that they borrow less than they could, and apparently, less than would maximise profit. For example, in the 1964 MAF Credit Survey (Miller, 1965), 26 per cent of farms were found to be "virtually free of all forms of debt". The debt-free farms "were by no means fully developed and interviewers commented that although credit could have been obtained for development it was often not sought." On the other hand... "Availability of credit seemed to be limited mostly in cases of already high commitment or poor personal factor." Similarly, Stanbridge (1973) observed a high correlation between investment and net farm income and cited this as evidence of a "preference for internal finance" in New Zealand consistent with that observed in some other countries (Pearce, 1955; Paul, 1963).
FIGURE 6.3
Changes in Equity Percentage between 1969/70 and 1978/79

FIGURE 6.4
Frequency of Borrowing over Period 1969/70 to 1978/79
Further evidence of farmers' tendency toward internal credit rationing was obtained from the 1982 Farmer Opinion Survey conducted by Pryde and McCartin (1983). With the co-operation of Pryde and McCartin several questions aimed at determining farmers' attitude to borrowing were included in the Survey (see Appendix 1). Unpublished results for North Island hill country farmers are presented in Tables 6.3 to 6.5. Table 6.3 shows that a large majority of farmers either did not attempt to borrow funds during the 1981/82 season (46 per cent), or were able to borrow all the funds they required for the season (37 per cent). Table 6.4 shows that 65 per cent of hill country respondents believed that they could have borrowed more if required, while Table 6.5 indicates that respondents' reasons for not borrowing more in 1981/82 were predominantly "internal" in nature. Only a very small minority of respondents were actually refused finance by a lending institution.

(b) Short-term credit

The above evidence relates mainly to long-term credit. Some interesting insights into farmers' behaviour and attitude toward short-term credit can be gained from the 1975 MAF Rural Credit Survey (MAF, 1975). This survey documented farmers' response to the significant fall in farm incomes in 1974/75. It was found that farmers tended to maintain farm operating expenditure at the expense of liquid reserves and capital and development expenditure. Changes in the use of credit were relatively minor and indicated that farmers did not use short-term credit as a means of supplementing income. Between 1973/74 and 1974/75 gross farm income fell by about 27 per cent. This fall was
TABLE 6.4

Respondent's Attitude to Borrowing

During the 1981/82 Season Did Respondent Either:
Not borrow but believe they could have obtained finance if required

OR

Borrowed finance but believed that if required could have borrowed more.

<table>
<thead>
<tr>
<th></th>
<th>All Sheep/Beef (%)</th>
<th>North Island Hill (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>68</td>
<td>65</td>
</tr>
<tr>
<td>No</td>
<td>14</td>
<td>13</td>
</tr>
<tr>
<td>Don't-Know</td>
<td>18</td>
<td>22</td>
</tr>
</tbody>
</table>

No. of valid observations 745 142

TABLE 6.5

Why Respondent Did Not Borrow More in 1981/82

<table>
<thead>
<tr>
<th></th>
<th>All Sheep/Beef (%)</th>
<th>North Island Hill (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refused by lending institutions</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Didn't want to increase indebtedness</td>
<td>43</td>
<td>43</td>
</tr>
<tr>
<td>Repayments too difficult</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>No profitable use for additional finance</td>
<td>35</td>
<td>31</td>
</tr>
<tr>
<td>Other</td>
<td>8</td>
<td>10</td>
</tr>
</tbody>
</table>

No. of valid observations 765 145
reflected to a greater extent in net farm income, which decreased by 70 per cent from about $9,250 in 1973/74 to $3,000 in 1974/75. Farm expenditure decreased by only 9 per cent and was thus maintained by drawing on liquid reserves built-up over the previous two years, and by severely limiting capital and development expenditure. Total current assets, comprising such liquid reserves as stock-firm and bank balances, and income equalisation deposits were reduced by 38 per cent relative to the 1973/74 levels. This liquidation offset 45 per cent of the reduction in gross income. Income equalisation deposits provided the largest contribution to liquidity. In 1973/74, they comprised 35 per cent of current assets, and were reduced by 54 per cent in 1974/75.

With respect to capital and development expenditure, the percentage of farms indicating some capital and development expenditure dropped from 85 per cent in 1973/74 to 55 per cent in 1974/75. The average expenditure on those farms with capital and development expenditure dropped by 20 per cent between the two years. The net effect was an average drop in capital and development expenditure of approximately 45 per cent. This "saving" offset a further 23 per cent of the reduction in gross income.

Changes in debt levels were minimal with average total liabilities per farm showing a decrease of 0.9 per cent from 1973/74 to 1974/75. This net effect was the result of current liabilities being 0.7 per cent higher and long-term debt being 1.32 per cent lower in 1974/75.
6.3 Analysis of Factors Affecting Long-Term Borrowing

6.3.1 Hypothesised factors

From the above review of past credit studies and (given government policy) it appears that farmers in the pastoral sector tend to be constrained by internal, rather than external, credit rationing. It was therefore hypothesised that long-term borrowing behaviour is mainly influenced by internal factors affecting expectations, ability to repay and collateral. The main external factor was hypothesised to be interest rate which affects the cost of borrowing. More specifically it was hypothesised that farmers' new long-term borrowing is a function of income, capital and interest rate.

(a) Income

Income, in particular recent income, can be expected to have a significant influence on new borrowing in two ways. Firstly, income in the recent past serves to establish a farmer's expectations about future farm profitability and income levels. As most long-term borrowing is for purposes of farm development or expansion it can reasonably be expected that income levels have a direct positive influence on borrowing behaviour i.e. high income increases a farmer's propensity to borrow and vice versa. Secondly, recent income is a measure of the farmer's capacity to repay a loan. As such, income can be expected to influence both the farmer and the lending agent. Again the direction of influence will be positive.
It is not obvious whether it is nominal income or real income that is likely to have the most influence on borrowing. Arguments can be put forward on both sides. First, in support of real income, it could be argued that real income is the best indicator of future farm profitability and the farmer's ability to repay a loan. Alternatively, nominal income levels may better reflect the effect of inflation on farmers' propensity to borrow. Inflation effectively reduces the real value and cost of outstanding fixed liabilities, because, while incomes may increase, interest rates, and thus debt servicing commitments, remain relatively stable. Debt servicing, as a proportion of total income, thus declines and the farmer's capacity to service further borrowing increases. Nominal income may also be more appropriate than real income if farmers suffer from a degree of money illusion and respond to changes in nominal income that may not be "real".

(b) Capital

Capital assets, especially land assets, can be expected to have an influence on farmer borrowing because such assets represent the collateral for borrowing. While real increases in capital assets may appear to be the most appropriate form of this factor, again, as with income, the real form may fail to capture the important effect of inflation on borrowing behaviour. Because the nominal value of outstanding fixed liabilities resulting from previous borrowing is not affected by inflation, nominal increases in asset values will effectively increase farmer equity. With increasing equity the farmers' capacity and propensity to borrow, and lending institutions willingness to lend, can be expected to increase.
(c) Interest rate

As the measure of the cost of borrowing, interest rate can also be expected to have some influence on borrowing behaviour; however, in times of inflation there may be significant differences between nominal and real (inflation adjusted) interest rates. Nominal interest rates can be thought of as a measure of the short-term cost of borrowing, in particular the impact of borrowing on short-term cash flow. On the other hand, the real interest rate is probably a better measure of the true, long-term cost of borrowing. Borrowing and lending interest rates tend to be highly correlated and thus the interest rate also provides a measure of the opportunity cost of farmer investment and as such, may have an additional influence on borrowing behaviour.

While as a general rule deflated data are usually most appropriate for econometric studies, in this case the situation is not clear. As has been illustrated and observed in previously reviewed studies, there is a strong correlation between the value of capital assets and the level of fixed liabilities; in other words, equity ratios remain relatively stable in times of inflation. Farmers therefore use the nominal increases in asset values as collateral against which to borrow. From a behavioural point of view it is the nominal values that appear most important. This argument extends to the form of the dependent variable. It is clear that many farmers actively borrow in times of inflation and yet they may not increase the real value of their fixed liabilities. Under these circumstances it is the change in the nominal value of fixed liabilities that reflects farmer borrowing behaviour.
6.3.2 Regression analysis.

To test the general hypothesis outlined above, various forms of the basic function were tested using a time-series of MWBES Published data for North Island hill country farms (Class 4) for the years 1961/62 to 1980/81. This Class-average data set was used, rather than the panel of individual farmer data, because it was felt that the discrete and infrequent nature of borrowing events for individual farmers would make it difficult to construct an effective explanatory model of their behaviour using continuous explanatory variables. On the other hand, changes in average borrowing rates for the whole Class is a measure of changes in borrowing propensities which could reasonably be expected to be related to the hypothesised explanatory variables.

(a) Variables used in the analysis

The following variables were used in the analysis:

(i) Changes in total fixed liabilities - This variable was assumed to be a satisfactory measure of new long-term borrowing, although it is influenced, to some unknown extent, by repayments of previous loans. For each year the change was positive indicating that new borrowing more than offset any reduction in fixed liabilities due to loan repayments.
(ii) Net farm income - This variable was selected as the best measure of farm income and ability to repay a loan.

(iii) Changes in capital value of land and improvements - This was regarded as the most appropriate variable to represent the collateral available to the farmer against which he could borrow.

(iv) Average rate of interest on new mortgages - This variable, published by the New Zealand Department of Statistics (NZDS (various)), was selected as a reasonable measure of interest rates. Although many loans to farmers may be at concessional interest rates, the change in those concessional rates is probably adequately reflected in the variable used. Also, the average rate of interest on new mortgages was thought to be a reasonable measure of the return to off-farm investments.

(v) Inflation in prices paid - Although, for reasons explained above, nominal data appeared most appropriate, one form of the basic function was tested with data in real terms. When this adjustment for inflation was necessary the "Prices Paid Index" published in the MWBES Annual Review of Sheep and Beef Industry (various issues) was used.

(b) Lags in the system

It seems reasonable to expect some lags in farmers' response to factors affecting borrowing behaviour; in particular, response to changes in income levels could be expected to be lagged as farmers wait to see if changes in income are permanent or transitory. Consequently,
various lags on the explanatory variables were tested in the estimated functions.

6.3.3 Results of estimation.

Table 6.6 shows a summary of results from estimating various forms of the hypothesised model. Equations 1 to 4 represent an initial round of estimation using functions which included each of the hypothesised explanatory variables in some form. Differences in the functional form related to minor differences in lags, and, in the case of Equation 4, to the use of real instead of nominal data. The use of data in real form (Equation 4) resulted in a very poor statistical fit. In no case were the estimated coefficients significantly different from zero, and the explanatory power of the function was also very low ($R^2 = 0.08$, $\bar{R}^2 = -0.12$).

Equations 1 to 3, estimated using nominal data, gave somewhat better results, although, of the explanatory variables, only "lagged net income" consistently showed a significant coefficient and a logical sign. Both "change in nominal land value" and "nominal interest", while having estimated coefficients which were significantly different from zero, also had illogical signs. There is no apparent reason why a lagged increase in land value should have resulted in reduced borrowing, or why an increase in nominal interest rates should lead to increased borrowing. Also the negative sign on the inflation coefficient defies a logical explanation.
TABLE 6.6
Results of Regressions Related to Fixed Liabilities

<table>
<thead>
<tr>
<th>EQU. NO.</th>
<th>DEP. VAR.</th>
<th>CONST.</th>
<th>NNY(1)</th>
<th>NNY(2)</th>
<th>RNY(I)</th>
<th>NDLV</th>
<th>NDLV(I)</th>
<th>RDLV(I)</th>
<th>NINT</th>
<th>RINT</th>
<th>INF</th>
<th>$\bar{R}^2$</th>
<th>D.W.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NDFLIAB</td>
<td>1.00</td>
<td>-0.080</td>
<td>2246.8**</td>
<td>-624.9**</td>
<td>0.63</td>
<td>1.83</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>NDFLIAB</td>
<td>0.270</td>
<td>-0.038</td>
<td>1577.5</td>
<td>-275.4</td>
<td>0.56</td>
<td>1.79</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>NDFLIAB</td>
<td>0.386**</td>
<td>-0.075**</td>
<td>3168.4**</td>
<td>-731.1**</td>
<td>0.76</td>
<td>1.69</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>RDFLIAB</td>
<td>0.180</td>
<td>-0.038</td>
<td>161.4</td>
<td>-1.84</td>
<td>0.12</td>
<td>1.84</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>NDFLIAB</td>
<td>0.204</td>
<td>-0.080</td>
<td>1192.5</td>
<td>-614.6</td>
<td>0.37</td>
<td>2.11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>NDFLIAB</td>
<td>0.325*</td>
<td>-0.058</td>
<td>802.1</td>
<td>-542.3</td>
<td>0.52</td>
<td>1.61</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>NDFLIAB</td>
<td>0.435**</td>
<td>-0.020</td>
<td>56.4</td>
<td>-176.9</td>
<td>0.65</td>
<td>1.31</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>NDFLIAB</td>
<td>0.404*</td>
<td>-0.060</td>
<td>176.9</td>
<td>-2.00</td>
<td>0.25</td>
<td>2.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>NDFLIAB</td>
<td>0.432**</td>
<td>-0.028</td>
<td>-28</td>
<td>-1.32</td>
<td>0.48</td>
<td>1.32</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>NDFLIAB</td>
<td>0.219*</td>
<td>-0.060</td>
<td>176.9</td>
<td>-2.00</td>
<td>0.25</td>
<td>2.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>NDFLIAB</td>
<td>0.355**</td>
<td>-0.028</td>
<td>-28</td>
<td>-1.32</td>
<td>0.48</td>
<td>1.32</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>NDFLIAB</td>
<td>0.046</td>
<td>-0.028</td>
<td>-28</td>
<td>-1.32</td>
<td>0.48</td>
<td>1.32</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For legend, see next page
Legend for Table 6.6

NDFLIAB - nominal change in fixed liabilities
RDFLIAB - real change in fixed liabilities
NNY - nominal net income
RNY - real net income
NDLV - nominal change in value of land and improvements
RDLV - real change in value of land and improvements
NINT - nominal interest rate
RINT - real interest rate
INF - inflation rate

Lags - numbers in parentheses after variable name represent period of lag

$R^2$ - $R^2$ adjusted for degrees of freedom

D.W. - Durbin-Watson statistic

Standard errors - numbers in parentheses below estimated coefficients are standard errors

* - significant at 5 per cent level

** - significant at 1 per cent level
Such perverse results could have been caused by the high degree of multi-collinearity between nominal interest rates and inflation rates. In an attempt to overcome this problem the inflation rate variable was dropped from the function. The results of this formulation, using both nominal interest rates (Equations 5 and 6) and real interest rates (Equation 7), are summarised in Table 6.6. Income lagged twice remained highly significant while "change in land value" and interest rate coefficients became not significantly different from zero. The signs on these coefficients remained illogical. The explanatory power of the models, as measured by the adjusted $R^2$ was reduced slightly relative to the original formulations.

The effect of dropping interest rate from the function was tested with Equations 8 and 9 in Table 6.6. The coefficients for income lagged once (Equation 8) and income lagged twice (Equation 9) were highly significant but lagged changes in land value remained non-significant. Adjusted $R^2$ for the functions were reduced slightly compared with Equations 5 and 6, while Durbin-Watson values continued to indicate either no autocorrelation or an inconclusive test.

The results of Equations 8 and 9 indicated that there was a marked difference in the power of net income as an explanatory variable, depending on the lag used. To clarify this the land value variable was dropped to leave net income lagged once as the sole explanatory variable in Equation 10, and net income lagged twice as the explanatory variable in Equation 11. Although both lagged income variables remained highly significant, it was net income lagged twice that was the more effective explanatory variable with an adjusted $R^2$ of 0.48,
compared with 0.23 for the once lagged variable.

Similarly, using both lagged income variables in the same function (Equation 12) failed to result in improved explanatory power. The coefficient of net income lagged twice remained highly significant but that for net income lagged once became very small and not significantly different from zero. Adjusted $R^2$ and the D.W. statistic remained very similar to those values for Equation 11 where net income lagged twice was the sole explanatory variable. It would appear that the explanatory power of net income lagged once is effectively accounted for by net income lagged twice.

6.3.4 Discussion

The results indicate that lagged income has the strongest influence on farmers' decision to borrow long-term. This is a logical result given the importance of income as a determinant of expectations, and as an indicator of the farmer's capacity to repay a loan. The two period lag may appear surprisingly long but, in fact, may not involve much more than one year. Most income on pastoral farms comes towards the end of the June year. Following this the financial status of the farm is not likely to be clear until well into the next June year when farm accounts are completed. The decision to borrow may then be made and actioned (after administrative delays) at the beginning of the next June year in preparation for development and pasture establishment in the spring of that year.
The lack of a logical sign and/or significance associated with the relationship between borrowing and changes in the capital value of land and improvements is interesting. There is little doubt that increases in the nominal value of assets provide farmers with the capacity to borrow. Also, it is obvious from previously reviewed surveys and analyses that a significant proportion of that borrowing capacity is utilised. The fact that this relationship could not be revealed in the analysis as one of direct cause and effect has a plausible behavioural explanation. While increases in the nominal value of capital assets increases the farmer's capacity to borrow, it does not automatically lead to this capacity being utilised. It would appear that increased borrowing capacity is only utilised periodically, and mainly in response to relatively high income levels in the recent past.

The non-significance of interest rate as a factor determining new borrowing conforms with results reported by Laing and Zwart (1983). While significant increases in nominal interest rates occurred over the time period tested, there was an even greater increase in inflation. As a result, real interest rates tended to fall over the period. Under these circumstances, a farmer's response to interest rates is likely to be ambivalent, if not confused. On the one hand the farmer will be inclined to reduce borrowing in response to high nominal interest rates because of the short-run interest burden that would be incurred. On the other hand, if, due to inflation, the real interest rate is low or even negative, he may be encouraged to borrow. This confusion of responses could well account for the lack of significance and/or logical sign found for interest rate in the analysis.
6.4 Analysis of Factors Affecting Short-Term Borrowing

6.4.1 Hypothesised factors.

The behaviour of farmers toward the use of short-term credit was also of interest in this study. It was considered important because short-term credit, including seasonal finance, plays an important facilitating role in agriculture, bridging the time gaps between expenditure and income. Farmers' behaviour with respect to short-term credit has not been studied in detail in New Zealand, although Pryde and Martin (1980) suggested that short-term credit is used to compensate for short-term falls in income. They stated that "In the short-term, fluctuations in the levels of farm incomes will influence credit demand, with the hypothesised relationship being that short-run falls in rural income are associated with an increased demand for short-term credit". Such a hypothesis is supported by other authors. (See for example, Baker (1968), Barry and Baker (1971), BAE (1977)). Baker (1968) argued that farmers tend to maintain a "reserve" of unused credit "that can be called upon to counter the effect of failure in expectations." The BAE (1977), in a review of credit in the Australian rural sector, reported that, "The uncertainty of income created by instability, influences the (rural) sector's demand for credit and is reflected in turn by the reluctance by many producers to enter fixed payment commitments and a preference for overdraft type finance. The demand for short-term carry-on finance is especially marked in periods of drought and price recession." Some intuitive support for the hypothesis that short-term credit tends to be used (in addition to its production facilitating role) to help "iron-out" short-run fluctuations
in income, comes from the study of consumption behaviour described in Chapter 5. North Island hill country farmers, in common with other farming communities both in New Zealand and elsewhere, maintain a relatively stable consumption pattern despite significant fluctuations in net income. To achieve this stability of consumption, recourse could be made to short-term credit. Alternatively, the farmer could maintain his own liquidity reserves in the form of liquid assets to be called upon in times of depressed income and restored in times of high income. Some evidence of this type of behaviour was found in the 1975 MAF Rural Credit Survey (MAF, 1975) described above.

6.4.2 Graphical observation and regression analysis.

To test the relationship between income, short-term credit and liquid assets, a series of regression models were tested, in conjunction with some graphical observation. The data used were the 20 year time-series of MWBES published data for North Island hill country (Class 4) farms. Figures 6.5 and 6.6 show net income and current liabilities in both nominal and real form. The data in real terms are in 1980/81 dollars "reflated" by the Index of Prices Paid (MWBES).

(a) "Pot-holing" hypothesis

The first hypothesis tested was that short-term credit is used to compensate for fluctuating incomes. From inspecting the data in

---

4 These data are averages based on current liability levels as at the end of the farm accounting year, usually June 30. No data are available on peak seasonal debt levels which would tend to occur earlier in the season.
FIGURE 6.5
Nominal Net Income and Current Liabilities for Years 1961/62 to 1980/81

FIGURE 6.6
Real Net Income and Current Liabilities for Years 1961/62 to 1980/81 - (1980/81 dollars)
graphical form it is clear that the level of current liabilities is relatively stable compared with the instability in net incomes. Current liabilities tend to increase steadily with inflation rather than fluctuate. In real terms current liabilities remained remarkably constant with only slight fluctuations around a mean of approximately $17000 in 1980/81 terms. Furthermore there is no apparent relationship between what variation there is in current liabilities, and the variation in either net farm income or gross farm income. This observation was confirmed by regression Equations 1, 2 and 3 in Table 6.7 where current liabilities was regressed on net farm income, lagged net farm income and gross income respectively. In all cases no significant relationship was discernible and the hypothesis suggesting a direct link between income and the use of short-term credit had to be rejected.

(b) "Facilitating" hypothesis

An alternative hypothesis, associated with the role of short-term credit as a facilitating medium for the day-to-day financial operations of the farm, was then tested. The hypothesis was that current liabilities is directly and positively related to the level of farm expenditure. Although this hypothesis appeared to have a logical foundation, prior expectations were that it would also be rejected, given the close relationship between income and farm working expenses. This relationship is illustrated in regression Equations 4 and 5. Figure 6.7 shows the time-series of working expenses and current liabilities in real terms.
### TABLE 6.7

Results of Regression Related to Current Liabilities

<table>
<thead>
<tr>
<th>EQU. NO.</th>
<th>DEP. VAR.</th>
<th>CONST.</th>
<th>RNY</th>
<th>RNY(1)</th>
<th>RGY</th>
<th>WEXP</th>
<th>RESLVL</th>
<th>$R^2$</th>
<th>D.W.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RCLIAB</td>
<td>18183</td>
<td>-0.012</td>
<td>(0.041)</td>
<td></td>
<td></td>
<td></td>
<td>-0.05</td>
<td>1.00</td>
</tr>
<tr>
<td>2</td>
<td>&quot;</td>
<td>18668</td>
<td>-0.028</td>
<td>(0.041)</td>
<td></td>
<td></td>
<td></td>
<td>-0.03</td>
<td>0.99</td>
</tr>
<tr>
<td>3</td>
<td>&quot;</td>
<td>18040</td>
<td>-0.003</td>
<td>(0.029)</td>
<td></td>
<td></td>
<td></td>
<td>-0.06</td>
<td>0.97</td>
</tr>
<tr>
<td>4</td>
<td>WEXP</td>
<td>18179</td>
<td>0.253**</td>
<td>(0.033)</td>
<td></td>
<td></td>
<td></td>
<td>0.76</td>
<td>1.38</td>
</tr>
<tr>
<td>5</td>
<td>&quot;</td>
<td>30423</td>
<td>0.295**</td>
<td>(0.063)</td>
<td></td>
<td></td>
<td></td>
<td>0.52</td>
<td>1.20</td>
</tr>
<tr>
<td>6</td>
<td>RCLIAB</td>
<td>15028</td>
<td>0.071</td>
<td>(0.101)</td>
<td></td>
<td></td>
<td></td>
<td>-0.03</td>
<td>0.81</td>
</tr>
<tr>
<td>7</td>
<td>RESFLO</td>
<td>-16975</td>
<td>0.701**</td>
<td>(0.058)</td>
<td></td>
<td></td>
<td></td>
<td>0.89</td>
<td>2.02</td>
</tr>
<tr>
<td>8</td>
<td>&quot;</td>
<td>7303</td>
<td>-0.088</td>
<td>(0.180)</td>
<td></td>
<td></td>
<td></td>
<td>-0.04</td>
<td>1.91</td>
</tr>
<tr>
<td>9</td>
<td>&quot;</td>
<td>-35216</td>
<td>0.472**</td>
<td>(0.061)</td>
<td></td>
<td></td>
<td></td>
<td>0.76</td>
<td>1.95</td>
</tr>
<tr>
<td>10</td>
<td>RESLVL</td>
<td>33646</td>
<td>0.689**</td>
<td>(0.166)</td>
<td></td>
<td></td>
<td></td>
<td>0.46</td>
<td>0.62</td>
</tr>
<tr>
<td>11</td>
<td>&quot;</td>
<td>41968</td>
<td>0.420</td>
<td>(0.217)</td>
<td></td>
<td></td>
<td></td>
<td>0.13</td>
<td>1.11</td>
</tr>
<tr>
<td>12</td>
<td>&quot;</td>
<td>12558</td>
<td>0.502**</td>
<td>(0.120)</td>
<td></td>
<td></td>
<td></td>
<td>0.47</td>
<td>0.56</td>
</tr>
<tr>
<td>13</td>
<td>RCLIAB</td>
<td>15297</td>
<td>0.272**</td>
<td>(0.084)</td>
<td>-0.150**</td>
<td>(0.034)</td>
<td></td>
<td>0.50</td>
<td>1.63</td>
</tr>
</tbody>
</table>

For legend, see next page
Legend for Table 6.7

RCLIAB - real current liabilities  
WEXP - real working expenses  
RESFLO - flow of funds to reserves  
RESLVL - level of reserves  
RNY - real net income  
RGY - real gross income  
Lags - numbers in parentheses after variable name represent period of lag  
R^2 - R^2 adjusted for degrees of freedom  
D.W. - Durbin-Watson statistic  
Standard errors - numbers in parentheses below estimated coefficients are standard errors  
* - significant at 5 per cent level  
** - significant at 1 per cent level
FIGURE 6.7
Reserves, Working Expenses and Current Liabilities for Years 1961/62 to 1980/81 (Real Terms: 1980/81 dollars)

- Liquid Reserves
- Working Expenses
- Current Liabilities
As expected, the hypothesis that there is a direct link between the level of farm working expenditure and the level of current liabilities had to be rejected. The result of testing this hypothesis is given in regression Equation 6, which shows no significant relationship.

From the relationships tested above it seems clear that short-term credit does not play a major role in stabilising farm consumption and expenditure during fluctuations in farm income. Given that this is the case, then farmers must maintain their own reserves, in the form of liquid assets, to moderate the effects of income fluctuations.

(c) Modified "facilitating" hypothesis accounting for reserves.

To investigate the role of liquid reserves in the operation of the farm, two composite variables were constructed from the MWBES published survey results; the first, a "flow of reserves" variable consisting of savings and income equalisation deposits; the second, a stock variable "liquid reserves" consisting of cash at bank or stock-firm, investments and deposits, and "other assets". Figure 6.7 shows the time-series of liquid reserves, working expenses and current liabilities.

To test the hypothesis that liquid reserves are used to help stabilise the effects of fluctuations in income, the reserve flow and reserve stock variables were regressed on income. The results are represented as Equations 7 to 12 and show a clear relationship between current income and the flow and level of liquid reserves.
Recognition of the importance of liquid reserves in the financial operation of the farm, gave rise to a third hypothesis to explain the use of short-term credit. Farmers' apparent preference for the use of their own funds to finance consumption and farming operations would suggest that farmers may use short-term credit more when the preferred alternative of using own reserves is not available. Similarly, short-term credit might be expected to be used less when large reserves of liquid funds are available. It was therefore hypothesised that the level of current liabilities could be explained as a function of total working expenses and the level of liquid reserves. A positive relationship would be expected for working expenses, and a negative relationship for the level of liquid reserves. Equation 13 shows the result of testing this hypothesis. The estimated coefficients for both working expenses and liquid reserves had the expected sign and were highly significant. A reasonable proportion of the variation in the level of current liabilities was explained by the function ($R^2 = 0.55$).

From this analysis a clearer picture of farmers' behaviour with respect to the use of short-term credit can be built up. In real terms the level of outstanding short-term credit has remained quite stable. Clearly farmers have a preference for internal financing to cover short-term shortfalls in income, and to provide some of the funds necessary for the day-to-day operation of the farm, and for consumption.
6.5 Conclusions

From this study certain general and specific conclusions can be drawn. Firstly, farmers do not appear to be averse to borrowing per se; rather they may be averse to incurring significant increases in their real level of debt. In times of inflation the difference in these two attitudes can be substantial. Because inflation reduces the real value of outstanding liabilities many farmers can actively borrow funds while at the same time enjoy an upward trend in their equity ratios.

The nominal level of long-term liabilities was found to be highly correlated with the nominal value of farm land and improvements, yet no direct causal link between increases in land values and new borrowing could be established. Rather, new long-term borrowing appears to be prompted mainly by lagged income; more specifically by income lagged two periods. While increasing land values provides the capacity to borrow, it appears that this capacity is not utilised until a period of high income improves expectations of future profitability and capacity to repay.

No relationship could be established between interest rate and new long-term borrowing. This result is not surprising given that, in times of high inflation, nominal interest rates can be high while real interest rates can be low or even negative. Since both nominal and real rates are likely to have an effect on borrowing behaviour the lack of a clear relationship is understandable.
With respect to the short-term borrowing, the amount of short-term credit used was shown to be relatively stable and related to the levels of both working expenses and cash reserves. The rationale for this result seems clear; farmers need funds to finance working expenses during the course of the year and, while some short-term credit will usually be used for this purpose, less appears to be used when the farmer has significant liquid reserves available. The hypothesis that farmers borrow to offset short-term slumps in income had to be rejected. It appears that, where possible, farmers use their own liquid reserves to augment low income.

The apparent general unwillingness of farmers to borrow to offset low incomes does not preclude the possibility that some farmers may be forced into this situation. This can occur when a slump in returns, coupled with limited liquid reserves, makes it impossible for some farmers to repay short-term credit, which had been used to finance working expenses. As a result short-term credit can become "hardcore" debt and refinancing becomes necessary. While some individual farmers have no doubt faced this situation at some time during the last ten years, this study would suggest that it has not been a widespread phenomena during this period.
NEW ZEALAND HAS A LONG HISTORY OF RESEARCH WHICH HAS ATTEMPTED TO
EXAMINE AND DESCRIBE THE INFLUENCE OF ECONOMIC AND ENVIRONMENTAL
CONDITIONS ON THE OPERATION OF THE PASTORAL FARMING SYSTEM. SUCH
STUDIES INCLUDE JOHNSON (1955), ROWE (1956), COURT (1967), RAYNER
AND ZWART (1983). RECURS TO THIS LEGACY OF RESEARCH WORK IN
ORDER TO ESTABLISH A CLEARER PICTURE OF PASTORAL SECTOR INVESTMENT
BEHAVIOUR IN GENERAL AND HILL COUNTRY FARMER BEHAVIOUR IN PARTICULAR.
SOME ADDITIONAL ANALYSIS IS ALSO UNDERTAKEN WITH RESPECT TO THE NORTH
ISLAND HILL COUNTRY SITUATION. FINALLY, CONSIDERATION IS GIVEN TO
PROCEDURES FOR MODELLING INVESTMENT ACTIVITIES.

7.2 A REVIEW OF PASTORAL SECTOR STUDIES

7.2.1 PRE-1970 MODELS.

THE STUDIES BY JOHNSON (1955), ROWE (1956), COURT (1967) AND
RAYNER (1968) WERE TYPICAL OF EARLY ATTEMPTS TO MODEL THE PASTORAL
SECTOR AND WERE REVIEWED IN DETAIL BY WOODFORD AND WOODS (1978). A
BRIEF REVIEW OF THESE STUDIES IS PROVIDED HERE TO GIVE AN HISTORICAL
CONTEXT TO MORE RECENT STUDIES.
Johnson (1955) analysed changes in aggregate agricultural output from 1928/29 to 1949/50 using a single equation model. The dependent variable was defined as the total volume of New Zealand's farm production as computed by the Government Statistician. For use as an explanatory variable Johnson constructed an index of climatic conditions based on total rainfall for the months January to March for each year, as measured at Ruakura Animal Research Station near Hamilton. A secondary explanatory variable was the area of hay and silage on New Zealand farms in the preceding year. Johnson suggested that this variable could be regarded as a measure of the lagged effect of climate. Johnson also attempted to isolate a systematic price response using both current and lagged prices.

The attempt to isolate any price influences in the farm production series failed and Johnson concluded that "We have only a negative indication that the supply function of New Zealand agriculture is highly inelastic. In other words, not only is the supply of farm products independent of the current market situation, but it also tends to be independent even of previous market situations". With respect to the explanatory variables related to climate, however, the coefficients of both variables proved significant at the 5 per cent level. The proportion of variation explained by the multiple regression was 0.46.

Rowe (1956) analysed economic influences on livestock numbers in New Zealand between 1920 and 1950, using a single equation model. The basic hypothesis of this study was that economic factors account for most of the observed variation in livestock numbers while residual variation may be attributed to technological, climatic and other
influences. He hypothesised further that climatic factors have relatively little influence on livestock numbers and, consequently, climatic factors were not incorporated in his model. Results were presented for five different classes of sheep and beef cattle numbers and explanatory variables included sheep and beef product price ratios and a time trend. Rowe's study was inconclusive with respect to the importance of economic factors influencing sheep and cattle numbers. He found, for example, that in equations where the time trend was included it provided the majority of the explanation. This result would seem to contradict Rowe's hypothesis that economic variables account for most of the observed variation in stock livestock numbers. Also, the statistical validity of Rowe's analysis can be questioned; in several equations the residuals were highly correlated, possibly leading to spurious results.

Court (1967) estimated supply functions for lamb, mutton and beef using both ordinary least squares and two-stage least squares. He used an adaptive expectations model to estimate short and long-run price elasticities for these three products. For mutton and beef his results were ambiguous and difficult to rationalise, with negative elasticities estimated for both short-run and long-run supply. This suggests model specification problems and Court admitted that the lamb, mutton and beef production data showed fairly strong trends over time which were due to reasons other than income maximising behaviour. Despite this he concluded that "It is almost certain that definite economic influences on the supply of New Zealand meat exist and that these can be obtained from a model taking account of the decision making processes of the New Zealand farmer over time. That these influences cannot be determined
very precisely seems to be characteristic of supply models in general".

Rayner (1968) developed a national sheep supply model in which sheep numbers were disaggregated into classes based on age and sex. The explanatory variables used were a combined lamb price and wool price lagged one year, and trend terms to account for technological change. The equations were originally estimated using data for years 1952 to 1965 and were subsequently updated by Woodford and Woods (1978) to cover the period 1952 to 1973. Although the prices index provided significant explanation over the period 1952 to 1965, it performed poorly over the longer period, giving $R^2$ values of only 0.04 and 0.11 for numbers of breeding ewes and ewe hoggets, respectively.

Of the four early studies reviewed above, only Johnson took explicit account of climatic conditions and, having done so, found strong evidence of climatic influences on aggregate production. On the other hand, all four attempts to isolate economic influences led either to inconclusive or ambiguous results. These results suggested to subsequent researchers that the influence of climatic conditions on the operation of pastoral farming systems was worthy of closer examination, and that the economic influences which were hypothesised to exist may be too complex to be handled in a simple single equation model. The hypothesis that climatic conditions are an important determinant of livestock numbers is supported by other studies linking agricultural output to climatic variability. See for example, Maunder (1974), Thompson and Taylor (1975), and Rich and Taylor (1977).
7.2.2 More recent studies

In response to the apparent shortcomings of earlier studies, researchers in more recent studies such as Woodford and Woods (1978), Tweedie and Spencer (1981) and Laing and Zwart (1983) have attempted to improve the accuracy and validity of model specifications related to climatic and economic influences in the pastoral sector.

(a) Woodford and Woods (1978)

Woodford and Woods (1978) developed a model that explicitly allowed for the influence of climate on both sheep and cattle numbers. The aim of their study was to explain annual changes in total livestock units on sheep and beef farms. The model was developed for the eight classes of farms defined in the New Zealand Meat and Wool Boards' Economic Service Sheep and Beef Farm Survey. Results were presented for four different formulations of the single equation model applied to the period 1963/64 to 1974/75.

As the dependent variable they used an index of total livestock units in which the numbers in each class of livestock were adjusted for their relative feed requirements. Two alternative variables were used to represent climatic and feed supply variability. Firstly, a rainfall index was constructed by grouping the survey farms in each class into geographical areas, and weighting recorded rainfall (October to March) according to the proportion of farms in each area. Secondly, wool weight per head was selected as a proxy index for feed availability per livestock unit over the total growing season.
With respect to economic factors, Woodford and Woods hypothesised four different responses to economic factors. These were:

(i) a positive "price expectations" response where farmers alter livestock numbers in response to a change in the expected level of product prices. In effect, this represents an intensification (or extensification) response where there is a movement along the production curve until the new equilibrium point is reached where expected marginal revenue equals expected marginal cost. (Although not explicitly stated by Woodford and Woods, this response would appear to imply a minimum of additional capital investment (apart from livestock) and could occur quite rapidly, in contrast to the investment response described below.)

(ii) an "investment" response which is a function of gross farm income in preceding years. In this case there is a shift in the production curve and stock numbers only increase or decrease as capital stock is adjusted to handle them.

(iii) a short-run "cashing-in" response where farmers sell more potential breeding stock when meat prices are high, in an attempt to "cash in" on the high prices while they are maintained.

(iv) a short-run "income supplementation" response where liquidity considerations force farmers to sell additional livestock when product prices are low.
To test for the existence of a price expectations response, Woodford and Woods regressed annual changes in livestock numbers against annual changes in deflated gross income per livestock unit, the latter being used as a proxy for changes in product prices. No significant relationship was found. To test for a distributed lagged response they calculated the simple correlation coefficients between annual changes in livestock units (lagged one year) for each farm class. None of the coefficients were significant; the coefficient in the equation related to North island hill country (Class 4) was the largest at only 0.43. Woodford and Woods suggested that this result indicated "...not only that there are no statistically significant distributed lag responses to price expectation effects, but also that there are unlikely to be significant distributed lag responses to other factors."

In testing for an investment response it was hypothesised that there is an investment relationship linking real gross farm income per livestock unit with subsequent changes in livestock numbers. This relationship was postulated as comprising the following components:

(i) Livestock Units = fn (Farm Investment)
(ii) Farm Investment = fn (Cash Farm Expenditure)
(iii) Cash Farm Expenditure = fn (Gross Farm Income)

The third of these postulated components was tested for validity by regressing farm cash expenditure on gross farm income in the same year for each farm class. A close link was established; thus, given the failure to establish any distributed lag effect, and to preserve
degrees of freedom, gross income lagged one year was used as the investment proxy. To test for the short-run economic responses ("cashing-in" and "income supplementation"), deflated gross income from meat per stock unit was used as a proxy for meat prices.

Results indicated that wool weights per head were positively correlated with the annual changes in livestock units; livestock units tended to increase at the end of a season when wool weights were high and either decrease or else increase at a lower rate following a season when wool weights were low. For hill country farm classes (i.e. Classes 2 to 4) this wool weight variable was significant at the 1 per cent level and explained an average of 68 per cent of variation in the dependent variable. The rainfall index proved to be a poor indicator of changes in stock numbers possibly because, in some cases, it was not a good measure of the actual rainfall on the sample farms. The economic variables appeared to be weak as factors determining annual changes in stock unit numbers. No statistical evidence was found for the presence of either price expectation or investment responses, nor, for Class 4 farms, could any evidence be found for short-run economic effects.

While these results suggest that fluctuations in the level of investment were not a major cause of annual fluctuations in stock units, they do not necessarily indicate that investment is unimportant in determining the underlying carrying capacity of sheep and beef farms.
(b) Tweedie and Spencer (1981)

Since the Woodford and Woods study, a much improved index of climatic conditions has become available. This index is based on soil moisture deficit days weighted by the sheep population, and is published by the New Zealand Meteorological Services. The use of this index in subsequent econometric studies of supply response (e.g. Tweedie and Spencer, 1981; Laing and Zwart, 1983) has confirmed Woodford and Woods' conclusion that climatic conditions have a major influence on annual fluctuations in stock numbers. Also, use of the index to account for climatic influences in these studies has allowed the true influence of economic factors to be explored more effectively.

Tweedie and Spencer (1981), for example, as part of a study of supply behaviour in New Zealand's export industries, estimated equations to explain changes in disaggregated sheep and beef numbers separately. Both equations were initially specified in a "stock adjustment" framework where lagged stock level was included as a regressor to enable an equilibrium or desired stock level equation to be derived from the estimating equation. Other explanatory variables included soil moisture deficit days, farm expenditure (as a proxy for investment), the terms of exchange facing beef and sheep farmers, and the relative return between beef and sheep. It was found that beef numbers were better explained by the stock adjustment framework than sheep numbers, but in both cases the explanatory variables listed above were found to be significant.
The econometric studies reviewed so far, including the Tweedie and Spencer models, were intuitive in their specification or were specified on the basis of a constrained dynamic profit maximising problem. Also, due to data problems, they were forced to handle investment in a very simplistic way often with farm expenditure used as a simple proxy for investment. This approach was necessary because farm survey data based on farm accounts (such as the MWBES Survey) does not separate investment expenditure from general operating expenses.

(c) Laing and Zwart (1983)

In what is the most comprehensive econometric study of the pastoral sector to date, Laing and Zwart (1983) took a more general view of the decision making process, and, as part of their pastoral sector model, they developed a sub-model to represent the farm investment decision-making process. In this sub-model investment decisions are related through income to current output and prices. Income acts as a constraint on farm investment, either as a direct source of funds or through the ability to service the debt which might be required for investment. A subsequent sub-model then relates investment decisions to livestock numbers and thence to production.

In an effort to overcome farm level data deficiencies with respect to investment, the Laing and Zwart model was estimated using a combination of the MWBES and New Zealand Dairy Board farm survey data, and aggregate investment statistics from the New Zealand Department of Statistics.
In contrast to many other econometric models of pastoral supply response which emphasise livestock as the major form of capital involved (for example, Freebairn (1973), Jarvis (1974), and Reynolds and Gardiner (1980)), Laing and Zwart explicitly accounted for other forms of investment which are often prerequisite to increasing livestock numbers. They argued that "...investment in land clearing, fencing, long-term fertilisers such as phosphate and lime, and even managerial skills are a necessary part of increasing livestock numbers and output". The approach they took was to "...view the producer as a portfolio manager who has at his disposal a wide range of potential assets which have considerably different characteristics and yet can be related to one another through the farm production process".

Portfolio choice models have been traditionally used by investors to determine the optimum combination of securities (Markowitz, 1959); however, Laing and Zwart argued that farmers face similar decisions. While this is no doubt true to some extent, it is also true that in practice there are important complementary relationships in investment. Thus, farmers tend to choose between a limited number of investment "packages" each involving a relatively fixed combination of new assets. With respect to land development, for example, Scott (1981) and Parker (1981) each define investment "packages" involving similar combinations of investment in land clearing, seed, fertiliser, fencing and livestock (see Chapter 4 for more detail). Also, land development and the associated increased stock carrying capacity, will lead to the need for investment in some extra plant, machinery and buildings. Laing and Zwart attempted to account for this to some extent by using the land development component of investment as the main determinant of changes
in livestock numbers.

Traditional portfolio models also account for risk in determining the optimum combination of investments, but the Laing and Zwart model does not incorporate risk.

Some results from Laing and Zwart's estimated model are reviewed below and provide useful insights into the operation of aspects of the pastoral farming system. It would appear, however, that direct use of some of their estimated relationships in a farm growth simulation model is either not justified or not feasible given, firstly, the more aggregated nature of their study and, secondly, that the relationships are often embedded in a system of equations and cannot readily be isolated.

(i) Expenditure and investment behaviour

With respect to drawings, off-farm investment, and capital investment in buildings, Laing and Zwart found that expenditure in these categories was, in some measure, stabilised around the trend in available income. In contrast, expenditure on land purchase and development, plant and machinery, and debt servicing were found to be relatively sensitive to changes in income levels. With respect to land development, these results indicated that "...a proportion of any sudden increase in available income is directed into land development expenditure. Conversely, sudden reductions will sharply restrict funds directed into land development".
The basic income effects described above can potentially be modified in the Laing and Zwart model by the effects of changing returns to investment in particular assets, and by the dynamic adjustments caused by the opening asset level variables. In practice, the effect of the return to an asset on the level of investment in that asset would appear to be low as in no case did such an explanatory variable prove to be significantly different from zero at the 5 percent level of significance, and have a logical sign.

These results are generally in line with the residual funds investment hypothesis (Campbell, 1958) which suggests that investment in agriculture is a residual after general farm expenses have been met and an allowance has been made for farm household consumption.

(ii) Livestock numbers and production.

Laing and Zwart used the land investment levels generated by the investment portfolio sub-model, together with other factors, to explain changes in livestock numbers. Other factors included livestock demographic, economic and environmental variables.

As would be expected, livestock demographic variables proved to be significant in explaining changes in sheep and cattle numbers in each age class. The influence of the economic variables was found to be complex but the predominant effect was on sheep/cattle ratios and on herd and flock composition, rather than on total stock numbers. The relative returns of lamb to prime beef were found to be important influences causing changes in the number of breeding ewes and ewe
hoggets respectively. Also change in wool prices had a strong positive effect on ewe numbers with higher wool prices altering flock composition in favour of breeding animals. Both the environmental effect (represented by a soil moisture deficit index) and capital investment in land development (lagged one year) were found to be significant factors determining sheep and cattle numbers, particularly those for breeding stock.

Following the estimation of livestock-number equations, Laing and Zwart estimated a series of equations to explain wool, mutton, lamb, prime beef, manufacturing beef and milkfat production. They found that "Apart from the livestock demographic variables which as expected are major contributors to each individual equation's significance, the most significant variables are those relating to capital intensity. In each case, increases in land capital per stock unit initiated growth in total output. Environmental constraints on pasture growth, as represented by days of soil moisture deficit, consistently reduced total production."

(iii) Elasticities

Further insight into the behaviour of the pastoral sector as a system can be gained from examining the elasticities generated using the complete Laing and Zwart model. Elasticities were estimated relating changes in various exogenous variables to changes in selected physical and financial aspects of the pastoral sector system. In addition to product prices for wool, lamb, mutton and beef, the other exogenous variables included fertiliser price, market rate of interest
Impact elasticities - Generally, the estimated impact elasticities were very low indicating that there is minimal short-run response to changes in economic conditions. For example, the elasticity of total stock units to changes in any product price did not exceed 0.02. Similarly, most categories of farm operating and investment expenditure were found to be insensitive to short-term changes in product prices. For example, the impact elasticity relating lamb price to expenditure on fertiliser and seed was 0.01, with 0.04 for repairs and maintenance, 0.05 for plant and machinery, and 0.04 for land development. These results suggest that farmers "wait and see" before responding to economic changes.

Further evidence of this behaviour is provided by the impact elasticities estimated for savings. Savings was found to be the variable most sensitive to changes in product prices. Elasticities relating change in savings to changes in wool, lamb, mutton and beef prices were 4.86, 0.69, 1.74 and 1.46 respectively.

Contrary to the findings of Woodford and Woods (1978) and the analysis conducted for this study (described below), the short-run response of livestock numbers to climatic conditions, while significant, was low (-0.02 for total stock units). This relatively low elasticity estimate may be a function of the aggregated nature of the Laing and Zwart study and the fact that the soil moisture deficit index calculated for the whole of New Zealand is likely to display less
variability than for regions or individual farms.

Long-run elasticities - In the longer run (10 years), adjustment to sheep/cattle ratios and the impact of investment, allow larger responses to occur. Laing and Zwart illustrated these responses for a 1.0 per cent increase in wool price. Such an increase led to an 11.0 per cent increase in sheep stock units but only a 0.71 per cent increase in total stock units. Fertiliser and seed, and repairs and maintenance were found to be the most income sensitive in the long-run with expenditure increasing 0.84 and 1.81 per cent respectively for a 1.0 per cent increase in wool price. Off-farm investment increased by 0.16 per cent in the short-run but was reduced by 0.72 per cent in the long-run as funds were used for on-farm investment. Of the capital investment categories, land development had by far the largest long-run elasticity, 1.38 per cent.

7.3 An Analysis of Factors Affecting North Island Hill Country Stock Numbers

The recent econometric studies reviewed above have confirmed the significant influence of climatic conditions on stock numbers in the pastoral sector. To measure the strength of this influence in North Island hill country, a soil moisture deficit-day index was derived and tested as an explanatory variable for annual changes in the stock units per hectare carried on Class 4 farms, over the period 1961/62 to 1980/81. The soil moisture index used was adapted from that published by Morgan (1981) which in turn was based on a time-series of soil moisture deficit-day values derived by Evans and Green (1981) for
counties in New Zealand over the period 1950 to 1981.

The series constructed by Evans and Green (1981) was monthly and, for each county, recorded the number of days when soil moisture was insufficient to permit pasture growth. From this data series Morgan (1981) derived June year moisture deficit indices for six districts (corresponding to Stats. Dept. Rural Districts) with significant North Island hill country farming activity i.e. North Auckland, South Auckland, Gisborne, Hawkes Bay, West Coast (N.I.) and Wairarapa. To derive these aggregated indices Morgan established a system of weights which was used to combine county data into district totals relevant to the North Island hill country farm distribution. To this end, the ratios of numbers of beef cows to total numbers of beef cattle for each country were used to determine the relative importance of beef breeding in each country. A comparison with MWBES survey results indicated that counties with a breeding/total ratio of at least 0.30 could be regarded as having significant North Island hill country farming activity within their boundaries. This criterion was used to select appropriate counties for the construction of a weighted average moisture deficit-day series for each district. The weights given to the counties in the weighted average were then determined as the total stock units in the county during the 1976/77 year relative to the total stock units in all "North Island hill country" counties in the district. As the final step in the construction of the indices Morgan transformed each series of district moisture deficit-day values into standard deviations around a ten-year moving average. These district indices are shown in Table 7.1; an abnormally dry year is shown as a positive value.
To establish an aggregate North Island hill country moisture deficit index for this study, the district indices calculated by Morgan were weighted by the district distribution of North Island hill country (Class 4) farms (as indicated in the 1980/81 MWBES survey) and combined into an average index. The weights used, together with the weighted North Island hill country average index, are shown in Table 7.1. This average soil moisture deficit-day index (SMDD), was regressed against changes in average stock units per hectare (DSU/HA) values for Class 4 for the period 1961/62 to 1980/81. The result was as follows:

\[
\text{DSU/HA} = 0.132 - 0.188 \text{SMDD} \quad R^2 = 0.25 \\
(0.074) \\
\text{D.W.} = 1.56
\]

The standard error of the SMDD coefficient (shown in brackets above) indicates that SMDD is significant at the 5 percent level.

The SMDD index, as used in the above equation, includes both positive and negative deviations around the moving average. When used to explain stocking rate variations the implication is that the impact on stock numbers of drier than average conditions will be proportional to the impact of wetter than average conditions; however, it might reasonably be expected that the relative impacts will differ. To test this hypothesis, the SMDD index was split into two series; one for all positive derivations from the mean (SMDD(+) i.e. for all drier than average years, and the other for all negative deviations from the mean (SMDD(-)) i.e. wetter than average years. Using these series separately as variables to explain changes in stock units per hectare,
### TABLE 7.1

Soil Moisture Deficit Indices for North Island Districts and North Island Hill Country (Weighted Average)*

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>57/58</td>
<td>1.00</td>
<td>-0.76</td>
<td>3.15</td>
<td>0.59</td>
<td>-1.87</td>
<td>0.56</td>
<td>-0.07</td>
</tr>
<tr>
<td>58/59</td>
<td>-1.48</td>
<td>-1.30</td>
<td>-0.29</td>
<td>-1.44</td>
<td>-0.97</td>
<td>-0.76</td>
<td>-1.12</td>
</tr>
<tr>
<td>59/60</td>
<td>1.06</td>
<td>-0.22</td>
<td>-1.34</td>
<td>-0.16</td>
<td>0.91</td>
<td>2.43</td>
<td>0.48</td>
</tr>
<tr>
<td>60/61</td>
<td>1.38</td>
<td>0.86</td>
<td>-1.48</td>
<td>-1.71</td>
<td>0.97</td>
<td>-1.47</td>
<td>-0.18</td>
</tr>
<tr>
<td>61/62</td>
<td>0.74</td>
<td>-0.05</td>
<td>0.80</td>
<td>1.03</td>
<td>0.71</td>
<td>0.55</td>
<td></td>
</tr>
<tr>
<td>62/63</td>
<td>0.26</td>
<td>-0.11</td>
<td>-0.52</td>
<td>0.59</td>
<td>0.06</td>
<td>0.51</td>
<td>0.18</td>
</tr>
<tr>
<td>63/64</td>
<td>1.80</td>
<td>0.97</td>
<td>0.52</td>
<td>2.08</td>
<td>1.52</td>
<td>1.57</td>
<td>1.46</td>
</tr>
<tr>
<td>64/65</td>
<td>-0.42</td>
<td>-0.16</td>
<td>-0.52</td>
<td>-0.05</td>
<td>-1.21</td>
<td>-0.81</td>
<td>-0.51</td>
</tr>
<tr>
<td>65/66</td>
<td>-1.96</td>
<td>-0.98</td>
<td>0.19</td>
<td>-0.27</td>
<td>-0.48</td>
<td>-0.10</td>
<td>-0.57</td>
</tr>
<tr>
<td>66/67</td>
<td>-0.42</td>
<td>-1.08</td>
<td>-1.15</td>
<td>-1.01</td>
<td>-0.85</td>
<td>-1.16</td>
<td>-0.98</td>
</tr>
<tr>
<td>67/68</td>
<td>1.38</td>
<td>0.38</td>
<td>0.81</td>
<td>1.07</td>
<td>0.91</td>
<td>0.10</td>
<td>0.71</td>
</tr>
<tr>
<td>68/69</td>
<td>-0.48</td>
<td>-0.76</td>
<td>0.43</td>
<td>0.11</td>
<td>0.12</td>
<td>0.35</td>
<td>-0.10</td>
</tr>
<tr>
<td>69/70</td>
<td>0.37</td>
<td>1.46</td>
<td>-1.34</td>
<td>-0.37</td>
<td>1.69</td>
<td>0.30</td>
<td>0.64</td>
</tr>
<tr>
<td>70/71</td>
<td>-0.05</td>
<td>-0.27</td>
<td>-0.62</td>
<td>-0.85</td>
<td>0.67</td>
<td>0.86</td>
<td>-0.03</td>
</tr>
<tr>
<td>71/72</td>
<td>0.05</td>
<td>0.22</td>
<td>-0.52</td>
<td>-1.12</td>
<td>-0.91</td>
<td>-0.71</td>
<td>-0.53</td>
</tr>
<tr>
<td>72/73</td>
<td>1.16</td>
<td>1.84</td>
<td>1.05</td>
<td>2.03</td>
<td>1.27</td>
<td>1.47</td>
<td>1.59</td>
</tr>
<tr>
<td>73/74</td>
<td>1.91</td>
<td>1.57</td>
<td>0.29</td>
<td>-0.53</td>
<td>0.67</td>
<td>0.25</td>
<td>0.65</td>
</tr>
<tr>
<td>74/75</td>
<td>0.48</td>
<td>-0.27</td>
<td>-0.76</td>
<td>-0.75</td>
<td>0.30</td>
<td>-0.30</td>
<td>-0.24</td>
</tr>
<tr>
<td>75/76</td>
<td>0.90</td>
<td>0</td>
<td>0.05</td>
<td>0.27</td>
<td>0.06</td>
<td>-1.56</td>
<td>-0.10</td>
</tr>
<tr>
<td>76/77</td>
<td>-0.69</td>
<td>0.49</td>
<td>-0.24</td>
<td>-0.37</td>
<td>-1.03</td>
<td>-0.46</td>
<td>-0.32</td>
</tr>
<tr>
<td>77/78</td>
<td>0.58</td>
<td>1.73</td>
<td>1.15</td>
<td>0.80</td>
<td>1.27</td>
<td>1.11</td>
<td>1.20</td>
</tr>
<tr>
<td>78/79</td>
<td>-0.74</td>
<td>-0.54</td>
<td>0.91</td>
<td>-0.11</td>
<td>-0.91</td>
<td>-0.46</td>
<td>-0.42</td>
</tr>
</tbody>
</table>

Weights 0.08  0.26  0.07  0.22  0.21  0.16  (1.00)

Source: District Indices; Morgan (1981)
Weights; MWBES Sheep and Beef Farm Survey, 1980/81

* Indices represent standard deviations around the ten year moving average of days of soil moisture deficit.
the following result was obtained:

\[
\text{DSU/HA} = -0.023 - 0.595 \text{SMDD(−)} - 0.010 \text{SMDD(+) (0.211)} \text{ (0.110)}
\]

\[
-2 \frac{R}{R} = 0.41
\]

D.W. = 2.22

This result indicates that negative deviations are highly significant in determining stocking rate changes while positive deviations are non-significant. Dropping the non-significant SMDD(+) from the equation gave the following result:

\[
\text{DSU/HA} = -0.029 - 0.606 \text{SMDD(−)} (0.170)
\]

\[
-2 \frac{R}{R} = 0.41
\]

D.W. = 2.24

Actual, and predicted changes in stock units per hectare based on this latter equation are shown in Figure 7.1. The fact that SMDD(−) is highly significant but SMDD(+) is non-significant suggests that farmers respond to good seasons by significantly increasing stock rate, but in poor seasons are reluctant to reduce stocking rates. Recent experience with the effects of the 1982/83 drought, which led to significant reductions in stock numbers, would suggest that this reluctance cannot be sustained in the face of extreme and prolonged adverse conditions.

In an attempt to isolate any economic influences which might further explain changes in stocking rates, two economic variables,
FIGURE 7.1
Changes in Class 4 Stock Units per Hectare
Actual and Predicted

FIGURE 7.2
Class 4 Stock Units per Hectare
Actual and Predicted
together with SMDD(-), were tested. These variables were:

(i) a variable reflecting current stock prices. This variable was included to test for short-term response to price; either a "cashing in" response where potential breeding stock are sold off when prices are high, or alternatively, an "expectation" response whereby stock are retained to take advantage of continuing high prices. The variable used in this case was the real price of PL grade lamb (RPL).

(ii) an investment proxy. Several variables were tested as investment proxies. These were lagged real gross income per hectare, lagged real cash expenditure per hectare and lagged real expenditure on fertiliser.

The equation which included lagged real gross income per hectare (LRGY/HA) as the investment proxy gave the following result.

\[
DSU/HA = -0.004 - 0.587 \text{ SMDD}(-) + 0.0008 \text{ RPL} + 0.0003 \text{ LRGY/HA} \\
(0.194) \quad (0.0042) \quad (0.0011)
\]

\[ R^2 = 0.30 \]

D.W. = 2.03

The soil moisture deficit index remained significant at the 1 per cent level but neither of the economic variables were significantly different from zero. The results remained similar regardless of the investment proxy used. Also, the testing of lagged lamb prices failed to show any significant effect.
The conclusion that can be drawn from these results and from the previously reviewed studies is that farmers respond most to climatic factors when determining annual changes in stocking rate. This response generally appears to be in the nature of a "rachet" effect and it provides a reasonable explanation for the levels of stocking rates attained on North Island hill country farms over the last 20 years. This explanatory power is illustrated when actual stocking rate (SU/HA) is regressed as a function of lagged stocking rate (LSU/HA) and SMDD(−) for the period 1962/63 to 1979/80:

\[
SU/HA = 0.819 + 0.915 \text{ LSU/HA} - 0.583 \text{ SMDD(−)}
\]

\[
R^2 = 0.92
\]

D.W. = 2.31

The coefficients of both lagged stocking rate and the negative deviations SMDD index are significant at the 1 per cent level. The overall explanatory power of the equation is high as is demonstrated in Figure 7.2 where both actual and predicted Class 4 stocking rates are shown.

A behavioural explanation for this "rachet" form of response could be that farmers wait for good seasonal conditions before increasing stocking rate to take advantage of previously developed pasture. This strategy would minimise the danger of feed shortages and minimise the need to buy in extra stock. Having achieved a new stocking level, continued investment in land development may allow that stocking rate largely to be maintained, even if poor seasons follow.
This hypothesis implies the existence of an investment response yet, with respect to economic factors tested in this study and others, there is little or no discernible short-term response to price, nor to the investment proxies. While a lack of a short-term price response is not surprising given the long-run costs of liquidating breeding stock and uncertainty about future price levels, the lack of an investment response cannot be accepted. The existence of an investment response on individual farms is obvious and Laing and Zwart (1983) found some evidence of it in their study; however, in aggregate this response has generally proved very difficult to measure. It would appear that the investment response, with its complexity caused by different forms of investment with different lags and different effects on the farm operations, defies measurement with the simple investment proxies used in this and most of the previously reviewed studies. Also, if the explanation presented above for the "ratchet" stocking rate response is correct, then climatic conditions may significantly affect the rate at which investment is manifested in increased stock carried.

7.4 Conclusions with Respect to Investment Behaviour

The apparent lack of short-term response to economic variables generally indicated by econometric studies can be rationalised by considering the nature of New Zealand pastoral farming systems. Being based predominantly on breeding flocks and herds which utilise pasture as the feed source, New Zealand pastoral farming systems are severely constrained with respect to the rate and the extent to which they can respond to economic variables, particularly in the short-term.
While in the short-term a rapid decrease in stock numbers is possible through liquidating breeding stock, knowledge of the time and cost of restocking or increasing stock numbers is likely to dampen this form of short-run response. Also, feed availability is likely to limit the extent to which increases in stock numbers are possible without further capital expenditure on land development. Changing stocking rate, given a particular state of farm development, does not appear to be a commonly applied management strategy in pastoral farming. Rather, farmers may perceive a particular level of per head performance and risk as being acceptable and set stock levels to avoid violating this standard. Under such a management system, "long-run" stocking levels are not likely to increase significantly until the capacity of the farm to produce feed and handle stock is similarly increased.

It can be argued that such a conservative stocking policy is rational given the significant potential management and financial penalties associated with overstocking; animal growth rates and reproductive performance can be adversely affected, while mortality and disease levels may increase. These effects are indicative of other general management difficulties likely to arise. Associated with these stocking rate effects is the increased risk of significant physical and financial difficulty in poor seasons. Also, overstocking can lead to deterioration in pasture quality and condition.

If farmers are unwilling to increase "long-run" stock numbers until feed production is similarly increased, then the availability of funds to undertake development may further dampen and delay response.
From this review of studies of the New Zealand pastoral sector, and consideration of the nature of the farming systems in that sector, a behavioural hypothesis can be deduced to explain the nature of changes in stock unit numbers on farms. It is hypothesised that:

(i) Farmers perceive a long-term target state of development and associated carrying capacity for their farms.

(ii) Farmers also perceive a current state of development and associated inherent carrying capacity of the farm. This carrying capacity is directly related to the capacity of the farm to grow and utilise feed and can be regarded as the permanent component of stocking rate.

(iii) Increases in the permanent or potential carrying capacity of the farm toward the long-term target depend on investment, particularly investment in land improvement. Such investment takes place largely out of residual funds which remain from high income years after other operating, debt servicing and consumption expenditure has been undertaken. Investment funds may initially be retained as savings or liquid reserves.

(iv) The rate at which stock numbers are increased to utilise newly developed pasture is dependent on climatic conditions. Also, there is a transitory component to annual stocking rate which is also as a function of climatic conditions.
7.5 Modelling Investment and Disinvestment in a North Island Hill Country Farm Growth Model

7.5.1 Funds available for investment.

The support found in past studies of the pastoral sector (reviewed above) for the residual funds hypothesis, and the lack of significant levels of long-term off-farm investment, would appear to justify a residual funds approach to estimating the funds available for investment. This approach can be handled satisfactorily in a simulation framework whereby, in each simulated year, estimated operating expenses, consumption expenditure, debt servicing costs and taxation can be determined, and deducted from gross income. The remaining funds can be regarded as being available for savings or investment. Investment funds would be augmented by a proportion of borrowed funds.

With respect to savings, the systems analysis in this and the previous Chapter indicated that a proportion of savings contributes to the maintenance of liquid reserves. These reserves are utilised to help maintain farm consumption and expenditure in poor years, and are replenished in high income years. For modelling purposes, this behaviour can be represented by assuming that the "representative farmer" seeks to maintain liquid reserves at some desired level. Residual funds will be saved until this desired level is achieved, then further residual funds will be available for investment.
The question of disinvestment must also be considered. As with investment, evidence of the impact of disinvestment in the pastoral sector as a whole is difficult to find using econometric techniques. Nevertheless, disinvestment or deferred maintenance expenditure, particularly in the form of reduced fertiliser applications, is known to occur when economic conditions are difficult. This is in-line with the observation (Chapter 6) that off-farm borrowing was not a strategy generally employed to off-set the effects of reduced income; rather, farmers tend to use liquid reserves and reduce discretionary expenditure.

Thus, if it is assumed that significant disinvestment will only occur when liquid reserves are reduced to some critically low level, then a procedure for modelling the extent of disinvestment in any year can be established. The level of disinvestment will be equal to the short-fall in income required to meet consumption and necessary farm expenditure, after allowing for the use of liquid reserves. This short-fall will be met by diverting funds from expenditure required to maintain the capital asset; expenditure such as maintenance fertiliser applications.

A feature of North Island hill country is the limited range of investment alternatives that exist. Pastoral farming of the type practiced in hill country uses only limited amounts of machinery and
buildings. By far the most important type of investment on the farm is land improvement - that is, the upgrading of the land resource to improve its productive capacity. It is this type of investment that is reflected most directly in increased stock carrying capacity and farm growth. Also, it seems likely that it is this type of investment that prompts a large proportion of investment in other assets such as machinery and buildings.

As mentioned in Chapter 4, hill country land-improvement options tend to be categorised by extension officers and researchers such as Parker (1981) and Scott (1981), into two distinct alternatives; land development, and land intensification.

(i) Land development investment - this involves new land being bought into production. The costs usually include scrub clearing, capital and maintenance fertiliser applications, oversowing with pasture seed, fencing and the building of access tracks. Also livestock must be retained (or bought-in) to stock the newly established pasture. The benefits of such investment can be measured in terms of increased carrying capacity; typically, carrying capacity on newly developed land can be increased from zero to 10 stock units per hectare in 4 years.

(ii) Intensification - this involves investment to improve the productive capacity of land already in production. Compared with land development costs, intensification costs tend to be low, and include such items as further subdivision, capital and maintenance fertiliser and oversowing. Stocking rate increases, typical of such
intensification, are in the range of 2 to 3 stock units per hectare.

Within each category of land-improvement investment there will be a range of cost and benefit "time-profiles" depending on the type of land involved and the associated costs of clearing, oversowing, fencing, etc. To represent these forms of investment, an appropriate cost and benefit time-profile can be established on a per hectare basis. Within the simulation model framework, as funds become available, land improvement can be undertaken with the resulting costs and benefits spread over time.

While land improvement is the major type of on-farm investment on hill country farms, it also provides an important opportunity for disinvestment. This takes the form of suspended or reduced maintenance fertiliser applications on improved pasture land. Farmers use this form of disinvestment when expenditure reductions are necessary, because pasture production only falls gradually (at least initially) when maintenance fertiliser applications are reduced or even withheld completely. As Quin (1982) points out ..."The accumulated store of fertility can be employed for short periods as an "income equalisation reserve", permitting reduced spending on fertiliser in seasons when input-output price ratios rise sharply or at times when natural events such as droughts cause major cash flow problems".

However, maintenance fertiliser applications can only be reduced for a short period before production effects become apparent. This is particularly true on many hill country farms where there is not a high residual soil-nutrient carry-over. Thus, to model the effects of
disinvestment of this type, a time profile of the costs and savings from reduced fertiliser application is required. Such a cost-benefit profile for a typical hill country farm was estimated by Quin (1982), who calculated the effect over time of reduced fertiliser applications on the stock carrying capacity of the farm. Using a profile of this type can allow the impact of deferred maintenance to be represented with the appropriate delays on the stocking rate effects. Also, in the event of increased income becoming available, "catch-up" fertiliser applications can be allowed for to minimise the long-run production effects.

7.5.4 Selecting between investment alternatives.

The limited range of on-farm investment options available on North Island hill country farms, and, in the case of alternative land improvement investments, the similar nature of those forms of investment, would appear to render unnecessary the use of relative complex investment-selection algorithms such as those used in the farm growth models reviewed in Chapter 3. Instead, a relatively simple priority procedure was assumed to be adequate. In this procedure one or more areas on the simulated farm are specified as having land improvement potential. For each area a profile of the costs and (stocking rate) benefits is estimated and a priority order for development established, perhaps based on the likely economic return measured by NPV or IRR. If the model is to represent a group of farms, or perhaps the North Island hill country farming sector as a whole, then a representative land improvement profile is established to account for the fact that a range of forms of land improvement will be
undertaken on different farms at the same time.

The system analysis conducted in this and the other Chapters in Part II of this study provided the basis for modelling the North Island hill country farming system. A complete description of the model, including more detail on the investment procedures, is provided in the next Chapter; this is followed by a description of validation procedures and sensitivity analysis in Chapters 9 and 10, respectively.
PART III

SYSTEM SYNTHESIS AND MODEL EVALUATION

CHAPTER 8 MODEL DESCRIPTION

8.1 Introduction
8.2 Model Overview
8.3 Production Components of the Model
8.4 Financial Components of the Model
8.5 Model Programming and Verification

CHAPTER 9 VALIDATION

9.1 Introduction
9.2 Validation Tests
9.3 Data Used for Validation
9.4 Validation Results
9.5 Conclusion

CHAPTER 10 SENSITIVITY ANALYSIS

10.1 Introduction
10.2 Approach to Sensitivity Analysis
10.3 Sensitivity Analysis Results
10.4 Conclusions
CHAPTER 8

MODEL DESCRIPTION

8.1 Introduction

Based on the analysis of the farming system described in Chapters 4 to 7, a simulation model was developed to simulate the physical and financial operation of a North Island hill country representative farm over an extended time horizon, up to 20 years.

The model is a skeleton type model with a modular structure. The "skeletal" nature of the model means that all major model parameters and, where possible, decision-rule variables, are input by the model user as data. This provides the model user with flexibility to manipulate and experiment with the model without being unduly constrained by inbuilt assumptions (Dent and Blackie, 1979). Nevertheless, it would be impossible to build a model without some structural assumptions and inbuilt decision rules. To allow a model user to modify these if required with a minimum of model redesign, a modular structure was used. All major components of the system were modelled as distinct modules and programmed using separate sub-routines (or sets of sub-routines).

In this Chapter the model as constructed is described. In the first part of this description an overview of the model structure is provided together with a description of data requirements and an outline of the model's operation. In the second part a more detailed description of the main model components is presented.
8.2 Model Overview

8.2.1 Production, income and costs.

A schematic diagram showing the main linkages and interactions between model components is presented in Figure 8.1. The model incorporates a sheep flock sub-model and a beef herd sub-model both of which represent self-replacing stock breeding activities. Each year they generate farm production in the form of sheep, lambs, wool, and store and fat cattle. Annual production is a function of the current flock and herd composition and a range of production parameters. Flock and herd composition is updated each year based on specified mortality and culling rates which, together with production parameters such as lambing and calving rates, and wool weights, are assumed to vary primarily as functions of seasonal conditions. Two versions of the model were developed, one stochastic and one deterministic. In the stochastic version the seasonal variability of these production parameters and culling rates is represented by randomly selecting values from specified probability distributions. In the deterministic version actual parameter values are specified for each simulated year.

Once total production for a given year is generated, it is valued to give gross revenue using farm-gate prices for each class of stock and for wool. Depending on the model version, these prices are either stochastically generated based on specified probability distributions, or are specified for each year of the simulation.
The Farm Firm System as Modelled

Seasonal Conditions

Production (Flock/Herd)

Capital Base (Stock Carrying Capacity)

Development Maintenance Costs

Investment (Residual)

Liquid Reserves

Disinvestment (reduced maintenance expenditure)

Extended Overdraft

Long-Term Borrowing

Revenue

Operating Expenditure

Consumption

Tax

Debt Servicing

Flow of funds

Direction of influence
Fixed and variable costs including depreciation, tax payable, debt servicing commitments and consumption requirements are then calculated and deducted from gross revenue to give a net operating surplus or deficit. Funds may also be borrowed at this point, depending on the outcome of a borrowing decision rule, to augment a surplus or, in some cases, to offset a deficit. Other methods of off-setting a deficit, however, are assumed to have higher priority than borrowing. These involve firstly utilising liquid reserves and then deferring maintenance (including fertiliser maintenance applications). If available liquid assets are exhausted and farm maintenance has been deferred to the extent of a specified maximum level, allowance is made for an increase in overdraft to occur. If a critical overdraft level is exceeded for two years then this is interpreted as "hard-core" debt and the overdraft is refinanced into the form of a mortgage with associated regular principal and interest payments in future years.

Given the availability of surplus funds, augmented in some years by borrowing, a priority schedule is assumed for its disposition. If an overdraft has been carried over from the previous year this is repaid by the current surplus. Any farm and fertiliser maintenance deferred in previous years is then compensated for by expenditure on additional maintenance and fertiliser applications. If funds remain after satisfying these priorities, then the liquid reserve fund is replenished to a specified target level. A specified proportion of funds remaining after this is available for new investment on the farm.
8.2.2 Adjusting stock numbers.

Each investment alternative is represented in the model by a time profile of annual costs and associated increases in stock carrying capacity. The type of investment carried out in any year depends on a pre-specified development priority schedule. Development of the top priority type continues until the capacity for that type of investment is exhausted; investment of the second priority type then begins. If the potential for profitable on-farm investment is exhausted, surplus funds are added to liquid reserves. Once some development is initiated it is assumed that the future cost of the development programme, together with any related maintenance requirements, will be met. The resulting cost commitment becomes part of future farm costs. Allowance is made for the tax deductibility of development expenditure as appropriate.

The profiles of annual increases in stock carrying capacity associated with each successive increment of development are accumulated and each year the potential carrying capacity of the farm is increased by the appropriate accumulated value.

The potential carrying capacity of the farm may also be reduced by the effects of deferred fertiliser and general maintenance. The extent of this effect is based on the estimates provided by Quin (1982) and depends on the area and duration of reduced fertiliser application. If reduced maintenance is subsequently offset by compensating increases in fertiliser applications and general maintenance expenditure, the stocking rate effects are also offset.
Farm development increases potential stock carrying capacity, but this may not be reflected immediately in increases in actual stock numbers carried. The rate at which actual stock numbers are increased depends on prevailing seasonal conditions and associated culling rates. In accordance with the "ratchet effect" observed with respect to changes in stock numbers and described in Chapter 7, culling rates in the model are increased in poor seasons but reduced more than proportionately in good seasons, thus tending to lead to increased stock numbers over time. Reductions in culling rates, however, will only occur to the extent that the resulting increase in stock numbers does not exceed the farm's potential stock carrying capacity. Similarly, if the potential carrying capacity of the farm is reduced by reduced fertiliser applications, then, if necessary, the seasonally determined culling rate is overridden to ensure that actual stocking levels are reduced to match the reduced potential farm stock carrying capacity.

8.2.3 Model operation.

For each year of the simulated operation of the farm, the major physical and financial variables are monitored. These include actual and potential stock carried, gross and net income, tax and debt servicing commitments, consumption, operating surplus, financial reserves and overdraft levels, investment levels, net worth and equity ratio.

For the stochastic version of the model the simulated operation of the farm is replicated a number of times so that the simulated farm
encounters a range of randomly generated price and production sequences. Results from the replicated simulations provide the basis for estimating probability distributions of the major model responses, thus providing a measure of the uncertainty involved in projections of the future.

By modifying any one or more of the numerous variables in the model which could be influenced by government policy, such as input and output prices, terms for finance, taxation provisions etc., alternative policy formulations can be represented and the resulting pattern of farm production and growth simulated.

8.3 Production Components of the Model

The analysis of the North Island hill country farming system (Chapter 4) revealed a strong predominance of stock breeding activities in this type of country. Consequently, the two production sub-models incorporated in the model represent self-replacing sheep and cattle breeding activities.

8.3.1 Flock and herd sub-models

Initial flock and herd composition is determined in the model by a "boot-strapping" procedure. Given, for both sheep and cattle, initial stock units and certain assumed demographic parameters such as mortality rates, typical culling rates for young and old stock, ram and bull rates, and the age at which stock are culled for age, a complete flock and herd structure is determined. To do this each class of stock
is given a standard stock unit value (see Lincoln College, 1983) and it is assumed that the initial flock and herd structures are dynamically stable, i.e. over time stock losses through mortality and culling would be just offset by young replacements, thus leaving total stock units constant. The advantage of this approach to establishing the initial flock and herd composition is that it minimises the need to input detailed flock and herd information.

The subsequent operations of the sheep and beef sub-models are basically similar so they are described here together. Where necessary, specific differences are noted. Total progeny produced by the flock or herd is determined each year by applying a seasonal lambing or calving rate to all female breeding stock. (The method of generation of lambing and calving rates and other production parameters is described below.) The number of ewe lambs or heifer calves needed as replacements is then determined based on average culling and mortality rates for breeding stock. To allow for some selection of replacements a maximum proportion of ewe lambs or heifer calves that can be retained as replacements can be specified. If replacement stock is required in excess of the specified maximum then two-tooth ewes or two-year old heifers are bought in to make up the difference.

Lambs other than replacements are sold in either fat or store condition, the proportions of each being determined each year, either stochastically or deterministically, to reflect seasonal conditions. With respect to the calves not needed as replacements, a specified proportion are sold while the remainder are retained for fattening to be sold as fat steers.
After progeny and replacement numbers have been determined, flock and herd composition is then updated using mortality rates and seasonally adjusted culling rates. These culling rates vary slightly from the expected culling rate to reflect the effect of seasonal conditions. In the deterministic version, this seasonal deviation from the average culling rate is specified for each year, while in the stochastic version the deviation is randomly determined from a specified probability distribution. Based on the observations of the impact of climatic conditions on stock numbers described in Chapter 7, the deviations from the average or equilibrium culling rate (i.e. the culling rate that would lead to constant stock numbers) are negatively skewed such that reductions in culling rate (leading to increases in stock numbers) are greater in size, although equal in frequency, relative to increases in culling rate. This mechanism reproduces the behaviour observed with respect to stocking rate changes whereby good seasonal conditions tend to correspond with significant increases in stock numbers, while poor seasonal conditions lead to relatively smaller reductions in stock numbers.

The extent of increases in actual stock numbers, however, is constrained by the farm's potential stock carrying capacity which is determined by land development investment or disinvestment. If the seasonally adjusted culling rates would lead to actual stock numbers exceeding potential carrying capacity then revised culling rates are calculated to make actual and potential stock numbers equal.

After allowing for appropriate changes to flock and herd composition, the final details of stock sales and purchases and wool
production are determined. Sheep sales include fat and store lambs, culled hoggets, mixed-age ewes and rams, and culled-for-age ewes. Sheep purchases will include some ram replacements and possibly some two-tooth ewes for replacements. Total wool cut is calculated by multiplying sheep numbers by the average wool weight per head, which is stochastically generated or specified for the year. Cattle sales involve sales of store calves, fat steers and culled bulls and mixed-age cows. Purchases include some bull replacements and possibly some two-year old cows for replacements.

8.3.2 Production parameters

The main production parameters used in the model are calving and lambing percentages, the proportion of lambs sold fat, and wool weights. Although, strictly speaking, not a production parameter, the deviation of the seasonally adjusted culling rate is also dealt with in this section. It is assumed in the model that, with the exception of culling rates, all these main production parameters are exogenously determined. (As described above, culling rates are generally exogenously determined but can be modified in the light of endogenous factors.) The implication of this assumption is that there is no significant interaction between stocking rate and per head animal production levels. While this is a simplifying assumption it appears justified on the basis of observations presented in Chapters 4 and 7 which indicated that hill country stocking rates tend to be conservative and that per head production levels are strongly climate related.
In the deterministic version of the model, a value for each of the production parameters is specified as an input for each simulated year. These values may be based on historical, subjective, or hypothetical data depending on the nature of the simulation experiment.

In the stochastic version of the model, parameter values are generated from triangular probability distributions. This type of distribution is simple to describe and has been widely used in simulation modelling as a convenient method of representing unimodal, non-normal continuous distributions (Sprow, 1967; Pouliguen, 1970; Cassidy, Rodgers and McCarthy, 1970; Beck, Harrison and Johnston, 1982). A triangular distribution is completely defined by just the mode, the lowest possible value, and highest possible value. For the purposes of modelling the system at hand it was regarded as being a satisfactory method of summarising the variation in production parameters. The actual specification of the triangular probability distribution parameters will be discussed further when the model is applied; however, in general these parameters can be based on historical observations, subjective elicitation or other real or hypothetical values.

Values are sampled from the triangular distributions using the inverse CDF (Cumulative Density Function) transformation method (Meier, Newell and Pazer, 1969) in which a uniform random variate (between 0 and 1) on the cumulative probability scale is projected through the CDF to the scale of the specified random variable. Using the computer's intrinsic uniform pseudo-random number generator, a new uniform random variate is generated for each year and provides the basis for seasonal
variability. Lamb fat rates, wool weights and ewe and cow culling rate adjustments are all assumed, primarily, to be functions of the current (June) year's seasonal conditions. Consequently, the current year's uniform random variate is used to sample from these distributions. Lambing and calving rates, however, being heavily influenced by seasonal conditions at mating, are sampled using the previous year's uniform random variate.

8.4 Financial Components of the Model

Before describing the financial components of the model, a comment on the handling of inflation is necessary; because of the likely importance of inflation in affecting farm financial decision making, the effect of inflation on farm costs and prices is handled directly in the model. A nominated price inflation rate is specified for each year of the simulated operation of the farm and is directly applied to all real product prices after they are randomly generated. This inflation rate is also applied to all costs in the model, but with the addition of an optional "cost surcharge". This "cost surcharge" takes the form of a specified percentage by which cost inflation is assumed to exceed price inflation, and allows a "cost-price squeeze" situation to be simulated. All subsequent calculations in the model are carried out in nominal dollar terms but results are usually converted back to real terms for reporting purposes.
8.4.1 Valuing production - gross revenue.

Prices for each class of stock and wool vary in the model from year to year. In the deterministic version actual prices are specified for each year, while in the stochastic version they are randomly determined. As with the generation of random seasonal production parameters described above, a series of triangular probability distributions are used in the stochastic version. For wool price, a single probability distribution is used, while for sheep, price distributions are used for store and fat lambs, mixed-age cull ewes, five-year old cull ewes, two-tooth ewe replacements and rams bought and sold. For cattle, price distributions are used for weaner steers and heifers, fat two-year old steers, cull cows, replacement heifers and bulls bought and sold. Once prices for each class of stock and wool are established, gross revenue from sheep, beef and wool is calculated. Gross revenue in this context is taken as net of any stock purchases for replacements.

In some situations price correlations may be significant and important; there is likely to be correlation between the prices of different classes of livestock, and serial correlation of prices over time. Depending on the nature of the correlations, alternative procedures can be used. If certain prices are highly correlated then this relationship can be approximated by sampling the respective price distributions with the same pseudo-random number; where no significant correlation exists, different (independent) random numbers can be used. If it is considered necessary to represent intermediate degrees of correlation then procedures similar to that described by Mihram (1972)
can be adopted.

8.4.2 Cost accounting.

Total cash expenditure is calculated by bringing together costs generated in various parts of the model. A standing or fixed cost value covering such items as insurance, rates and general administration and maintenance expenses is read in as data and is assumed to remain constant (in real terms) over the course of the simulation. Variable costs are assumed to be a function of gross revenue. In addition, values are calculated (in other components of the model described below) for development costs, loan interest and principal repayments, taxation costs, and the cost-saving effects of deferred maintenance and fertiliser applications.

8.4.3 Taxation.

Total cash expenditure is adjusted to give tax deductible expenditure by subtracting loan principal repayments and adding values for depreciation and "other deductions". These latter two items are read in as data and are assumed to remain constant in real terms over the course of the simulation. Unless specifically modified for experimental purposes, development expenditure is regarded as tax deductible in accordance with current taxation provisions.

Taxable income is then derived by subtracting tax deductible expenses from gross income. Again, unless otherwise modified for experimental purposes, stock purchases accounted for in the derivation
of gross income are regarded as having "nil" standard value for tax purposes. Accordingly the full value of stock sold is taxable.

Two alternative procedures for calculating tax payable were developed, one suited to ex ante studies and representative farming situations, and the other more appropriate for ex post studies and simulations using average farm data. The choice of method is made using a switch variable when the model is run. They are described below:

(a) **Tax schedule method**

The tax schedule method involves the use of a typical tax schedule of income increments and corresponding marginal tax rates; both the income increments and tax rates are read-in as data. Unless otherwise modified, the increments are adjusted for inflation to remove the effect of "fiscal drag". Tax payable is calculated by applying the appropriate scheduled tax rates to the estimated taxable income. (If it is assumed that the modelled farm is a partnership, taxable income is halved before the tax schedule is applied. The resulting tax payable is then doubled.) The tax calculated using this method is assumed to be paid in the following simulated year in order to account, albeit simplistically, for the delays involved in the provisional and terminal tax payment system. The advantage of this procedure, particularly for ex ante representative farm studies, is that the effects of a particular tax schedule can be explored, including the effect of a progressive tax structure in a fluctuating income situation. If, however, the model is used with average farm data in an ex post or historical context, then a specific tax schedule has little
meaning. Consequently, an alternative procedure was developed to handle an empirical tax function.

(b) **Empirical Tax Function Method**

With the tax function method, tax paid each year is calculated as a function of current and lagged taxable income and, if necessary, other factors. Function parameters would usually be based on a regression equation, such as that estimated in Chapter 4 with North Island hill country average farm data, but could be hypothetical for the sake of experimentation. The advantage of this method in an ex post simulation is that the complex effects of inflation and historical changes in tax regulations, together with farmer tax-paying behaviour, can be effectively summarised in a relatively simple function.

8.4.4 **Consumption function.**

In Chapter 5 a variety of consumption functions were hypothesised and their validity tested in the context of a North Island hill country farming situation. Although it was found that a number of these functions might provide a satisfactory representation of consumption behaviour, the following form of function was chosen as the model standard:

\[ C_t = a + bY_t + cC_{t-1} \]

where: \( C_t \) is the value of farm consumption in year \( t \); and

\( Y_t \) is cash income remaining after farm expenditure, debt and tax commitments have been met.
This form of consumption function was chosen, not only because it appeared to have both some theoretical and empirical validity, but also because, if required, it provides considerable flexibility for experimentation. The function coefficients are read-in as data and can readily be modified if necessary.

The nature of this consumption function is such that consumption may exceed the available revenue. This situation can occur when income drops and particularly when current consumption is still significantly influenced by the previous year's higher income through the lagged term $C_{t-1}$. Procedures to handle this deficit situation are described in Section 8.4.6 below. First, however, the procedure for simulating borrowing behaviour is described.

8.4.5 Borrowing decision rules for long-term loans.

The exploration of long-term borrowing behaviour described in Chapter 6 revealed several features of borrowing behaviour which were incorporated into borrowing decision-rules in the model. The main features are as follows:

(1) Inflation, through its influence on capital values and equity, plays an important role in maintaining and increasing a farmer's capacity to borrow.

(2) Most farmers actively borrow but, on average, they do not fully exploit their borrowing potential as indicated by their increasing equity capital levels.

(3) The level of new borrowing tends to be influenced by income levels
in the recent past, but not significantly by the level of interest rates.

(4) The rationing of borrowed funds is primarily internal rather than external.

(5) Major borrowing events for individual farms tend to occur periodically.

In the model the decision to borrow is assumed to be made at regular, specified intervals. (If an average farm is being simulated, annual borrowing can be assumed.) When a borrowing event is scheduled, a value is calculated representing the annual amount the farmer is prepared to commit to new interest and principal repayments. This value is a specified proportion of the pre-tax, post-consumption surplus accumulated over the period since the last borrowing event. The proportion can be regarded as a measure of the farmer's attitude to borrowing and the risk he is prepared to take with respect to his level of debt.

Using the calculated amount the farmer is prepared to commit to additional debt servicing as the instalment available to amortise a mortgage, the amount that can be borrowed is determined. The loan is assumed to be in the form of a table mortgage with regular and equal instalments; the length of term and prevailing interest rate are read-in as data for each simulated year. An equity limit check is then applied; the equity ratio of the farm, with the new loan included, is calculated to ensure that it does not fall below a specified minimum level. If the minimum equity ratio limit is violated then the amount of the new loan is reduced so that actual equity just equals the
minimum. Once the amount borrowed is finalised, a complete interest and principal repayment schedule is calculated to establish future debt servicing requirements. With each successive loan, new debt servicing requirements are accumulated with those from previous borrowing events to give total debt servicing costs.

In addition to loans which arise through the process described above, long-term loans may occur in the model in two other ways. Firstly, provision is made for a level of long-term debt to exist at the beginning of the simulated period. This debt is represented by a single table mortgage of a specified amount, interest rate and term, taken out some specified number of years prior to the commencement of the simulation period. The principal outstanding from this loan at the commencement of the simulation period is calculated, together with the interest and principal repayment schedules for the remainder of the loan term.

The other long-term borrowing situation occurs when overdraft borrowing becomes "hard core" debt and refinancing occurs. The circumstances of this occurrence are described in more detail below but at this stage it suffices to note that when necessary a table mortgage for the amount of the hard core debt is taken out using the specified interest rate and loan term conditions for that year.

Funds borrowed in a particular year (excluding those used for refinancing), together with funds remaining from income, are available for investment or other purposes as described below in Section 8.4.9.
8.4.6 Use of reserve funds.

As mentioned in Section 8.4.4 above, a deficit vis-a-vis the year's cash revenue may occur after payments for farm expenses, taxation, consumption and debt servicing commitments. In the model the first recourse for off-setting such a deficit is assumed to be accumulated liquid reserves. This assumption is based on the findings described in Chapter 6 which indicated the importance of liquid reserves as a prime source of funds to stabilise the financial operation of the farm.

At the commencement of the simulation run, values are given as data for, (i) an assumed target level for reserve funds, (ii) an assumed minimum acceptable reserve level, and (iii) an initial starting level for the funds. In the event of a deficit, reserve funds are used until the minimum level is reached. Recourse is then taken, firstly to deferring farm maintenance, including fertiliser maintenance applications, and ultimately to increasing the overdraft.

In the event of a cash surplus occurring after farm expenses, taxation, consumption and debt servicing commitments have been met, priority is given, firstly to repaying any extended overdraft, and then to paying for additional farm maintenance and fertiliser applications to off-set any previously deferred expenditure. If surplus funds still remain, any deficit in the liquid reserve fund is made up. The target level for reserves is adjusted for inflation and remains constant in real terms. A proportion of funds remaining after the reserve target is reached are available for investment. In Figure 8.2 the priorities
FIGURE 8.2
Linkages between Income and Investment

Priorities for allocating a cash surplus
Priorities for offsetting a cash deficit
for allocating a surplus of funds or offsetting a deficit are shown.

8.4.7 Deferring repairs, maintenance and fertiliser applications.

Several authors (Laing and Zwart, 1983; MWBES, 1982a, for example) have noted the sensitivity of expenditure on repairs, maintenance and fertiliser to changes in income. In the model, deferring expenditure on these items is regarded as the "second line of defence" used by farmers to offset an annual cash deficit. In order to model the production effects of such deferment it is assumed that normal maintenance expenditure on a part of the farm is reduced by 50 per cent. The size of the area affected by deferred expenditure in a particular year depends on the size of the deficit and is calculated using a specified annual maintenance cost per hectare figure. Conceptually, a proportion of this maintenance cost figure can be regarded as the cost of fertiliser maintenance with the balance being general farm repairs and maintenance. If necessary the value of deferred maintenance expenditure can accumulate to a predetermined maximum level.

With each year of deferred expenditure, a schedule is maintained of the areas involved and the period of deferment. Based on these areas and periods, an impact on the farm's potential carrying capacity is calculated. In order to maintain the schedule some simple rules were established. If deferred maintenance is necessary in a particular year, and an area of land is currently in a deferred-maintenance state, then maintenance on that land or part of it will be deferred again to provide the required cost saving. If the required cost saving cannot
be met fully in this way, or if no land is currently in a "deferred" state, then maintenance is deferred on another area of the farm. If deferred maintenance is necessary, and a number of areas of the farm are in various "states of maintenance deficit" (i.e. maintenance deferred 1, 2, 3 or more times), then further maintenance will be deferred on the "most deficit" area. The rationale for this procedure is based on the findings by Quin (1982) that there is a diminishing marginal loss of stock carrying capacity with each successive deferment of fertiliser applications. Thus the adverse effects of deferred fertiliser maintenance are minimised if it is limited to as small an area of land as possible.

In some simulated years, as in reality, funds may be available for normal maintenance work and fertiliser applications, but not for additional "catch-up" expenditure. In this situation all areas with deficit maintenance status are assumed to receive normal maintenance, thus not altering their deficit status. In other years additional funds may be available to catch up all or some deferred maintenance. If this occurs then additional maintenance, equivalent to a normal year's expenditure (adjusted for inflation) is applied to all deficit areas, starting with the most deficit area. If funds still remain then further maintenance is applied until the available funds are exhausted or all deferred maintenance has been "caught up".

Each year the deferred maintenance situation resulting from these changes is recorded in the schedule in terms of the area on the farm with a given maintenance deficit status. For example, 50 hectares with one reduced maintenance application, 90 hectares with two reduced
applications, 70 hectares with three reduced applications and so on. The impact (positive or negative) on potential stock carrying capacity is calculated by monitoring the changes in these areas each year.

A change in the area with a particular deficit status will result in a change in potential carrying capacity. The assumed carrying capacity change is based on figures published by Quin (1982) who estimated the carrying capacity effects of reducing fertiliser maintenance dressings in North Island hill country. The assumed stocking capacity effects associated with given degrees of reduced fertiliser maintenance are presented in Table 8.1. The change in potential farm carrying capacity, associated with a change in the farm's maintenance deficit situation in a particular year, is used to adjust the farm's actual stock numbers in the following year in the way described earlier in Section 8.3.1.

8.4.8 Overdraft Provisions.

The study of the use of short-term credit described in Chapter 6 revealed that, on average, short-term credit was not used by farmers as a primary means of stabilising farm income expenditure. There was, however, some evidence that the level of short-term credit increased when liquid reserves were low. This finding was consistent with the observation made by Johnson (1981) that short-term credit may be extended for some farmers in times of low income, not through choice, but through an inability to repay seasonal finance commitments. This extended credit tends to be tolerated by financial institutions, typically stock firms and trading banks, in the expectation of
TABLE 8.1
The Stock Carrying Capacity Effect of
Reduced Fertiliser Maintenance

<table>
<thead>
<tr>
<th>Years of Reduced Maintenance Fert.</th>
<th>50% Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>-1</td>
</tr>
<tr>
<td>3</td>
<td>-1</td>
</tr>
<tr>
<td>4</td>
<td>-2</td>
</tr>
<tr>
<td>5</td>
<td>-2</td>
</tr>
<tr>
<td>6</td>
<td>-2</td>
</tr>
<tr>
<td>7</td>
<td>-2</td>
</tr>
<tr>
<td>8</td>
<td>-3</td>
</tr>
<tr>
<td>9</td>
<td>-3</td>
</tr>
<tr>
<td>10</td>
<td>-3</td>
</tr>
<tr>
<td>11</td>
<td>-3</td>
</tr>
<tr>
<td>12</td>
<td>-3</td>
</tr>
<tr>
<td>13</td>
<td>-4</td>
</tr>
<tr>
<td>14</td>
<td>-4</td>
</tr>
<tr>
<td>15</td>
<td>-4</td>
</tr>
<tr>
<td>16</td>
<td>-4</td>
</tr>
<tr>
<td>17</td>
<td>-4</td>
</tr>
<tr>
<td>18</td>
<td>-4</td>
</tr>
<tr>
<td>19</td>
<td>-4</td>
</tr>
<tr>
<td>20</td>
<td>-4</td>
</tr>
</tbody>
</table>

Source: Quin (1982)

repayment as soon as possible. If the short-term debt is not repaid within two or three seasons, however, refinancing is likely to be necessary to secure the debt and regularise repayment (D. Newman, Lincoln College, pers. comm.).

Although, as indicated by the analysis in Chapter 6, this situation does not appear to have been a common occurrence in North Island hill country farming in the last ten years, it probably represents a typical scenario for farms in financial difficulty. As a
"last resort", therefore, after depleting liquid reserves and reaching the deferred maintenance limit, provision is made in the model for extending the use of short-term credit. This provision, as modelled, does not include the typical seasonal financing role of an overdraft where the overdraft is effectively reduced to zero at some time during the farming year. Rather, it allows for a situation where, in order to offset a cash deficit, a significant overdraft is carried over into the next season. In the model, the repayment of this debt is given top priority if surplus funds are available; however, if repayment is not possible, and the overdraft has exceeded a certain designated upper limit for two consecutive years, then refinancing is carried out. The short-term debt is converted to a table mortgage as described in the section on borrowing above (Section 8.4.5).

8.4.9 Investment.

The situation that occurs when there is a cash surplus (from income and borrowing) after normal farm expenditure, taxation, debt servicing and consumption can be summarised as follows (see also Figure 8.2): To the extent possible, any outstanding short-term debt is repaid, any deferred maintenance is carried out, and any short-fall in the liquid reserve funds is replenished. In the spirit of the residual funds hypothesis, if funds remain after these priority requirements have been satisfied, a proportion of them is available for investment.

As discussed in Chapter 7, there is a limited range of on-farm investment alternatives available to North Island hill country farmer, with the options usually dominated by land improvement programmes. It
...be argued that other forms of investment (in buildings, plant and machinery, etc) are ultimately linked to the level of investment in land. This limited range of on-farm investment options would appear to justify a relatively simple investment algorithm based on a system of land investment priorities. In line with this approach, it is primarily the costs and benefits of land improvement investment which are explicitly represented in the model; however, to account for other components of investment, a specified proportion of investment funds available are assumed to be spent on plant, machinery and buildings, etc. This expenditure does not have a direct effect on farm stock carrying capacity, but it does add to the capital valuation of the farm (see Section 8.4.10 below).

The balance of investment funds, after allowing for non-land investment, is allocated to land improvement. Up to five types of land improvement programme can be handled in the model with the order of investment being determined by a priority schedule established before the simulation experiment. The priority order for investment could be related to expected profitability or some other criterion.

Each land improvement programme is defined in terms of the area suitable for that type of investment, and a "time-profile" of annual per hectare costs and expected stocking rate improvements. Based on the funds available, and the first-year cost of the top-priority programme, as much land as possible is started on this improvement programme. Once an improvement programme has been initiated for an area it is assumed to continue, with future development and maintenance costs being met, and incremental carrying capacity improvement occurring, in
accordance with the "time-profile".

With each year that development funds are available, more land is initiated into the top-priority improvement programme, until no more suitable land remains. The next highest priority programme is then commenced, and so on until the end of the simulated period, or improvement potential is exhausted. If the latter occurs then investment funds are added to liquid reserves.

Each year, the incremental improvements in the potential stock carrying capacity for that year, resulting from all the development programmes initiated in the past, are aggregated and, together with any adjustments resulting from changes to the deferred maintenance situation, are used to establish a new potential stock carrying capacity for the year. Within the herd and flock sub-models, actual stock numbers are then adjusted in the way described in Section 8.3.1 above. Continuing annual development and maintenance costs for all development programmes are also aggregated each year and are included in the farm's cost and tax structure.

The nature of the land improvement programmes used in the model will depend on the purpose of a particular simulation run. As described in Chapter 7, land improvement options for an individual farm can generally be categorised into land development and land intensification. If the model is used to simulate an individual representative farm then time-profiles of costs and benefits based on these alternatives could be used. If, however, the model is used to represent an average farm and simulate average responses, then the
specific options referred to above have little meaning. Rather, a single composite land improvement profile must be established which subsumes the range of land improvement investment that is possible on different farms at the same time. Alternative composite profiles could be used with the model to reflect the way certain types of government policy, such as the Land Development Encouragement Loans, may change the cost of certain types of land improvement programme.

8.4.10 Capital monitoring.

The capital status of the farm is important as a performance measure and it also plays a role in the borrowing decision rule. Accordingly, each simulated year, the capital position of the farm is assessed and updated. Various valuations are calculated corresponding as closely as possible to the capital items used in the MWBES Sheep and Beef Farm Survey. A "Farm Capital" value is calculated by valuing land (and improvements) on the basis of its stock carrying capacity, and adding the value of plant and machinery, and livestock. The per stock-unit value of land and an initial plant and machinery valuation are read in as data and are assumed to remain constant in real terms. Actual livestock numbers are valued using the livestock prices appropriate to the current year. A "Total Assets" figure is then calculated by adding to "Farm Capital" the value of liquid reserves and a specified value (assumed to remain constant in real terms) for the homestead.

"Total Liabilities" are determined by adding the level of principal outstanding on all long-term loans, to the level of
outstanding overdraft, if any. "Net Worth" is then calculated as "Total Assets" less "Total Liabilities" and an equity ratio is determined as "Net Worth" over "Total Assets".

8.5 Model Programming and Verification

The complete operational model comprises a FORTRAN 77 program for the simulation, interfaced with the MINITAB statistical package (Ryan, Joiner and Ryan, 1982) to analyse and summarise the results. To enhance portability the FORTRAN program includes no machine specific features or routines except the pseudo-random number generator. The simulation program comprises approximately 1500 FORTRAN statements and was designed with a modular structure involving one main routine and 30 sub-routines. A full listing of the FORTRAN program is provided in Appendix 4.

With a model program of this size, verification procedures are important to ensure that the model program performs as intended. Verification of the model program was undertaken using "antibugging" techniques as well as "debugging" techniques, as outlined by Dent and Blackie (1979). Antibugging is the use of techniques of model construction and programming which make the occurrence of programming bugs less likely and facilitate the tracing of remaining bugs. Such techniques used here included:

(i) modular construction - a separate subroutine was used for each major model component. Such a structure facilitates systematic programming and allows each component to be programmed and tested
independently before being incorporated into the whole model.

(ii) program documentation - extensive use was made of "working" documentation both within the program listing and externally. Part of the documentation process included the incorporation in the model of output routines which provide a complete annotated listing of all input data and simulation results. Various levels of detail are available for the output of model results, ranging from a detailed list of 120 parameter values for each simulated year, to a graphical summary for 12 major model responses. As well as helping to maintain record of the logic of program algorithms, such documentation is important for subsequent model users.

(iii) external data files - the advantages of a skeleton model structure for experimentation are outlined at the beginning of this Chapter, but such a structure also provides an antibugging facility. With all major model parameters "read-in" from external data files, this allows the model to be tested and verified under a wide range of input conditions without changes to the model program.

In conjunction with antibugging procedures, extensive debugging tests were applied. Initially all subroutines were tested and verified in isolation from the complete model. The complete model was then tested in its deterministic mode with comprehensive "hard-checking" of calculations. Finally, the stochastic version was tested to ensure consistent, logical and repeatable results.
While verification ensures that a model is operating as it was intended to, it does not ensure that the model will be useful for its intended purpose. In this respect validation tests are necessary; the validation procedures applied in this study are described in the next Chapter.
CHAPTER 9

MODEL VALIDATION

9.1 Introduction

Validation of a simulation model is necessary if it is to have credibility and utility for its intended purpose. Appropriate procedures for validation, however, remain the topic of considerable debate - a debate which extends across a range of issues from the philosophy of testing models, hypotheses and theories (Friedman, 1953; Samuelson, 1965; Hermann, 1967) to the usefulness of various statistical procedures (Cohen and Cyert, 1961; Aigner, 1972), and the value of subjective procedures (van Horn, 1971; Anderson, 1974).

Naylor and Finger (1967) reviewed many of the philosophical and practical problems of simulation model verification/validation and, in doing so, developed a three-step procedure which appears appropriate in this context. These steps were summarised by Anderson (1974) as:

(a) a rationalist step ensuring that assumptions (in model building) accord with theory, experience and general knowledge judged relevant,

(b) an empirical step of subjecting assumptions to empirical testing where this is possible, and
(c) a positive step of comparing model performance with simuland performance.

In the context of this study, steps (a) and (b) coincide with the system analysis and synthesis stages of the model building process. During these stages various sources of data and general knowledge about the North Island hill country farming system were reviewed and analysed to provide a sound basis for model assumptions. Where possible, particularly with respect to consumption, borrowing and investment behaviour, a range of postulates were subjected to formal empirical testing. The resulting model would at least appear to be logically consistent with empirical observations about the simuland. Nevertheless, the most critical step in the validation process remains i.e. testing the model's ability to predict the behaviour of the system under study.

9.2 Validation Tests

The appropriate data and tests for assessing the predictive power of a model will depend on a number of factors. These include:

(a) the purpose of the model
(b) the available data
(c) the nature of model output
9.2.1 Purpose of the model.

While the model was deliberately developed with an individual farm structure in mind, its value as a policy analysis tool will depend largely on its capacity to indicate aggregate farm class responses. To be useful in this respect the model must be able to reproduce, with some acceptable degree of accuracy, the behaviour of a hypothetical "average" farm. If the behaviour of the "average" farm can be predicted, then simple aggregation will give farm class predictions. However, as a general rule in representative farm studies, it would be expected that aggregation bias would severely limit the value of a single representative farm model for aggregate analyses. In this case, however, the peculiarities of North Island hill country farming may reduce aggregation bias to the extent that the model can provide results useful for the aggregate. Firstly, North Island hill country farming is generally homogeneous with respect to the nature of production, and generally involves a very limited range of alternative production activities. Secondly, North Island hill country farms tend to be independent production units with most production originating on the farms (through stock breeding), and supplying markets external to the hill country; either export markets for finished stock, or flatter finishing areas for store stock. Consequently, input and output prices, which would be expected to have a major influence on the operation of hill country farms, can be regarded as exogenous at both the farm level and the aggregate farm-class level.
9.2.2 Available data.

The amount and type of data available for model validation is often the major factor restricting effective validation of simulation models. Either appropriate data are not available, or the data available have been used in the model building process. In this case, time-series data were available for a wide range of physical and financial variables from the MWBES Sheep and Beef Farm Survey. These data were available for both the Class 4 average and for individual Class 4 farms. On the other hand, some of these data were used in various aspects of the model building process. Survey data from the MWBES were used, together with other sources of data, mainly to provide background information and insight into various aspects of the farming system, such as farm structure, and farmer borrowing and investment behaviour. It was only in the case of consumption, taxation, expenditure and culling functions that the data were used directly to estimate model relationships. While these functions are important in the model they only represent a small proportion of the total number of relationships and decision-rules in the model. Consequently, the data would appear still to have value for validation purposes. In the absence of a better independent data set, the MWBES data were used here for validation testing.

9.2.3 Nature of model output.

The model generates an annual time-series for a large number of physical and financial parameters. (In the stochastic version of the model these time-series are replicated under the influence of randomly
selected prices and seasonal production parameters.) An appropriate validation test, therefore, was to test the model's capacity to reproduce the historical behaviour of the system given historical starting conditions and historical price and production parameters. Using this approach the model was used in deterministic mode to generate a single simulated time-series for each model parameter. These time-series, for selected model responses described below, were then compared directly with the corresponding historical time-series using a range of graphical and statistical tests.

9.2.4 Tests applied.

A number of statistical tests are available for comparing simulated and actual time-series (Naylor and Finger, 1967; Cohen and Cyert, 1961; Kleijnen, 1974). For this study five statistics are reported: the mean absolute percentage error (MAPE); the Theil U statistic (U); and three statistics generated by regressing the predicted series on the actual series. These are the "intercept" value, the "slope coefficient" and the "coefficient of multiple determination", \( R^2 \). These five statistics were used because each one tests a slightly different aspect of the model's predictive performance. In addition, a graphical comparison was also made.

(a) Mean Absolute Percentage Error

The MAPE value measures the size of prediction errors in relation to the actual series and is calculated as follows:
MAPE = \frac{1}{n} \sum_{t=1}^{n} \left| \frac{A_t - P_t}{A_t} \right| \times 100

where \( A_t \) = actual observation in time period \( t \),
\( P_t \) = predicted observation in time period \( t \),
and \( n \) = number of observations.

The perfect MAPE score is zero indicating an exact matching of the actual and simulated series. Although the MAPE statistic provides an effective measure of the overall correspondence between the actual and simulated series it is prone to "bias" in some situations. This is particularly so when dealing with time-series which include fluctuations which are large relative to the value of some of the observations. Under these circumstances a moderate error, measured as a proportion of a small actual value, can result in a disproportionately large percentage error. Where this problem arises in this analysis it is noted.

(b) Theil's U Statistic

The U statistic measures the accuracy with which the model predicts changes in the actual variable. The U statistic is defined mathematically as:

\[ U = \sqrt{\frac{\sum (DP_t - DA_t)^2}{\sum DA_t}} \]

where \( DA_t \) = actual change in parameter over period \( t \),
and \( DP_t \) = predicted change in parameter over period \( t \).

A perfect matching of simulated changes with actual changes will produce a U value of zero. A value of the U statistic greater than or equal to one implies that the model is no better predictor of change
than a naive, no-change forecast (Koutsoyiannis, 1977). Theil's U statistic deals only with changes and takes no account of any systematic bias in the simulated series which may result from a model's tendency to over or under-estimate reality. The regression statistics described below deal with this aspect of model performance.

(c) Regression Statistics

Under this test a simple regression is performed between the simulated and actual response series. The intercept and slope estimates generated by the regression provide an indication of any systematic bias in the predictions. A perfect model would provide a line with an intercept and slope equal to zero and one respectively i.e. a 1:1 correspondence. Student's 't' test can be applied to test for these equalities.

Aigner (1972) questions the use of this regression test for stochastic simulation, arguing that the resulting regression line cannot be expected to be homogeneous with unit slope; however, for the deterministic comparisons used here the test is regarded as appropriate (Howrey and Kelejian, 1969; Aigner, 1972).

The nature of any significant deviation from the ideal intercept and slope values in this test provides an indication of the type of bias inherent in the model projections. A deviation in the intercept alone indicates a consistent tendency for the model to over or under-estimate the value of actual system responses. A deviation in the slope alone, indicates a tendency for a differential bias varying
with the response level; for example, the slope coefficient would be significantly different from one if the prediction error increased as the response level increased. Deviation of both the intercept and the slope will indicate varying degrees and types of predictive failure.

In addition to the intercept and slope tests, the regression provides the coefficient of multiple determination ($R^2$), which gives a measure of the proportion of variation in the actual time-series which is explained by the regression equation. If considered in conjunction with the slope and intercept values, the $R^2$ value can provide another measure of the overall predictive power of the model.

(d) Graphical Comparison

While statistical measures of model validity are useful, the subjective, graphical comparison of actual and simulated results still remains an effective - perhaps the most effective - method of assessing model performance. In many cases the statistical assessment only serves to indicate what is more clearly apparent from a critical graphical comparison. One aspect of graphical comparison, however, is open to manipulation; the scale of the graph can sometimes be chosen to minimise the apparent differences between the actual and simulated series. In the interests of achieving an effective comparison in this study, extended graph scales have been used which tend to highlight differences rather than disguise them.
9.3 Data Used for Validation

The data chosen for the validation tests were MWBES Class 4 average data for the ten year time-series from 1971/72 to 1980/81. Some sampling variability is inherent in this data series because of the change in the sample of farms surveyed from year to year. To reduce this variability, at least to some extent, the series was adjusted to a constant effective hectare basis. All financial comparisons were made in real terms (1980/81 dollars).

Starting conditions for the financial and physical status of the simulated farms were set to correspond to Class 4 average conditions at the end of 1970/71, based on MWBES published data. Production parameters which are assumed constant in the model, such as stock mortality rates and the ratio of sheep to cattle stock-units, were based on average values for the historical 10 year period. Inevitably, some parameters, particularly those related to the investment and borrowing decision-rules, had to be set at somewhat arbitrary values. The assumptions used and associated rationale are described in the following sections.

9.3.1 Reserve limit.

The reserve limit is an important value in the model. When reserve funds fall below this limit it is assumed that no investment will occur; rather, available funds are used to augment the reserve fund. If reserves are available in excess of the limit a specified proportion of them is assumed to be available for investment. For the
validation test the reserve limit was set at $16,000 (in 1970/71 terms) or approximately $55,000 in 1980/81 terms. This level was chosen because it approximated the average level of reserves maintained on Class 4 farms throughout the 1960's when farm incomes were relatively stable (see Chapter 6). During the 1970's reserve levels fluctuated markedly as a result of income fluctuations but did not fall below the $16,000 level.

9.3.2 Proportion of reserve funds invested.

Based on the observation that, historically, reserves in excess of the $16,000 level tended to be reduced quite rapidly after an increase resulting from a high income year, it was assumed that 50 per cent of available funds, in excess of the reserve limit, would be available for investment in any year.

9.3.3 Investment profile.

The cost/benefit time-profile for investment used in the model was based on a cash-flow budget described by Parker (1981) for the intensification of hill country production. While in reality there will be many forms of land development, this particular form was regarded as indicative of a typical response to land development. In this case a capital expenditure of $30 per hectare (1970/71), followed by continued maintenance expenditure of $2 per hectare, leads to a stock carrying capacity increase of 2.5 stock units per hectare. Allowance for non-land investment such as buildings and machinery was made by an additional cost added to the first year of the investment
profile. New Zealand Department of Statistics (Agricultural Statistics) figures for total farm investment indicate that land investment, as a proportion of total investment, varied between 25 and 29 per cent for the 10 years 1971/72 to 1980/81. It can reasonably be expected that the proportion will be greater for hill country farming where there is limited need for large scale machinery; accordingly a value of 30 per cent was assumed. On this basis the first year of the investment cost profile was set at $100 per hectare ($30 for land development and $70 for non-land investment). A proportional adjustment was also made for the continuing annual maintenance cost figure to give $6 per hectare per year ($2 for fertiliser maintenance and $4 for other maintenance).

9.3.4 Debt servicing allowance.

The analysis of borrowing behaviour described in Chapter 6 indicated that new borrowing, on average each year, amounted to the equivalent of approximately 35 per cent of annual net income (see Equation 11 in Table 6.8). Assuming, say, a 10 year loan at 10 per cent interest, the debt servicing requirement would be the equivalent of 6 per cent of average annual net income. For determining borrowing rates, however, allowance had to be made for the fact that, in the model, borrowing is suspended in some years due to adverse economic conditions. If it is assumed that this will happen one year in five, a new-debt servicing commitment of 7.5 per cent of net income is needed for each loan year to maintain an annual average of 6 per cent; accordingly, a value of 7.5 per cent was used in the model.
9.3.5 Minimum equity limit.

Borrowing levels may also be affected by the minimum equity limit imposed in the model. In accordance with the observation of a generally upward trend in equity levels over the period 1971/72 to 1980/81, the minimum equity level was set at the level that existed at the beginning of the period. This value was 77 per cent.

9.3.6 Proportion of borrowed funds used for investment.

As noted in Chapter 6, not all borrowed funds are intended or used for on-farm investment; other major uses include purchase of additional land and refinancing of existing loans. Little information is available on the uses made of borrowed funds and how these uses change over time; however, a recent indication of the reasons for new borrowing in one season, 1979/80, was provided by a detailed survey of term liabilities in the pastoral sector carried out by the Meat and Wool Boards' Economic Service (1984). For North Island hill country (Class 4) it was found that 35.7 per cent of all new borrowing was for on-farm investment purposes. As a proportion of borrowing for purposes other than initial farm purchase this represented 44 per cent. For the validation test a value of 40 per cent was assumed.

9.3.7 Prices.

Historical stock prices were used for the validation test. Store stock prices were based on prices published by the MWBES in their Annual Review of the Sheep and Beef Industry (various issues) for
autumn sales in the Hawkes Bay district. The same source was used for wool prices; the average price for 35 micron wool at all New Zealand auctions was the standard used. Prime stock prices were based on the export schedule with appropriate adjustments to give farm gate prices. The lamb schedule price was adjusted for pelt and wool payments, while prime steer values were adjusted for the Meat Board's buffer fund deduction and supplementary payments (N.Z.M.P.B. Annual Reports, various issues).

These price data, while representative of hill country product prices, are likely to introduce some error into revenue calculations as they do not account for price differences between districts or between different wool grades.

9.3.8 Working expenses function.

From previous analyses (Woodford and Woods, 1978; Laing and Zwart, 1983) and the analysis carried out in Chapter 6 of this study, it seems clear that working expenditure is significantly influenced by the level of income, and this relationship is reflected in the model where working expenses are a function of gross revenue. Ideal data are not available to estimate this relationship because, as mentioned previously, the MWBES Survey data for "Working Expenses" are likely to include some element of capital expenditure. In the absence of better data, however, a function based on the MWBES data was used. This function was estimated as part of the analysis in Chapter 6 and is represented by Equation 4 in Table 6.7.
9.3.9 Culling rate adjustments.

It is through a process of culling rate adjustments in the model that changes in stock numbers are brought about. Culling rates are assumed to vary primarily as a result of climatic variation but they may also be modified as a result of investment decisions. If a seasonally related culling rate would lead to total stock numbers exceeding the stock carrying potential of the farm, then the culling rate is revised upward. Culling rates used for the validation test were calculated based on the climatic conditions of the period. Actual culling rates, based on actual changes in stock numbers over the period, were regressed on the soil moisture deficit index for North Island hill country derived from figures published by Morgan (1981) to give:

\[
DCULL = -0.0143 + 0.0237 \times SMD \\
(0.0079)
\]

\[
R^2 = 0.60
\]

where DCULL = change from standard culling rate,

SMD = soil moisture deficit index, and

\( (\quad) \) shows standard error.

This regression equation was used to generate predicted culling rates for each year based on climatic conditions.

9.3.10 Production and consumption parameters.

Published historical average values from the MWBES Survey were used for wool weights, lambing percentages and calving
percentages. Consumption function coefficients were based on Equation 2.1b estimated in Chapter 5 (see Table 5.2). This equation was estimated with published MWBES time-series data for the period 1970/71 to 1977/78.

9.4 Validation Results

9.4.1 Selected key parameters.

Potentially, over one hundred responses could be recorded from the model. To examine all these responses would be prohibitively time-consuming, even if actual historical data were available for comparison. Rather, a subset of twelve key variables was selected for monitoring against the equivalent published historical values. These variables, with their comparable MWBES Survey items, are listed in Table 9.1.

The results of statistical validation tests are presented in Table 9.2 while graphical comparisons of actual and simulated values are presented in Figures 9.1 to 9.13. The results for the validation tests are discussed below. All financial values are specified in 1980/81 dollars unless otherwise stated.

9.4.2 Gross income estimates.

Projections for gross income from sheep and wool are shown plotted against actual values in Figures 9.1 and 9.2. The mean absolute percentage error (MAPE) was less than 10 per cent in both cases and U
### TABLE 9.1

Model Variables and Corresponding Survey Items Compared in Validation Tests

<table>
<thead>
<tr>
<th>Model Variable</th>
<th>M.W.B.E.S. Survey Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Gross income - Wool</td>
<td>Gross Farm Income: Wool A/c</td>
</tr>
<tr>
<td>2. Gross income - Sheep</td>
<td>Gross Farm Income: Sheep A/c</td>
</tr>
<tr>
<td>3. Gross income - Cattle</td>
<td>Gross Farm Income: Cattle A/c</td>
</tr>
<tr>
<td>4. Total expenditure</td>
<td>Total Costs plus Depreciation</td>
</tr>
<tr>
<td>5. After-tax cash surplus</td>
<td>Net Income less Taxation</td>
</tr>
<tr>
<td>6. Tax paid</td>
<td>Taxation</td>
</tr>
<tr>
<td>7. Consumption</td>
<td>Personal Drawings</td>
</tr>
<tr>
<td>8. Long-term debt</td>
<td>Fixed Liabilities</td>
</tr>
<tr>
<td>9. Reserves</td>
<td>Cash at Bank or Firm plus Other Assets plus Investments and Deposits</td>
</tr>
<tr>
<td>10. Total assets</td>
<td>Total Assets</td>
</tr>
<tr>
<td>11. Equity ratio</td>
<td>Total Assets less Fixed Liabilities, as proportion of Total Assets</td>
</tr>
<tr>
<td>12. Total stock units</td>
<td>Total Stock Units</td>
</tr>
</tbody>
</table>
TABLE 9.2

Results of Validation Tests

<table>
<thead>
<tr>
<th>Variable</th>
<th>MAPE</th>
<th>U</th>
<th>INTERCEPT</th>
<th>COEFF</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gross Income: Sheep</td>
<td>8.99</td>
<td>0.51</td>
<td>-6532</td>
<td>1.251</td>
<td>0.88</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(4911)</td>
<td>(0.160)</td>
<td></td>
</tr>
<tr>
<td>Wool</td>
<td>4.40</td>
<td>0.15</td>
<td>-150</td>
<td>1.026</td>
<td>0.95</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(3539)</td>
<td>(0.088)</td>
<td></td>
</tr>
<tr>
<td>Cattle</td>
<td>10.27</td>
<td>0.69</td>
<td>-11123**</td>
<td>1.607++</td>
<td>0.95</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(2941)</td>
<td>(0.129)</td>
<td></td>
</tr>
<tr>
<td>Total Expenditure</td>
<td>4.04</td>
<td>0.50</td>
<td>3657</td>
<td>0.961</td>
<td>0.74</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(11439)</td>
<td>(0.199)</td>
<td></td>
</tr>
<tr>
<td>After-Tax Net Cash Surplus</td>
<td>17.09</td>
<td>0.26</td>
<td>-2190</td>
<td>1.060</td>
<td>0.96</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(2243)</td>
<td>(0.078)</td>
<td></td>
</tr>
<tr>
<td>Tax Paid</td>
<td>15.65</td>
<td>0.67</td>
<td>-4735**</td>
<td>1.546++</td>
<td>0.94</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(1582)</td>
<td>(0.137)</td>
<td></td>
</tr>
<tr>
<td>Consumption</td>
<td>10.11</td>
<td>0.91</td>
<td>-1781</td>
<td>1.169</td>
<td>0.73</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(4516)</td>
<td>(0.250)</td>
<td></td>
</tr>
<tr>
<td>Long-Term Debt</td>
<td>4.27</td>
<td>0.75</td>
<td>3727</td>
<td>0.926</td>
<td>0.82</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(14266)</td>
<td>(0.155)</td>
<td></td>
</tr>
<tr>
<td>Reserves</td>
<td>12.13</td>
<td>0.56</td>
<td>32232**</td>
<td>0.438++</td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(7308)</td>
<td>(0.113)</td>
<td></td>
</tr>
<tr>
<td>Total Assets</td>
<td>6.05</td>
<td>0.53</td>
<td>86766</td>
<td>0.882</td>
<td>0.74</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(118298)</td>
<td>(0.184)</td>
<td></td>
</tr>
<tr>
<td>Equity Ratio</td>
<td>1.60</td>
<td>0.50</td>
<td>0.028</td>
<td>0.978</td>
<td>0.89</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.104)</td>
<td>(0.123)</td>
<td></td>
</tr>
<tr>
<td>Total Stock Units</td>
<td>0.74</td>
<td>0.47</td>
<td>79.2</td>
<td>0.973</td>
<td>0.83</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(554.6)</td>
<td>(0.155)</td>
<td></td>
</tr>
</tbody>
</table>

*   (**) - intercept significantly different from zero at 5 (1) per cent significance level
+   (++) - slope coefficient significantly different from one at 5 (1) per cent significance level
FIGURE 9.1
Actual and Simulated Gross Revenue from Sheep

FIGURE 9.2
Actual and Simulated Gross Revenue from Wool
values were less than one. The intercept values in the regressions were not significantly different from zero and the slope coefficient estimates were not significantly different from one. $R^2$ values were satisfactory at 0.88 and 0.95 for sheep and wool respectively. By all these criteria the model appeared to predict gross wool and sheep income satisfactorily, although some instances of over and under-estimation are apparent in the graphical comparison.

With respect to gross income from cattle (see Figure 9.3), a MAPE of 10 per cent and a $U$ value of 0.69 indicate that the variation in cattle gross income is reasonably well predicted; however, the estimated regression coefficients and graphical observation reveal some over-estimation by the model, relative to the actual values. This occurred mainly in the first three years of the projection. Close examination of the output from the herd sub-model revealed that the model over-estimated the number of cattle sold (net of purchases) for the three years 1971/72 to 1973/74. The reason would appear to be the apparent importance of cattle trading, relative to cattle breeding, over that period. Subsequently, there was a reduction in cattle trading and a corresponding increase in cattle breeding. This change is evidenced by the reduction in cattle purchases as a proportion of cattle sales; in 1971/72 the number of cattle purchased was 46 per cent of the number of cattle sold but by 1974/75 this figure had fallen to 29 per cent and it remained at or below that figure for the rest of the

5 All significance tests were applied at the 5 per cent level of significance unless otherwise stated.
FIGURE 9.3
Actual and Simulated Gross Revenue from Cattle

FIGURE 9.4
Actual and Simulated Total Expenditure Levels
validation period. For this latter period the herd sub-model, which simulates a cattle breeding system, estimated cattle gross income satisfactorily.

Notwithstanding important price data, a generally satisfactory performance from the model in projecting gross income was indicated and would be expected, given that the major determinants of gross income, i.e. prices and stock performance parameters, are exogenously specified from historical data. Nevertheless, the tests do confirm that methods used in the model to generate and value total production are generally appropriate.

9.4.3 Total expenditure.

Total expenditure in the model is linked to gross revenue through the working expenses function but also includes components generated endogenously such as debt servicing costs, and development expenditure. Testing the simulated variable against actual total expenditure gave reasonable results; the MAPE was only 4 per cent and the $U$ statistic was 0.5. In the regression test the estimated intercept and slope coefficients did not differ significantly from the ideal values and the $R^2$ value was 0.74. The graphical comparison, presented in Figure 9.4, confirms the generally satisfactory performance of the model with respect to this variable; although a possible tendency to slightly over-estimate expenditure is also apparent.
9.4.4 After-tax cash surplus.

The model's capacity to reproduce this variable is a more critical test of model validity. This is because "after-tax cash surplus" is a function of a number of endogenous model procedures, including the estimation of revenue, expenditure, costs associated with past investment expenditure, interest charges and allowance for deferred maintenance expenditure. In this respect the model performed reasonably well (see Figure 9.5). The intercept and slope estimates were satisfactory and the regression $R^2$ value of 0.96 and the Theil U statistic of 0.26 indicate that changes in the actual parameter were well matched by the model estimates. The MAPE value of 17 per cent appears high but is heavily influenced by the error associated with one observation - that for 1974/75. Actual surplus in that year was low, consequently the moderate error measured as a proportion of this low base tended to be magnified in percentage terms.

9.4.5 Tax paid.

Model estimates of annual tax paid were variable in accuracy (see Figure 9.6). The general pattern and average level of actual tax payments were reproduced by the model; however, the projection included some over and under-estimates in particular years; larger fluctuations were inherent in the simulated tax payments than occurred in reality. This tendency is reflected in regression coefficients which differ significantly from the ideal, and results, at least to some extent, from the structure of the model and the way tax deductible investment expenditure is assumed to respond to income fluctuations. Due to the
FIGURE 9.5
Actual and Simulated After-tax Cash Surplus

FIGURE 9.6
Actual and Simulated Tax Payments
sequential nature of the simulation process, investment response to income fluctuations tends to occur in the year following the income year. In reality a larger proportion of this investment response probably occurs within the income year thus tending to moderate the tax burden in high income years.

On the positive side, all turning points in the actual series were matched by the simulated projection and the total tax paid over the period ($111,975) was reasonably well matched by the simulated equivalent ($125,781). The $U$ statistic value of 0.67 was satisfactory.

9.4.6 Consumption.

The actual and simulated consumption series are presented in Figure 9.7. Statistically, the estimation of consumption values appears acceptable by most criteria. The MAPE value was 10 per cent and the $U$ statistic was 0.91. This latter value appears relatively poor but is heavily influenced by the overestimation of consumption in 1972/73, 1973/74 and again in 1978/79. This latter year was the only turning point missed in the series.

The cause of the overestimation in 1972/73 and 1973/74 is due to the bias inherent in the estimated regression function used in the model (see Chapter 5) which tends to overestimate consumption in high income years. With respect to the overestimation of consumption in 1978/79, the cause is not clear.
FIGURE 9.7
Actual and Simulated Consumption

FIGURE 9.8
Actual and Simulated Long-term Debt Levels
Despite the errors in some years, the overall performance of the model, as measured by the regression of simulated on actual values, was reasonable. The estimated coefficients were not significantly different from the ideal, i.e. zero for the intercept and one for the slope, and the $R^2$ was 0.73 ($R^2$ was 0.70). These values should be considered in the light of the $R^2$ for the originally estimated consumption function (see Chapter 5) of 0.75.

**9.4.7 Long-term debt.**

New long-term borrowing is handled in the model in a relatively mechanistic fashion. An amount available for new debt servicing is calculated each year as a proportion of net cash surplus in previous years. This amount is then used to calculate new funds borrowed on the basis of the current year's mortgage interest rate. Principal and interest repayments are calculated for each loan; aggregated principal outstanding on all loans represents the long-term debt level. This procedure appears to predict debt levels with reasonable accuracy, given the results of this validation test. Actual and predicted debt levels are presented in Figure 9.8. The relevant U statistic was 0.75 and the MAPE was 4 per cent. Neither the intercept nor the estimated slope coefficient in the regression test were significantly different from zero or one respectively. The $R^2$ for the regression was 0.82.

---

6 As with all calculations in the model, new borrowing and debt levels are calculated in nominal terms and reflated to 1980/81 values for reporting and testing purposes.
The only turning-point missed in the series, and the point of maximum deviation between the actual and simulated values, occurred with the 1978/79 observation. The model underestimated new borrowing for this year but a greater than predicted fall-off in borrowing in the following year bought the simulated and actual series back together. Investigating this phenomena revealed that this unexpected borrowing behaviour corresponded to a period of marked expansion and subsequent contraction in the money supply in the economy (Reserve Bank of New Zealand, 1980). This would appear to be one of the few occasions where external credit conditions significantly affected borrowing.

9.4.8 Reserves.

The accuracy with which the model predicts the level of reserves could be expected to be a telling test of the internal validity of the model. This is because reserves represent a residual item which is subject to variation in many of the other components of the model, on both the income and expenditure sides. The estimate of the amount to be added to, or spent from, reserves will depend on estimates of gross income, general expenditure, taxation, consumption, new borrowing, debt servicing commitments and investment expenditure. In this respect the model performed with mixed results (see Figure 9.9). The $U$ statistic of 0.56 and the MAPE value of 12 per cent suggest satisfactory model performance; however, both the intercept and the slope estimates were significantly different from the ideal at the 1 per cent level.

The major period of deviation between the actual and simulated series occurred for 1975/76 to 1977/78 values. In response to the very
FIGURE 9.9
Actual and Simulated Reserve Levels

RESERVES (1980/81 DOLLARS)

○ Actual
○ Simulated

YEARS.

72 73 74 75 76 77 78 79 80 81
significant fall in incomes in 1974/75 the model predicted a large liquidation of reserves and some deferred maintenance. For 1975/76 the model failed to match the recovery in actual reserves and this resulted in a gap between the actual and simulated values of some $10,000. Between 1975/76 and 1977/78 the model matched actual changes in reserves reasonably closely but the gap of $10,000 remained. Several factors appear to have led to this situation; both consumption and tax paid in 1973/74 were overestimated by the model resulting in the simulated reserve level being less than the actual level immediately prior to the slump in incomes. Also, in reality, greater cost savings may have occurred through deferred maintenance than was allowed for in the model. This would have reduced the pressure on reserves.

The other point of significant deviation of the simulated results from the actual results occurred in the last two years of the series where the model tended to overestimate the level of reserves. In particular, the model failed to match the large reduction in reserves which occurred in 1979/80. The source of this discrepancy can be traced to the unpredicted borrowing behaviour referred to in Section 9.4.7 above. In reality, the "credit squeeze" of 1979/80 appears to have led to a liquidating of reserves starting in that year and continuing as real prices fell in 1980/81. In the model projection this depletion was largely matched but was delayed until 1980/81 as a result of continued borrowing in 1979/80.

Despite these discrepancies, and given the residual nature of the variable in question, it would appear that the model performance is probably satisfactory.
9.4.9 Total assets.

The model calculates various capital values for each simulated year, including total assets, farm capital, net worth and the equity ratio. An examination of model estimates of total assets and equity ratio provide an indication of the validity of model algorithms and assumptions associated with these capital valuations.

A total assets value is estimated for each simulated year by imputing a valuation for "land, buildings and improvements" based on a specified real value per stock unit of carrying capacity, plus a constant real value for plant and machinery. In addition, current reserves are included, together with a valuation of all livestock based on current market values.

An initial projection with the model using the historical per-stock-unit valuation for 1970/71 tended to underestimate the value of total assets, relative to the historical valuations. By breaking down the model valuation into its components and comparing them with the published values it was apparent that the model consistently undervalued the "land, buildings and improvements" component of the valuation after 1972/73. Checking on the changes in the real value of land and improvements over the period revealed a rapid increase in the valuation between 1971/72 and 1973/74 (see Figure 9.10). The average value then plateaued until 1977/78 and subsequently increased rapidly again until the end of the test period in 1980/81. Given that any changes in the real value of land which are independent of changes in land productivity, are beyond the scope of the model, it seemed
FIGURE 9.10
Land Value per Stock Unit Carried
Class 4—1971/72 to 1980/81

FIGURE 9.11
Actual and Simulated Total Asset Values
reasonable to make some allowance for the changing real land values in the calculation of capital values. Accordingly, a differential inflation rate of 9 per cent (flat rate) was applied to land values as measured on a per-stock-unit carrying capacity basis. The resulting total asset projection, which is part of the same set of projections discussed above for other parameters, is presented in Figure 9.11. The statistical tests on the projection proved satisfactory with the regression estimates for the intercept and slope values not differing significantly from their ideal values. MAPE (6 per cent) and $U$ statistic (0.53) values were also satisfactory.

9.4.10 **Equity ratio.**

The other measure of capital status reviewed here is the equity ratio, defined as total assets less total liabilities expressed as a proportion of total assets. Generally the matching of actual and simulated values was good (see Figure 9.12) with acceptable MAPE and $U$ values and an $R^2$ of 0.89 for the regression. Regression results did not differ significantly from the ideal values.

Although not representing a major deviation from reality, the model tended to slightly overestimate both total asset and equity values in the latter half of the test period. The cause of this tendency was traced back to the estimation procedure for total assets and the fact that the simple flat rate adjustment used on land values tended to undervalue land in the early years and overvalue it in later years. In the absence of a more detailed procedure for specifying historical land values, which was felt unwarranted given the intended
FIGURE 9.12
Actual and Simulated Equity Ratios

FIGURE 9.13
Actual and Simulated Stock Unit Numbers
use of the model in ex ante analyses, the performance of the model with respect to total assets and the equity ratio was deemed satisfactory.

9.4.11 **Total stock units.**

Short-term changes in stock units in the model are determined primarily as a function of annual climatic conditions, while the longer term trend in stock numbers is affected by investment or disinvestment. Thus in comparing actual and predicted changes in stock units both the short and longer term features of the projection are of interest.

Short-term variation was generally predicted satisfactorily by the model as evidenced by the graphical comparison (Figure 9.13) and the Theil U statistic of 0.47. Also, all turning points were matched, although the level of increase from 1973/74 to 1974/75 was underestimated by 50 stock units. Subsequent changes in stock numbers compensate for this error and the resulting matching of actual and predicted stock numbers appears satisfactory. In the longer term there was an upward trend in stock numbers over the period of the order of 25 stock units per year. This trend was matched by the model projection, indicating that appropriate investment was simulated by the model to accommodate the increased stock numbers.

Statistically the model performs well with respect to this important parameter giving a MAPE value of less than 1 per cent and regression intercept and slope coefficient estimates that do not vary significantly from the ideal values. The $R^2$ value for the regression was 0.83.
The long-run increase in stock numbers in the model is only possible within the constraint of "potential stock units" which are calculated internally as a function of investment and disinvestment. While the estimation of potential stock units in the model cannot be validated directly against observed data, a subjective assessment can be made as to whether the generated series is sensible.

As mentioned above sufficient investment was generated in the model to increase potential stock units and accommodate the actual and simulated increase in stock numbers. While this is an important test of model validity, it is also important that simulated investment does not lead to a potential stock carrying capacity that is unrealistically greater than actual stock numbers carried. Potential carrying capacity, which is also shown in Figure 9.13, was originally set (arbitrarily) at 3 per cent more than actual stock units carried at the beginning of 1971/72. Over the simulated period potential carrying capacity increased by approximately 7 per cent which effectively matched the rate of increase in actual and simulated stock numbers. On this basis it would appear that the investment algorithm in the model is a reasonably valid approximation of the actual mechanism.

9.5 Conclusion

The results of this validation exercise would suggest that the model generally performs satisfactorily and that it has sufficient validity to warrant its use as a policy analysis tool. It is appropriate, however, to consider those aspects of the model projections where the simulated series deviated from the actual series.
The causes and implications of such deviations should be noted in the interests of ensuring the prudent use of the model.

Deviant projections can probably be attributed to one of two possible causes; either the model structure is at variance with the real world system or the data available to estimate model relationships and run the model are imperfect. Since the essence of modelling is to provide a simplified representation of a real world system, some structural "imperfection" is inevitable and acceptable if the model as a whole performs satisfactorily. In this case several structural assumptions appear to have led to deviations from reality in some responses. Firstly, the assumption that production is based primarily on stock breeding activities appears to have led to some over-estimation of cattle revenue particularly in the early stages of the projection. Secondly, the sequential structure of the model affects the way (tax deductible) investment expenditure responds to income fluctuations and this affects the taxation projections. Another structural simplification relates to credit rationing; internal rationing only is assumed and, consequently, model projections such as long-term borrowing and reserve levels deviate from reality on (rare) occasions when external credit conditions affect borrowing.

With respect to imperfect data for estimating structural relationships and running the model, these may lead to deviant projections but do not necessarily invalidate the underlying structural assumptions. As mentioned earlier in this study, in relation to various aspects of system analysis, some deficiency seems likely to be present in much of the data used in model construction and operation.
In particular, revenue, expenditure, consumption and investment relationships are likely to be affected to some extent.

The apparent validity of the model in the light of the structural simplifications and data deficiencies mentioned above, would suggest that the model structure is basically sound and that the modelled system is relatively insensitive to the various effects of imperfect data. To further explore this issue of model sensitivity, an analysis was carried out to investigate the sensitivity of model responses to variation in a wide range of model parameters. The analysis is described in Chapter 10.

At the beginning of this Chapter it was acknowledged that it would not normally be expected that a single representative farm model could simulate the aggregated behaviour of a large sub-sector without excessive aggregation bias. It was also argued, however, that in the case of North Island hill country some features of that sub-sector were likely to mitigate against aggregation bias, perhaps to the extent of rendering the model, in "single farm" format, useful for sub-sector analyses. Overall it would appear that the validation tests against the historical Class 4 average data, reported in this Chapter, support this possibility, and use of the model for both aggregated and disaggregated experiments should yield useful results.

\[7\] Under these circumstances, however, the possibility of some compensating errors cannot be discounted.
10.1 Introduction

While the validation tests described in Chapter 9 go some way towards establishing the value of the model as a credible experimental tool, further tests are needed, particularly in relation to uncertain model parameters, in order to learn more about the structural soundness of the model. Such tests can be classified under the general heading of sensitivity analysis i.e. measuring the sensitivity of model responses to perturbations in uncertain model parameters.

10.2 Approach to Sensitivity Analysis

As with validation testing, there is no definitive test of model sensitivity; rather a range of procedures are possible each providing a slightly different insight into the sensitivity of the model. Anderson (1974) reviews these procedures but points out that the dimensionality of sensitivity tabulation can get out of hand in four ways: (a) the number of performance variables, (b) the number of accounting intervals, (c) the number of measures of sensitivity, and (d) the number of unsure parameters. The approach taken in this study with respect to each of these aspects of sensitivity analysis is described in the following sections.
10.2.1 Performance variables.

As mentioned in relation to validation testing, there is a large number of variables generated by this dynamic simulation model which could be regarded as performance variables. A subset of these variables was selected to measure the sensitivity of the model. This subset was similar to that set used for validation testing but expanded to include "funds borrowed" and "investment" variables for which no historical comparison was possible. The set, therefore, was as follows:

(a) Total gross revenue  
(b) Expenditure  
(c) After-tax cash surplus  
(d) Consumption  
(e) Tax paid  
(f) Reserves  
(g) Total assets  
(h) Equity  
(i) Funds borrowed  
(j) Investment  
(k) Potential stock units  
(l) Actual stock units

This set of performance variables was regarded as being comprehensive enough to monitor the operation of all the major components and structures of the model.
10.2.2 Accounting intervals.

To keep computing costs within reasonable bounds, sensitivity analysis was undertaken with the model in deterministic mode (Dent and Blackie, 1979), with starting conditions and price and production parameters set at the same values as were used for the validation tests i.e. to correspond with historical values for the ten year period 1971/72 to 1980/81.

The deterministic and stochastic versions of the model are identical except for the treatment of livestock and wool prices and the main production parameters, such as annual lambing and calving rates, wool weights and culling rates. Therefore, sensitivity analysis related to variables in the deterministic version of the model will generally be directly relevant to the stochastic version. What is lost, however, is a measure of effect of different sequences of prices and seasonal conditions on model responses. Two factors moderate this disadvantage of testing sensitivity deterministically; firstly, the historical period used includes a wide range of price and seasonal conditions thus exposing the model to a range of conditions, albeit within the one model encounter; secondly, model experimentation explicitly considering the variance of model responses will be covered in Chapter 11.

Given an accounting period of ten years, three "points" of sensitivity were selected. The first was the variation in model responses for year 2 of the simulation, selected to measure short-term or "impact" sensitivity; the second was the variation in year 10
responses selected as a measure of longer term sensitivity. The third value examined was the mean value of the response variable over the ten year period. This value was useful because, unlike the year 2 and 10 "point" sensitivities, it was not influenced excessively by the price or climatic conditions for a particular year.

10.2.3 **Sensitivity measures.**

Anderson (1974) outlines a number of measures of model sensitivity. These include absolute and proportional changes in model responses, as well as an estimated "elasticity" of response. This latter measure was chosen for this study as it provides a "dimensionless" value which indicates the variation in model responses relative to the variation in the uncertain parameter. The elasticity $E$ of model response $Y$ to variation in parameter $M$ is given by:

$$ E = \frac{D(Y/Y)}{(DM/M)} $$

where $Y$ and $M$ are "standard" values and $DY$ and $DM$ are the changes induced by sensitivity analysis.

The question arises as to the appropriate value for $DM$ i.e. to what extent should the uncertain parameters be varied. For some absolute or proportional measures of sensitivity, the variation should perhaps ideally reflect the degree of uncertainty associated with the tested parameter; however, with elasticities this is not appropriate as the variation in model response is measured in relation to the variation in the uncertain parameter. Accordingly, a standard $\pm 10$ per
240

cent variation was used for all parameters; some consideration of the relative uncertainty of the various parameters is included in the discussion of the results. In addition, a special analysis examining the behaviour of the model under extreme price conditions was also undertaken.

To keep sensitivity analysis results to a manageable set, only one parameter was varied at a time; while some interaction effects may not have been examined, it is believed that the inherent sensitivity of the model was satisfactorily explored.

10.2.4 Parameters tested.

Selection of uncertain model parameters as candidates for sensitivity analysis must depend on the modeller's judgement as to areas of inherent uncertainty in the model. The approach taken here was to consider each of the major components of the model and select what were believed to be the most uncertain parameters in each case. The following components and associated parameters were selected.

(a) Production

The production components of the model involve many parameters but some were regarded as either being known with reasonable certainty (such as average sheep and cattle mortality rates), and/or as being relatively unimportant in the context of modelling the whole farm (such as ram and bull rates). Others, however, were perceived as being important and uncertain enough to warrant sensitivity analysis. Production parameters selected for sensitivity analysis were:
(i) initial stock units
(ii) sheep/cattle ratio
(iii) seasonal culling rate adjustments
(iv) proportion of steers retained for fattening
(v) proportion of lambs turned-off fat

(b) Prices

Stock and wool prices are major components driving the model; although historical prices can be established with a high degree of accuracy, future prices are uncertain; thus sheep, wool and cattle price levels were tested, together with an "across-the-board" change in all product prices. These tests were carried out as part of the general sensitivity analysis. Extreme price conditions were also tested involving substantial "across-the-board" reductions in prices.

(c) Working expenditure

Working expenditure in the model is calculated as a function of gross income. Deficiencies in the data available to estimate this relationship justify sensitivity analysis with the function. The constant and marginal components of the expenditure function were first tested separately, then together to represent an overall change in the expenditure level.

(d) Taxation

Tax paid in any year is a function of current and lagged taxable income plus a constant term. As with the expenditure function each coefficient in the function was tested independently and then varied together to test the effect of an overall change in the tax structure.
(e) **Consumption**

Consumption is a function of current net income and lagged consumption, plus a constant. The effect of variations in the marginal propensity to consume out of current income, the coefficient on lagged consumption, and the constant were tested along with an overall change in the function.

(f) **Borrowing**

In simulating borrowing behaviour, two parameters are important and both were subjected to sensitivity analysis. The first and most critical is the parameter which represents the proportion of net cash surplus which is committed to the repayment of new long-term loans. This parameter determines the level of new borrowing unless the level is modified by the second relevant variable, the minimum equity limit.

(g) **Reserves**

The level and change in reserves in the model are determined by three parameters each of which were tested. The first is the lower reserve limit below which reserve funds cannot be used to offset a trading deficit; the second is the upper limit above which a proportion of reserve funds are assumed to be available for investment. The third factor is the proportion of reserve funds in excess of the upper level which are available for investment.

(h) **Investment**

A range of parameters were tested in conjunction with the investment components in the model, in addition to the proportion of reserve funds available for investment, mentioned above. These included:

(i) the proportion of borrowed funds used for on-farm investment and;
(ii) aspects of the investment profile; in particular, the initial per hectare capital cost of farm development, and the resulting increase in stock unit numbers over time.

10.3 Sensitivity Analysis Results

All parameters were tested for a 10 per cent increase and decrease relative to its "standard" value. Model responses were found to be approximately linear over this range of perturbation; consequently, only elasticities for changes in one direction are reported. Detailed tables showing the elasticities estimated for all parameters and responses are presented in Appendix 2. Details of the "extreme price" analysis are given in Appendix 3. A summary and discussion of all results are presented below.

10.3.1 Production parameters.

(a) Initial stock units

The results of sensitivity analysis with the production parameters are presented in Table A2.1 in Appendix 2. As might be expected several of the model responses proved sensitive to a change in the initial stock carrying capacity of the farm and displayed elasticities of response greater than one. In particular, after-tax cash surplus, tax paid, funds borrowed, investment and potential stock units were found to be sensitive. These results appear sensible and can readily be explained in the following way. Several components of expenditure, notably standing costs and initial debt levels, are not affected by the
reduction in stock carrying capacity; consequently, farm expenditure is relatively insensitive to the change (elasticity of mean response \( E = -0.77 \)) compared with the change in gross revenue \( E = -1.02 \). The effect is that the residual after-tax cash surplus is particularly sensitive to the change \( E = -1.57 \). This same effect leads to tax paid also being relatively sensitive \( E = -1.13 \). Funds borrowed is largely a function of after-tax cash surplus and this is reflected in its sensitivity \( E = -1.86 \).

The residual nature of investment results in it being particularly sensitive to the change \( E = -5.41 \) and this, in turn, leads to an additional reduction in potential stock units \( E = -1.12 \), year 10 elasticity \( E_{10} = -1.27 \) and actual stock units \( E_{10} = -1.14 \).

In most cases the short-term impact, indicated by the year 2 elasticity \( E_2 \), was less than the longer term effect, indicated by the year 10 elasticity \( E_{10} \). While this is the expected trend, given the long-term decline in actual stock numbers, in some cases the strong influence of conditions in a particular year out-weigh the trend effect. For example, for both consumption and funds borrowed, year 2 sensitivity was greater than year 10.

The only response particularly insensitive to the change was equity \( E = -0.06 \); in this case the reduction in total assets was offset by the reduction in funds-borrowed, leaving equity relatively stable.
The stock carrying capacity on hill country farms is known with reasonable certainty from the Meat and Wool Boards' Economic Service Annual Survey, and consequently the sensitivity of model responses is not of particular concern, at least as far as the value of the model is concerned; however, the results are likely to be of interest if long-term investment or disinvestment lead to significant changes in the stock carrying capacity.

(b) Sheep/cattle Ratio

The sheep/cattle ratio on hill country farms is also known with relative certainty and has not fluctuated widely over the last fifteen years. Consequently, it is assumed constant in the model; sensitivity analysis with the ratio indicates that this assumption is not likely to lead to serious distortions. Mean, short-term and long-term responses were generally insensitive to changes in the ratio, although, in the case of funds-borrowed and investment, sensitivity in particular years was indicated. For investment, $E_2 = -1.28$ and $E_{10} = 5.92$ indicating that sheep/cattle price ratios in particular years may reflect in the residual available for investment. On average, however, investment was not particularly sensitive ($E = 0.65$).

(c) Culling Adjustment Rate

Similarly, changes in culling rate adjustments, designed to simulate the effect of climatic conditions on stock numbers, were found to lead to minimal changes in model responses. The only exception to this general conclusion was the investment response in year 10 ($E_{10} =$
which reflected the long-term effect of reduced stock numbers on funds available for investment.

Two relatively minor but uncertain parameters were also tested — these were (i) the proportion of steers retained for fattening and (ii) the proportion of lambs turned-off in prime condition. Results of sensitivity testing with these parameters are presented in Table A2.2. In both cases minimal sensitivity was observed.

10.3.2 Stock and wool prices.

(a) Separate Price Effects

The results of the standard sensitivity analysis with sheep, beef and wool prices are presented in Table A2.3. With respect to separate changes in the product prices, model sensitivities were similar with differences mainly reflecting the contribution of each product to gross income. Most response elasticities were less than one with the notable exception of investment. As noted above with respect to stock numbers, the residual nature of investment leads to a sensitive response to factors affecting gross income. This can be particularly so in specific years; for example, the elasticity of year 10 investment response for a change in wool price was 10.00.

For each product price changed, the resulting reduction in investment was reflected in a minor reduction in potential stock units but not in actual stock units. This result occurred because there was a degree of "slack" stock carrying capacity in the system not fully
utilised under the "standard" historical seasonal conditions assumed. In a longer simulation it is likely that the reduction in potential stock carrying capacity would eventually lead to a reduction in actual stock numbers. The E10 value for potential stock numbers is probably, therefore, the best measure of the long-term effect on stock numbers and thus production. E10 values for reductions in sheep, wool and beef prices were -0.11, -0.14 and -0.09 respectively.

(b) Across-the-board Price Changes

The sensitivity of model responses to a 10 per cent across-the-board reduction in all product prices was obviously more pronounced than for the independent reduction in particular product prices. Sensitivities were generally similar to those encountered for a change in stock units and the same explanations apply. The exceptions relate to stock unit changes which, in the case of price changes, reflect changed investment levels. In this case the reduction in potential stock units was sufficient to reduce actual stock units. The E10 value for potential stock units (-0.31) indicates that a permanent one per cent reduction in real prices will eventually lead to a 0.31 per cent decline in stock numbers. This result supports the observation and conclusions made in other studies (see Chapter 7) that, even in the long-term, total output from pastoral farming systems in New Zealand is relatively price inelastic, at least for this level of price change.
(c) **Extreme Price Conditions**

To examine the operation of the model under extreme price conditions, the model was run four times with successive reductions in all product prices. The four price scenarios represented 100, 75, 50 and 25 per cent of the historical price levels. A more detailed discussion of the performance of the model under these conditions, together with a graphical presentation of results, is provided in Appendix 3.

In summary, the results confirm the conclusions about price sensitivity outlined above. Taking the 50 per cent scenarios for example, gross revenue was affected more than proportionally as disinvestment eventually led to reduced stock numbers. Expenditure exhibited less than proportional reductions due to the fixed components of costs with the result that after-tax cash surplus was relatively sensitive to the price reduction. The decline in consumption was slightly less than proportional to the decline in prices but, never-the-less, was substantial. Reserves were reduced to the minimum and significant disinvestment, in the form of reduced maintenance, was necessary to offset trading deficits. As a result stock carrying capacity and actual stock units were reduced by 10 per cent over the 10 year projection. It could be argued that this is a conservative reduction given the fact that the return from sheep and beef farming under these conditions would be low and that the main alternative land-use, forestry, would be likely to make inroads into the area under grazing. The effect of such a land-use change is beyond the scope of this model. On the other hand, for farms staying in pastoral
production, albeit under restructured conditions, a move to a more extensive, lower-cost form of production may reasonably be represented by the model results.

The projected value of total assets remained relatively stable despite the low product prices, mainly because land values are assumed to be exogenously determined and not linked to product prices. Under extreme price conditions this assumption is probably unrealistic. Under these circumstances alternative land-value scenarios could be tested with the model in conjunction with price or policy changes.

10.3.3 Working expenditure

The results of sensitivity analysis with respect to the expenditure function are presented in Table A2.4. Model responses, apart from investment, were found to be relatively insensitive to changes in both the standing cost (constant) and marginal cost coefficients of the expenditure function, and to changes in both simultaneously. This insensitivity of response is partly due to the fact that the impact of a change is spread across several components of the farm system, such as consumption, tax paid and reserves. Despite this the residual investment component is still significantly affected (E = -3.24) and leads to a slight reduction in potential stock numbers (E10 = -0.18) and actual stock numbers (E10 = -0.03) in the long-term.
10.3.4 Taxation.

Investment expenditure again proved to be a sensitive model component when changes to the tax function parameters were tested (see Table A2.5). Other responses were relatively insensitive. When the tax function as a whole was increased it is interesting to note that actual tax paid increased more than proportionally \( E = -1.18 \). There would appear to be a "multiplier" effect operating in the model which could well occur in reality. This occurs because funds are diverted into paying tax which would otherwise be used for tax-deductible purposes, such as working expenditure and investment.

10.3.5 Consumption.

Model responses were generally insensitive to consumption function parameters varied independently and simultaneously. This was particularly so in the short-term (see Table A2.6). The long-term response elasticities, except for investment, were also low; however, they may not fully reflect the true long-term impact of increased consumption on farming operations. As mentioned above, the historical pattern of seasonal conditions used in the analysis and reflected in culling rates, was such that a reduction (increase) in potential stock units may not be matched fully by a decrease (increase) in actual stock units. In this case, taking the increase in total consumption as the example, a 0.18 per cent decrease in potential stock units led to a 0.04 per cent decrease in actual stock units which, in turn, led to a 0.02 per cent decrease in gross revenue. Under different seasonal conditions, or over a longer term period, the change in actual stock
units would be expected to match more closely the change in potential stock units. The effect of these reduced stock numbers on gross revenue would then be reflected in reduced consumption. In other words, an increase in consumption in the short-term may eventually lead to a long-term decrease in consumption. 8

10.3.6 Borrowing

The results of sensitivity analysis with the two parameters which determine borrowing behaviour are presented in Table A2.7. The first parameter tested was the proportion of net surplus funds committed to servicing new borrowing. Reducing this proportion reduced funds-borrowed and investment. Slight reductions also occurred in total expenditure (through reduced interest payments), reserves, total assets and potential stock units. The reduced expenditure led to increased consumption, tax paid and after-tax cash surplus. In no case, however, were the average response elasticities greater than one.

In both the "standard" and test cases, borrowing in year 2 was limited by the specified equity limit; consequently, funds borrowed in both cases were the same and E2 was zero for all model responses. In the longer term some sensitivity was apparent with respect to investment (E10 = -1.42).

8 The true impact of this long-term feed-back effect on consumption and other system responses could be measured effectively using the stochastic version of the model in which the modelled system encounters varying patterns of seasonal conditions.
The second parameter tested was the specified equity limit imposed in the model. An increase in this limit led to a similar pattern of responses to those encountered for the first borrowing parameter, although more sensitivity was apparent with $E = -3.22$ and $-1.38$ for funds-borrowed and investment respectively. The effect of the change in the parameter varied noticeably between the short and long-term. Borrowing in year 2 was significantly reduced by the stricter equity limit ($E_2 = -10.00$); this reduced the debt repayment burden in later years, increased cash surpluses ($E_{10} = 1.92$), and facilitated increased borrowing ($E_{10} = 0.90$) when, through inflation, the equity limit was no longer a constraint. This change of effect was also manifested in reserve and investment responses.

10.3.7 Reserves.

Two parameters were tested with respect to the determination of reserve levels in the model (see Table A2.7). The main parameter tested was the upper reserve level, above which a proportion of reserves are assumed to be available for investment. Increasing this level tended to increase reserves ($E = 0.55$) and decrease investment ($E = -2.15$); reduced tax deductible investment also increased tax paid ($E = 0.27$). Only in the case of investment were response elasticities greater than one.

The second parameter tested was the absolute lower level for reserves. When reserves reach this limit extra funds to offset a deficit must come from deferred maintenance. As the lower level cannot exceed the upper level both parameters were increased and the results
compared with the previous test; the extra effect on model responses was minimal. As would be expected, reserves were maintained at a slightly higher average level \( (E = 0.66) \) but little else changed in comparison with the first parameter test. Greater sensitivity could be expected with respect to this lower level reserve parameter under lower income conditions where substantial deficits occur. If these deficits had to be offset by reduced maintenance (disinvestment) rather than reduced reserves, then a reduction in stock carrying capacity could result, with associated adverse effects on various model responses.

10.3.8 **Investment.**

Four parameters were tested in relation to the investment component of the model with results presented in Table A2.8. The first was the proportion of liquid reserves available for investment. The value of this parameter was originally, rather arbitrarily, set at 0.50. The effect of decreasing this value was found to be minimal for most model responses. The average level of reserves increased slightly \( (E = 0.14) \) and the average level of investment was reduced slightly \( (E = -0.38) \). The effect on investment in particular years was not always negative as evidenced by the \( E_{10} \) value of 1.94 for investment in year 10. This result occurred for two reasons: firstly, reduced investment in earlier years resulted in reduced maintenance expenditure and, because the adverse effects of this reduced investment were still to occur, this led to an increased after-tax cash surplus in year 10 \( (E_{10} = 0.09) \); secondly, reduced investment also led to increased reserves in year 10 \( (E_{10} = 0.10) \). Together these factors resulted in more funds being available for investment in year 10.
The second investment parameter tested, also relatively uncertain, was the proportion of borrowed funds used for on-farm investment. Again the impact of change was minimal for most model responses. Only for investment \( E = -0.99 \) did an average response elasticity exceed 0.11. The other two parameters tested related to the investment profile of costs and (stock unit) benefits. The initial investment cost was increased, and the associated change in stock carrying capacity decreased. In both cases the model was relatively insensitive to the changes; in neither case did an average response elasticity exceed 0.10.

The insensitivity of model responses for all four investment parameters contrasts with the high sensitivity of the investment response to changes in other parameters, such as stock units, prices and costs. It would appear that the model is most sensitive to those factors which determine the level of residual funds for investment, rather than to changes in the way those residual funds are invested.

10.4 Conclusions

Formal sensitivity analysis described in this Chapter indicated that the model was, in general, relatively insensitive to perturbations in most model parameters. There were some notable exceptions which should be recognised when using the model for policy analysis. Firstly, many model responses such as cash surplus, taxation, borrowing and investment, were sensitive to variation in parameters which had a direct influence on total revenue; in particular total stock units and the general level of stock prices. This sensitivity appears logical
and acceptable given the importance of total revenue in actual farming operations.

The second major area of sensitivity was related to investment expenditure. In addition to the parameters just mentioned above, investment levels were found to be sensitive to changes in a wide range of model parameters such as working expenditure, tax rates, consumption levels, reserve and borrowing assumptions. This sensitivity is inherently related to the structure of the model and its foundation in the "residual funds" hypothesis of investment (albeit modified to account for the use of reserves, deferred maintenance, etc.). Evidence presented in Chapters 6 and 7 suggests that the residual funds hypothesis of farm investment is valid, or is at least a workable explanation of actual investment behaviour; if this is true then farm investment will inevitably be sensitive to a wide range of factors which affect the farming operation and it is appropriate that the model reflects this sensitivity. On the other hand, simulated investment levels will also be sensitive to errors in the model's data-base and this aspect of the model should be recognised when the model is used.

In contrast to investment expenditure, total stock units were found to be insensitive to changes in virtually all model parameters tested. This result is in line with findings from the econometric studies reviewed in Chapter 7 and can be explained by the "buffer" provided by reserves and the potential to defer maintenance expenditure for some time before a significant adverse effect on stock numbers results. Similarly, significant levels of investment expenditure must occur before even a small increase in stock carrying capacity is
Testing the model under extreme price conditions allowed various aspects of the model, particularly those dealing with disinvestment, to be illustrated and verified, although true validation could not be attempted. This testing showed that the disinvestment level, as well as investment level, was a sensitive aspect of the model. Also, the relative insensitivity of total stock units and thus production, to price changes was confirmed. In addition, various aspects of the model which could lead to biased results under extreme conditions were identified. These included the lack of an explicit link between farm profitability and land values and the lack of any consideration of competition from alternative land uses. Also in the model there is no attempt to identify a point where farming would no longer be considered viable or where extensive restructuring of the farm system would be necessary. These model limitations are only likely to seriously bias model projections under extreme conditions. Under more normal conditions, sensitivity analysis and experimentation with a range of input scenarios may be appropriate to gain an understanding of the effect on model projections of some of these aspects of the model. Overall it would appear that the model is reasonably robust under a range of conditions, and that useful analyses should be possible with the model.
CHAPTER 11 ANALYSIS OF ALTERNATIVE FARM SUPPORT AND STABILISATION POLICIES

11.1 Introduction
11.2 Approach to the Analysis
11.3 Data Used
11.4 Supplementary Minimum Price Analysis
11.5 Alternative Farm Support Policies
11.6 Alternative Stabilisation Policies
11.7 Conclusion

CHAPTER 12 CONCLUSIONS

12.1 Value of the Study
12.2 Model Implementation
12.3 Further Model Development
12.4 Further Research
CHAPTER 11

ANALYSIS OF ALTERNATIVE FARM SUPPORT AND
STABILISATION POLICIES

11.1 Introduction

Given the results of evaluation procedures described in Chapters 9 and 10, the model would appear to have value as a medium for policy analysis. The use of the model for this purpose is illustrated in this Chapter in relation to alternative farm support and stabilisation policies based on those described in Chapter 2. Three sets of simulation experiments were conducted. In the first, the past and possible future impact of Supplementary Minimum Prices (S.M.P.s) was explored, together with the effect of suspending S.M.P.s under different future price scenarios. Attention was given to both the income support and stabilisation effects of S.M.P.s.

The second set of experiments dealt with alternative farm support policies; in particular the effects of output subsidies, investment subsidies and reduced input costs were projected and compared with the projected effects of S.M.P.s.

The third set of experiments were designed to explore the effects of alternative stabilisation policies. The effects of buffer price schemes, similar in principle to those operated by the Meat and Wool Boards, were compared with those of a moving average price scheme and the increased use of farm liquid reserve assets for stabilisation.
purposes. Again the effects of these policies were compared with the effects of S.M.P.s.

11.2 Approach to the Analysis

11.2.1 Combined expost/exante projections.

For each policy scenario the stochastic version of the model was used to project average farm operations for the 10 year period 1981/82 to 1990/91. The model was modified slightly to run deterministically for the first three years of each projection using historical price and production parameters, while the final seven years of the projections were stochastically generated. This combined expost and exante technique has the advantage of allowing the past, as well as the likely future effects of S.M.P.s to be examined. It also allows the effect of price and climatic conditions in the recent past to be accounted for in any scenarios involving new policies which could be introduced in the near future.

11.2.2 Replications and comparison of results.

The comparison of policies described in this Chapter is based on a series of "experiments". In this context an experiment involves the use of the model to compare two or more policy alternatives. Each alternative policy is defined as a "treatment" and is represented by the appropriate manipulation of the model's input data and/or structural assumptions. In order to assess policies under a range of
price and climatic conditions, each policy treatment was replicated to generate distributions of model responses. To compare such distributions, generated under different policy conditions, requires the use of statistical hypothesis testing techniques. Alternative techniques are possible, depending on the nature of the experiments and the way the "treatments" are replicated (Dent and Blackie, 1979).

The approach chosen in this analysis provides an effective means of comparison without the need for a large number of (expensive) replicates. This was achieved by using the same set of random-number seeds for the replicates in each treatment, thus, in effect, allowing the policy scenarios to be compared under identical "sets" of price and climatic conditions. Identical seeding effectively eliminates random price and climatic effects as sources of variability and sharpens the comparison between policy treatments. Model responses generated by corresponding replicates may be regarded as paired observations and it is possible to test whether the mean difference in performance between "sets" or distributions of the paired observations is significantly different from zero.

The hypothesis $H_0: \mu_0 = 0$ is tested on the basis of the statistic

$$t = \frac{\bar{D}}{\frac{S_D}{\sqrt{n}}}$$

where $\mu_0$ is the expected difference between treatment effects, $\bar{D}$ is the observed mean difference in response values between treatments involving paired replicates, $S_D$ is the standard deviation of the differences, and $n$ is the number of replicates (Dent and Blackie, 1979). For the comparison of different policy scenarios, 25
replications of each "treatment" were generated. This was found to provide an effective basis for comparison; only response differences which were significant at the 5 per cent level of significance or better are discussed in the comparison of policies.

The results of each set of experiments are summarised in three ways. Firstly, for the selected model responses listed in Section 10.2.1, the mean and standard deviation of the annual response values for the last five years of the projected period are tabulated for each policy scenario. This provides an indication of the annual response level, and the variability of that level, once a policy is operative. The second basis for summarising the results involves the tabulations of the year 10 response means, and associated standard deviations, for the same 13 selected model responses. These values show the status of the simulated farm at the end of the simulated period and provide an indication of the medium-term effects of the various policies. Finally, a graphical comparison of mean response values over the simulated period is provided for some model responses of particular interest. All results are presented in terms of 1980/81 dollars.

11.3 Data Used

Model starting conditions were set where possible to match North Island hill country conditions at the end of 1980/81 as recorded for Class 4 in the Meat and Wool Boards' Economic Service survey of that year. Other model parameters, related to reserve limits, proportions of reserve and borrowed funds invested, the investment profile, debt servicing allowance, and consumption function were set in accordance
with the rationale described in Chapter 9 (Sections 9.3.1 to 9.3.10), with appropriate adjustment for inflation.

An updated working expenditure function was established to better represent the cost structure of the average farm at 1980/81. Using published MWBES data for the ten years 1971/72 to 1980/81 and reflating to 1980/81 dollars, the following expenditure function was estimated for Class 4 average working expenditure (EXP) as a function of total gross income (TGY):

\[
\text{EXP} = 35990 + 0.181 \text{ TGY} \\
(0.044) \quad R^2 = 0.68
\]

() indicates standard error

11.3.1 Price assumptions.

Historical market or supplemented prices (depending on the presence or absence of S.M.P.s in the analysis) were used for 1981/82 and 1982/83 based on sources described in Section 9.3.7. At the time of analysis, market price data for the 1983/84 season were not available; however, the "State of Agriculture 1983-84" report by the Agricultural Review Committee (1984) provided a summary of market outlook which was used to establish 1983/84 market prices. On the basis of this outlook the assumed 1983/84 price for wool was 50 cents per kilo up on the 1982/83 price, beef prices were increased 9 per cent over 1982/83 prices, while it was assumed that lamb and mutton prices would be the same as for 1982/83.
Stochastic price generation for 1984/85 and subsequent years was based on historical price frequencies represented as triangular probability distributions. Farm-gate price information from the sources described in Section 9.3.7 for the period 1966/67 to 1980/81 was collated into a 15 year annual time-series for each class of stock and for wool. These were converted to $1980/81 terms using the MWBES "Prices Paid" index. A statistical summary of each series is provided in Table 11.1.

The use of these historical price series implies the expectation that product prices will return (from the current low levels) to levels more typical of the past. This expectation is supported by Ojala (1980) who concluded that in the medium to longer term there will be increasing demand for New Zealand pastoral products, taking into account population growth, income growth and demand elasticities. Also, the 20 per cent devaluation of the New Zealand dollar in July 1984 should contribute to a price recovery. Never-the-less, the effect of a decline in future prices, relative to prices in the past, was also tested as part of the analysis process.

To test for the presence of significant trends in real product prices over time, each series was regressed against a simple time variable. In no case was the time-trend coefficient significantly different from zero at the 5 per cent level. While a trend could not be isolated for any individual product price series, there would appear to be discernible long-term decline in the general terms of exchange for the sheep and beef farmer. Regressing the MWBES Terms of Exchange Index for the period 1970/71 to 1982/83 (estimated for 1981/82 and
TABLE II

Statistical Summary of Annual Price Series*—
1966/67 to 1980/81

<table>
<thead>
<tr>
<th>Product</th>
<th>Unit</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Median</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Runs Test ( \alpha )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wool</td>
<td>$/kg</td>
<td>2.67</td>
<td>0.82</td>
<td>2.40</td>
<td>1.64</td>
<td>4.08</td>
<td>0.20</td>
</tr>
<tr>
<td>Prime Lambs</td>
<td>$/hd</td>
<td>21.54</td>
<td>3.68</td>
<td>21.30</td>
<td>16.61</td>
<td>29.83</td>
<td>0.54</td>
</tr>
<tr>
<td>Store Lambs</td>
<td>$/hd</td>
<td>17.22</td>
<td>3.49</td>
<td>17.29</td>
<td>10.35</td>
<td>22.78</td>
<td>0.17</td>
</tr>
<tr>
<td>Two-tooth Ewes</td>
<td>$/hd</td>
<td>35.74</td>
<td>9.09</td>
<td>34.48</td>
<td>24.44</td>
<td>51.53</td>
<td>0.15</td>
</tr>
<tr>
<td>Cull Ewes</td>
<td>$/hd</td>
<td>25.07</td>
<td>7.91</td>
<td>21.82</td>
<td>15.14</td>
<td>41.51</td>
<td>0.20</td>
</tr>
<tr>
<td>Weaner Cattle</td>
<td>$/hd</td>
<td>238.20</td>
<td>78.60</td>
<td>221.30</td>
<td>118.60</td>
<td>392.00</td>
<td>0.01</td>
</tr>
<tr>
<td>Prime Steers</td>
<td>$/hd</td>
<td>391.00</td>
<td>101.00</td>
<td>399.00</td>
<td>230.00</td>
<td>614.00</td>
<td>0.01</td>
</tr>
<tr>
<td>Cull Cows</td>
<td>$/hd</td>
<td>292.00</td>
<td>100.00</td>
<td>295.00</td>
<td>116.00</td>
<td>457.00</td>
<td>0.31</td>
</tr>
</tbody>
</table>

* 1980/81 Dollars
1982/83 excluding S.M.P. payments) against time gave the following result:

\[ \text{TOE} = 1126 - 24.9T \]

\[ (12.0) \]

\[ R^2 = 0.98 \]

where TOE is terms of exchange (1975/76 = 1000),

\[ T \] is time in years, and

\( () \) indicates standard error.

The declining trend of approximately 2 per cent per annum was significant at the 5 per cent level. To accommodate these results in the model the cost inflation rate was set at 2 per cent higher than the product price inflation rate.

Each real price series was then tested for the presence of serial correlation using the "Runs" test (Conover, 1971). The results of this test are also shown in Table 11.1. For most classes of stock and for wool the hypothesis of "no serial correlation" could not be rejected at the 5 per cent level of significance; the exceptions were for weaner beef cattle and fat steers. In both these cases positive serial correlation resulted from a period of above average real beef prices which occurred during the late 1960s and early 1970s. While this phenomena could have resulted from an underlying "beef cycle", such a cycle is not easily discernible and the work required to model the cycle, or simulate its effect on beef prices, was regarded as beyond the scope of this study. In the absence of significant trends or serial correlation in the main price series it was concluded that independent sampling from triangular distributions would be a satisfactory method of generating annual price sequences. Parameters for the triangular distribution were established as the maximum, minimum and modal values.
from each real price series.

While prices were generally independent year to year, price dependence was assumed between classes of stock in a particular year. Correlation coefficients were calculated for each combination of price series and are presented in Table 11.2. A generally high correlation was found between prices for different classes of sheep and between prices for different classes of cattle, with low correlation between sheep and cattle prices, and wool and cattle prices. A medium level of correlation of approximately 0.6 was found for sheep and wool prices. As a simple method of approximating these correlations, three different random-number seeds were used for price selection in each simulated year; one for all sheep prices, a second for beef cattle prices and a third for wool prices.

11.3.2 Production parameters.

Production parameters for the experimentation were generated using procedures similar to those used for prices. Published production parameters were available for 1981/82 from the MWBES Farm Survey, and for 1982/83 and 1983/84 unpublished estimates were provided by the MWBES (R. Davison, pers. comm.). For the stochastic component of the projection, triangular probability distributions were set up based on published Class 4 lambing percentages and wool production for the 20 year period 1961/62 to 1980/81. Calving percentages were not published before 1970/71 so an 11 year series was used for this variable. A statistical summary of these series is presented in Table 11.3.
TABLE 11.2
Correlation Matrix for Livestock and Wool Prices

<table>
<thead>
<tr>
<th>Prices</th>
<th>Wool</th>
<th>Prime Lambs</th>
<th>Store Lambs</th>
<th>Two-tooth Ewes</th>
<th>Cull Ewes</th>
<th>Weaner Cattle</th>
<th>Prime Steers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prime Lambs</td>
<td>0.565</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Store Lambs</td>
<td>0.560</td>
<td>0.832</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two-tooth Ewes</td>
<td>0.610</td>
<td>0.706</td>
<td>0.690</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cull Ewes</td>
<td>0.565</td>
<td>0.727</td>
<td>0.756</td>
<td>0.943</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weaner Cattle</td>
<td>-0.254</td>
<td>0.266</td>
<td>0.128</td>
<td>0.126</td>
<td>0.168</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prime Steers</td>
<td>-0.220</td>
<td>0.269</td>
<td>0.113</td>
<td>0.016</td>
<td>0.091</td>
<td>0.934</td>
<td></td>
</tr>
<tr>
<td>Cull Cows</td>
<td>-0.164</td>
<td>0.131</td>
<td>0.053</td>
<td>-0.019</td>
<td>0.044</td>
<td>0.905</td>
<td>0.906</td>
</tr>
</tbody>
</table>
### TABLE 11.3

**Statistical Summary of Production Parameter Series — 1961/62 to 1980/81**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Median</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Runs test α</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wool cut</td>
<td>kg/s.u.</td>
<td>5.38</td>
<td>0.18</td>
<td>5.35</td>
<td>5.06</td>
<td>5.76</td>
<td>0.50</td>
</tr>
<tr>
<td>Lambing Rate</td>
<td>%</td>
<td>94.00</td>
<td>2.67</td>
<td>93.90</td>
<td>90.50</td>
<td>100.90</td>
<td>0.36</td>
</tr>
<tr>
<td>Calving Rate *</td>
<td>%</td>
<td>82.73</td>
<td>1.42</td>
<td>82.00</td>
<td>81.00</td>
<td>85.00</td>
<td>0.60</td>
</tr>
</tbody>
</table>

* for 11 year series 1970/71 to 1980/81
11.4 Supplementary Minimum Price Analysis

11.4.1 Projections with and without S.M.P.s - 1981/82 to 1990/91.

The first experiment in the analysis was a comparison of projected average farm performance with and without S.M.P.s for the period 1981/82 to 1990/91. The model was run first with historical market prices for years 1981/82 to 1983/84 and with prices after 1983/84 drawn from the long-term historical price distributions. Then, for the treatment with S.M.P.s, the estimated market prices for 1981/82 to 1983/84 were replaced with the supplemented prices. For the stochastically generated prices over the period 1984/85 to 1990/91, each price was generated and compared with the appropriate S.M.P. value; where the S.M.P. exceeded the generated price, the S.M.P. value was substituted. The S.M.P.s were assumed to remain at their 1983/84 levels and were inflated in line with product prices. Each treatment, with and without S.M.P.s, was replicated 25 times using the same set of random number seeds.

The results are presented in Tables 11.4 and 11.5 and illustrated graphically using selected model responses and associated standard deviations in Figures 11.1 to 11.5. The response distributions from these and subsequent model experiments were tested for normality using the Shapiro-Wilk test (Shapiro and Wilk, 1965). Except for the deferred maintenance and investment distributions, both of which were positively skewed with a lower limit of zero, the hypothesis of normality could not be rejected at the 5 per cent level of significance. It was concluded, therefore, that the mean and standard
### TABLE 11.4

Five Year Annual Averages for Model Responses, and Associated Standard Deviations, for Simulated Years 1986/87 to 1990/91—Various Price and S.M.P. Scenarios

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Standard Deviation</td>
<td>Mean</td>
<td>Standard Deviation</td>
</tr>
<tr>
<td>Gross Revenue</td>
<td>107180</td>
<td>11670</td>
<td>104720</td>
<td>12690</td>
</tr>
<tr>
<td>Expenditure</td>
<td>81290</td>
<td>2780</td>
<td>79220</td>
<td>2800</td>
</tr>
<tr>
<td>After tax Cash Surplus</td>
<td>14970</td>
<td>7830</td>
<td>15280</td>
<td>8690</td>
</tr>
<tr>
<td>Consumption</td>
<td>14520</td>
<td>2020</td>
<td>14470</td>
<td>2150</td>
</tr>
<tr>
<td>Tax Paid</td>
<td>10910</td>
<td>2370</td>
<td>10210</td>
<td>2580</td>
</tr>
<tr>
<td>Reserves</td>
<td>55440</td>
<td>4930</td>
<td>50720</td>
<td>7310</td>
</tr>
<tr>
<td>Total Assets</td>
<td>812900</td>
<td>30580</td>
<td>801720</td>
<td>30960</td>
</tr>
<tr>
<td>Equity</td>
<td>0.893</td>
<td>0.007</td>
<td>0.897</td>
<td>0.008</td>
</tr>
<tr>
<td>Funds Borrowed</td>
<td>10218</td>
<td>3833</td>
<td>10490</td>
<td>4180</td>
</tr>
<tr>
<td>Deferred Maintenance</td>
<td>380</td>
<td>1100</td>
<td>815</td>
<td>1750</td>
</tr>
<tr>
<td>Investment</td>
<td>2150</td>
<td>2670</td>
<td>1050</td>
<td>1940</td>
</tr>
<tr>
<td>Potential Stock Units</td>
<td>4082</td>
<td>24</td>
<td>4055</td>
<td>16</td>
</tr>
<tr>
<td>Actual Stock Units</td>
<td>3987</td>
<td>111</td>
<td>3942</td>
<td>111</td>
</tr>
</tbody>
</table>
TABLE 11.5
Average Model Responses, and Associated Standard Deviations, for Simulated Year 1990/91 - Various Price and S.M.P. Scenarios

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Gross Revenue</td>
<td>110860</td>
<td>108910</td>
<td>110000</td>
<td>87740</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>13910</td>
<td>14780</td>
<td>14810</td>
<td>11850</td>
</tr>
<tr>
<td>Mean Expenditure</td>
<td>85590</td>
<td>83720</td>
<td>85090</td>
<td>75670</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>3370</td>
<td>3350</td>
<td>3460</td>
<td>2560</td>
</tr>
<tr>
<td>Mean After tax Cash Surplus</td>
<td>13900</td>
<td>13820</td>
<td>13650</td>
<td>4910</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>9360</td>
<td>10010</td>
<td>10020</td>
<td>7980</td>
</tr>
<tr>
<td>Mean Consumption</td>
<td>13800</td>
<td>13650</td>
<td>13580</td>
<td>4910</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>2310</td>
<td>2400</td>
<td>2400</td>
<td>2010</td>
</tr>
<tr>
<td>Mean Tax Paid</td>
<td>11380</td>
<td>11370</td>
<td>11260</td>
<td>7160</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>2390</td>
<td>2750</td>
<td>2750</td>
<td>2280</td>
</tr>
<tr>
<td>Mean Reserves</td>
<td>54430</td>
<td>51260</td>
<td>53320</td>
<td>33490</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>5560</td>
<td>7920</td>
<td>6280</td>
<td>3870</td>
</tr>
<tr>
<td>Mean Total Assets</td>
<td>823170</td>
<td>811280</td>
<td>821080</td>
<td>751750</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>38810</td>
<td>38370</td>
<td>38560</td>
<td>31034</td>
</tr>
<tr>
<td>Mean Equity</td>
<td>0.90</td>
<td>0.90</td>
<td>0.90</td>
<td>0.92</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Mean Funds Borrowed</td>
<td>9690</td>
<td>10080</td>
<td>9740</td>
<td>5330</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>3940</td>
<td>4460</td>
<td>4420</td>
<td>3730</td>
</tr>
<tr>
<td>Mean Deferred Maintenance</td>
<td>650</td>
<td>960</td>
<td>2000</td>
<td>1810</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>1710</td>
<td>2000</td>
<td>1810</td>
<td>1810</td>
</tr>
<tr>
<td>Mean Investment</td>
<td>1900</td>
<td>1480</td>
<td>1810</td>
<td>2730</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>2810</td>
<td>2500</td>
<td>1810</td>
<td>0</td>
</tr>
<tr>
<td>Mean Potential Stock Units</td>
<td>4111</td>
<td>4065</td>
<td>4106</td>
<td>4022</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>40</td>
<td>20</td>
<td>41</td>
<td>52</td>
</tr>
<tr>
<td>Mean Actual Stock Units</td>
<td>4013</td>
<td>3970</td>
<td>4012</td>
<td>3968</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>126</td>
<td>120</td>
<td>126</td>
<td>100</td>
</tr>
</tbody>
</table>

==============================================
deviation would be sufficient to describe the model response distributions, bearing in mind the non-normality of the above mentioned distributions.

(a) Gross Revenue

Clearly, S.M.P.s have had a significant effect on average gross revenue during the period 1981/82 to 1983/84 (see Figure 11.1). The model projections indicated that this effect ranged from a revenue supplement of around $17,000 in 1981/82 to a projected $10,000 in 1983/84. Longer term average supplementation, given that the long-term price probability distributions applied, was approximately $2,000 or 2 per cent of gross revenue per annum (Table 11.4). The standard deviation of future annual gross revenue with S.M.P.s was reduced from around $12,700 to $11,700. The projections show that, even with S.M.P.s, the real levels of gross revenue encountered during the years 1981/82 to 1983/84 were low compared with the long-term average. The assumed return in 1984/85 to prices based on long-term historical frequency distribution, therefore, implies a high probability of significantly better market conditions. Consequently, for any particular year, only in a small proportion of replicates do S.M.P.s significantly supplement revenue.

(b) Consumption, Taxation and Reserves

Annual consumption (Figure 11.2) increased, as a result of S.M.P.s, by between $2,700 and $3,600 during the period 1981/82 to 1983/84. In the longer term, the expected increase in annual
FIGURE 11.1
Gross Revenue Projections With and Without S.M.P.s

GROSS REVENUE (1980/81 DOLLARS)

\[ \text{YEAR: } 82, 83, 84, 85, 86, 87, 88, 89, 90, 91 \]

- △ Without S.M.P.s (1982–91)
- ○ With S.M.P.s (1982–91)
FIGURE 11.2
Consumption Projections With and Without S.M.P.s

Without S.M.P.s (1982-91)

With S.M.P.s (1982-91)
consumption would be around $400, while the reduction in standard deviation of annual consumption would be of the order of $130 (from $2,150 to $2,020). An average of $2,600 extra tax was paid each year for the years 1981/82 to 1983/84. Longer term increases in expected level of tax paid were of the order of $700 per annum.

Supplementary Minimum Prices had a significant effect on reserve levels; without S.M.P.s the model projected a decline in reserves to below $40,000 before a recovery to around $51,000 for years 7 to 10. With S.M.P.s, expected reserves remained at levels between $2,000 and $12,000 higher throughout the projection.

(c) Investment and Disinvestment

The responses described above indicate the various "sinks" for the extra revenue from S.M.P.s which do not directly maintain or increase the productive resource base of the farm i.e. increased consumption, taxation and reserves. Given that one of the stated objectives of S.M.P.s was to encourage an "expansion of output" (see Chapter 2), the effect of S.M.P.s on the projected levels of deferred maintenance and on-farm investment is of particular interest (see Figures 11.3 and 11.4). Model results indicated that the level of deferred maintenance in the period 1981/82 to 1983/84 would have been substantial in the absence of S.M.P.s, accumulating to a level of around $16,000 per farm by 1983/84. With S.M.P.s, deferred maintenance only occurred in 1983/84 and only to the extent of approximately $1,900 per farm. In neither case was there significant investment over this period.
FIGURE 11.3
Deferred Maintenance Projections With and Without S.M.P.s

FIGURE 11.4
Annual Investment Levels With and Without S.M.P.s
For the ex ante stage of the projections the model indicated a wide range of investment/disinvestment scenarios, depending on the particular sequence of price and seasonal conditions in a replicate. Taking the extremes that prevailed in year 6 without S.M.P.s, for example, one replicate projected deferred maintenance of approximately $4,100 while another projected investment of $10,000. Taking the means of the response distributions for the without-S.M.P. projection for the five years 1986/87 to 1990/91 (see Table 11.4), the model results indicate an average deferred maintenance level of $815 per year and an average investment level of $1,050; for the with-S.M.P. projection the average deferred maintenance level was $380 per year and the average investment level was $2,150.

(d) Stock Numbers

The net effect of these differences in investment and disinvestment levels is apparent in the potential stock carrying capacity projections (Figure 11.5). The projections with and without S.M.P.s do not differ markedly until year 5 (1985/86) when the significant levels of deferred maintenance which occurred without S.M.P.s results in a reduction of 148 stock units in stock carrying capacity. This loss is recovered by year 7 but by year 10 stock carrying potential is still only 4,065 stock units, 13 stock units above starting conditions. With S.M.P.s, significant levels of disinvestment do not occur; rather, increased investment leads to a steady increase in stock carrying capacity after year 5 to reach 4,111 in year 10.
FIGURE 11.5
Potential Stock Unit Projections With and Without S.M.P.s

△ Without S.M.P.s (1982–91)
○ With S.M.P.s (1982–91)
Actual stock numbers are heavily influenced by seasonal conditions as well as the effects of investment/disinvestment described above. In particular the drought conditions of 1983, reflected in the simulation by a heavy culling rate for 1983/84, led to a significant fall in stock numbers during 1983/84. Stochastic replication from this point on led to a wide range of possible outcomes for both projections, some involving significant increases in stock units, and some significant decreases. The standard deviation of year 10 stock units was around 120 for both projections.

Taking the actual mean stock unit projections, with and without S.M.P.s, these show a steady rate of recovery from 1983/84 levels although without S.M.P.s the recovery is delayed (due to deferred maintenance) and slower (due to reduced investment). In absolute terms, however, the difference in actual stock units between the two projections (comparing means for each year) is not great; it is never more than 73 stock units or 2 per cent. This reflects the extent of "buffering" which appears to be possible in the hill country pastoral system. The impact of significant reductions in income can be absorbed for some time through reduced consumption, taxation and reserves, and through deferred maintenance spending, without seriously impairing the productive base of the system. Similarly, an increase in gross revenue seems likely to be distributed to a number of uses, most of which will not have a direct impact on the productive capacity of the farm.
(e) Disposition of Extra Revenue

The model provides a method of estimating the relative disposition of the extra revenue provided by S.M.P.s over the simulated period. This was done by finding the differences between the sums of the various mean cash flows in the projections with and without S.M.P.s, and expressing these as a percentage of the difference in gross revenue attributable to S.M.P.s. The breakdown was done at the end of year 4 to show the short-run effects of S.M.P.s, and at the end of year 10 to determine the long-term effects. The distribution of the extra income cannot be determined precisely because of the dynamics of the system, the growth of the farm over time, and the effect of extra income on funds borrowed; however, the estimated figures provide a useful insight into the use made of direct income subsidies. The results are shown in Table 11.6.

In the short-term the income supplement was used mainly for the most immediately pressing categories of expenditure i.e. operating expenses and consumption, with a significant proportion of the balance being added to reserves. Also, increased taxable income led to an immediate taxation "claw-back" of 15 per cent of the value of the supplement.

Over the longer term the total real increase in gross revenue was approximately $60,000. While most of this increase was directly attributable to S.M.P.s (and particularly to S.M.P.s in the first three years of the projection), some of the increase was due to the extra stock units that were maintained with the help of S.M.P.s. As the
### TABLE 11.6

**Estimated Distribution of Extra Revenue from Supplementary Minimum Prices between Alternative Uses ($1980/81)**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$</td>
<td>$</td>
</tr>
<tr>
<td><strong>Total S.M.P. Supplement</strong></td>
<td>42820</td>
<td>59960 *</td>
</tr>
<tr>
<td><strong>Plus extra funds borrowed</strong></td>
<td>7760</td>
<td>7490</td>
</tr>
<tr>
<td></td>
<td><strong>50580 (102)</strong></td>
<td><strong>67450 (103)</strong></td>
</tr>
<tr>
<td><strong>Expenditure including extra debt servicing</strong></td>
<td>10150 20</td>
<td>22710 35</td>
</tr>
<tr>
<td><strong>Consumption</strong></td>
<td>11300 23</td>
<td>12670 19</td>
</tr>
<tr>
<td><strong>Taxation</strong></td>
<td>7240 15</td>
<td>12340 19</td>
</tr>
<tr>
<td><strong>Reserves</strong></td>
<td>11720 24</td>
<td>3170 5</td>
</tr>
<tr>
<td><strong>Reduced deferred maintenance</strong></td>
<td>3460 7</td>
<td>300 &lt; 1</td>
</tr>
<tr>
<td><strong>On-farm investment</strong></td>
<td>1190 2</td>
<td>9570 15</td>
</tr>
<tr>
<td><strong>Off-farm investment (other)</strong></td>
<td>4660 9</td>
<td>4500 7</td>
</tr>
<tr>
<td></td>
<td><strong>49720 100</strong></td>
<td><strong>65260 100</strong></td>
</tr>
</tbody>
</table>

* will include some extra revenue generated by extra stock units carried.
extra revenue will tend to be distributed in the same way regardless of its source, the long-term distribution pattern shown in Table 11.6 is relevant to this discussion. This distribution shows that, in the longer term, extra funds which were temporarily deposited as reserves are used for on-farm investment and to "catch up" on accumulated deferred maintenance. While the proportion of S.M.P. payments used for on-farm investment increased in the long-term it still only accounted for 15 per cent of the extra revenue.

The importance of general expenditure as a sink for S.M.P. payments also increased in the long-term. In the model this item includes debt servicing costs and maintenance costs after capital investment (both of which increase with S.M.P.s), as well as general operating expenses, which were assumed to increase at the rate of 2 per cent per annum relative to the increase in expected income. It is assumed in the model that there is some degree of discretionary spending with respect to general operating expenditure, and that, in the short-term, marginal changes in annual operating expenditure will not have a significant effect on farm production. In this case, however, there was a long-term difference totalling $22,700 over 10 years. This change was of the order of 3 per cent in total general expenditure. To the extent that this change would affect the level of production, so the model may underestimate the effect of S.M.P.s.

In the long-term, the "claw-back" of extra revenue through taxation was of the order of 20 per cent, and represents a significant return of funds to the government.
11.4.2 The effect of suspending S.M.P.s after 1984/85.

(a) With historical price distribution

The next two policy "treatments" explored the effect of suspending S.M.P.s and gave very similar results. In the first case, S.M.P.s remained operative after 1983/84 at 1983/84 levels but were not inflated in line with product prices as was the case in the previous experiment. A 6 per cent inflation rate was assumed for product prices after 1983/84 with an 8 per cent inflation rate for costs. In the other case, S.M.P.s were maintained at 1983/84 levels in nominal terms until the end of 1984/85, after which time they ceased to operate. (The Government appears to be committed to the continued operation of S.M.P.s or equivalent support until the end of the 1984/85 season.) For both projections, stochastic prices were again drawn from the long-term historical price distribution.

Supplementary Minimum Prices at nominal 1983/84 levels had minimal and decreasing effect on revenue after 1984/85 (less than a 1 per cent supplement to gross revenue); consequently the projections from both treatments were very similar. For discussion purposes here only the results from the "no policy" treatment, where S.M.P.s were discontinued after 1984/85, are used to assess the effect of discontinuing the scheme. Results are presented in Tables 11.4 and 11.5 and Figures 11.6 to 11.10.

As might be expected, the projected performance of the farming system in the long-term was intermediate between the "no S.M.P.s at
FIGURE 11.6
Gross Revenue Projections under Different Price and S.M.P. Scenarios

- ○ With S.M.P.s (1982-91)
- □ S.M.P.s Suspended 1985
- ◊ S.M.P.s Suspended 1985 (20% price reduction)
FIGURE 11.7
Consumption Projections under Different Price and S.M.P. Scenarios

- With S.M.P.s (1982-91)
- S.M.P.s Suspended 1985
- S.M.P.s Suspended 1985 (20% price reduction)
FIGURE 11.8
Deferred Maintenance Projections under Different Price and S.M.P. Scenarios

![Deferred Maintenance Projections Graph](image)

- With S.M.P.s (1988–91)
- S.M.P.s Suspended 1985
- S.M.P.s Suspended 1986 (20% price reduction)

FIGURE 11.9
Annual Investment Projections under Different Price and S.M.P. Scenarios

![Annual Investment Projections Graph](image)

- With S.M.P.s (1988–91)
- S.M.P.s Suspended 1985
- S.M.P.s Suspended 1986 (20% price reduction)
FIGURE 11.10
Potential Stock Unit Projections under Different Price and S.M.P. Scenarios

- With S.M.P.s (1982–91)
- S.M.P.s Suspended 1985
- S.M.P.s Suspended 1985 (20% price reduction)
all" projection and the projection with S.M.P.s maintained at real 1983/84 levels. After S.M.P.s were discontinued, annual expected gross revenue was about 1.2 per cent lower than with S.M.P.s maintained at real 1983/84 levels. This resulted in a small decrease in most expenditure items and ultimately led to slightly lower stock numbers by year 10. Overall the mean projection was one of slight growth with expected potential stock carrying capacity increasing from 4052 stock units in 1981/82 to 4106 in 1990/91, with a standard deviation of 41 stock units. The actual stock unit projection for 1990/91, affected as it is by climatic conditions, displayed much wider variation; a mean of 4012 stock units was indicated with a standard deviation of 126 stock units. The replicate extremes ranged from 3665 to 4180 stock units.

If, as was assumed in these experiments, the long-term past price distribution is applicable in the future, i.e. future prices will display a similar frequency distribution to those which have occurred in the past, then it would appear that the removal of S.M.P.s would not reduce farm revenue by more than an average of about 1.2 per cent per annum. Consequently, given the potential inherent in the pastoral system for buffering the effects of short-term price slumps, it would appear that removal of S.M.P.s after 1984/85 would not have a significant impact on hill country production. Based on the without-S.M.P. projection it could similarly be argued that S.M.P.

9 This does not preclude the possibility that in some years the effect of S.M.P.s would be substantial; for one replicate, for example, the supplement to gross revenue in one year was of the order of 12 per cent; for most replicates in most years, however, no supplementation occurred.
payments during the period 1981/82 to 1983/84 will have little long-term effect on production if product prices recover after 1983/84.

While observing that "buffering" minimises the production effects of low prices it may not occur without considerable hardship on the part of some farm families, caused through reduced consumption. In this respect S.M.P.s appear to have provided a significant supplement to consumption over the period 1981/82 to 1983/84; a supplement of the order of 33 per cent over estimated consumption without S.M.P.s. To the extent that this supplement reduced genuine hardship it could be regarded as an appropriate use for taxpayers' funds; this use could be questioned, however, where it represents a supplement to an already adequate level of consumption.

(b) With reduced prices

The next simulated treatment relaxed the assumption that future prices will be consistent with the long-term past. If the low product prices of the early 1980's are indicative of a permanent decline in real price levels, rather than a short-term aberration, then a significant impact on hill country farming could be expected. To test the effect of such a permanent shift in product prices, the parameters of the price distributions used in model were all reduced by 20 per cent. The projection covered the same period as previous projections with historical price levels (including S.M.P.s) applying for the first three years (1981/82 to 1983/84) and product prices generated from the modified price distributions for the subsequent seven years (1984/85 to 1990/91). Supplementary Minimum Prices at nominal 1983/84 levels were
operative for 1984/85 and were then discontinued. Results are shown in Tables 11.4 and 11.5 with projections for selected model responses shown graphically in Figures 11.6 to 11.10.

The reduction in the price distribution brought the estimated mean gross revenue level over the period down from approximately $106,000 to around $85,000 per annum (in 1980/81 dollars). This was similar to that which actually occurred in 1981/82 and 1982/83 (see Figure 11.6). A relatively large standard deviation was indicated for this annual gross revenue; typically around $10,000.

Mean expenditure displayed a steady upward trend resulting mainly from the assumed 2 per cent per annum relative increase in input prices. This led to a low and declining after-tax cash surplus which was reflected in a downward trend for expected consumption (Figure 11.7), taxation and reserves, and an upward trend for the accumulated value of deferred maintenance (Figure 11.8). Investment was negligible (Figure 11.9) and potential stock carrying capacity (Figure 11.10) and actual stock numbers carried, declined over the period. The mean decline in actual stock units over the 10 year projection was 84 (2 per cent) with a standard deviation of 100. Replicate extremes for terminal stock units ranged from just maintaining stock unit numbers over the period to a decline of 390 or around 10 per cent.

As in previous experiments, these results indicate that stock numbers and thus total production are price inelastic, whereas consumption, taxation, reserve level, deferred maintenance and investment are relatively sensitive to price changes. Price
elasticities for a range of model responses were calculated and are presented in Table 11.7. The elasticities were estimated by comparing the year 10 projection values for the treatment where the historical price distribution was used, against the values generated using the 20 per cent discounted price distributions. Both these sets of values are shown in Table 11.5. From a welfare point of view the decline in mean consumption is of interest - it represents a 36 per cent fall relative to 1980/81 levels and could be expected to cause hardship and adjustment problems for many farm families.

11.5 Alternative Farm Support Policies

If S.M.P.s were maintained indefinitely at 1983/84 levels in real terms, and assuming that the long-term price probability distribution continued to apply, then S.M.P.s would provide an average annual subsidy of approximately $1,200 per farm or 1.2 percent of gross revenue. Two alternative methods of providing the same average level of subsidy were examined; these were a 1.2 percent subsidy on the value of production, and an investment-linked input subsidy equivalent to 50 percent of on-farm (non-livestock) investment. This latter policy would conceptually be similar in effect to a fertiliser subsidy or the Land Development Encouragement Loans. A third alternative (not strictly comparable) was also simulated whereby the assumed 2 percent per annum decline in the terms of trade was eliminated. The results of simulating the effects of these policies are presented in Tables 11.8 and 11.9 and in Figures 11.11 to 11.15.
TABLE 11.7

Price Elasticities for Model Responses Based on a Twenty Percent Reduction in the Product Price Probability Distributions

<table>
<thead>
<tr>
<th>Elasticities</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Revenue</td>
<td>1.01</td>
</tr>
<tr>
<td>Expenditure</td>
<td>0.55</td>
</tr>
<tr>
<td>Consumption</td>
<td>1.66</td>
</tr>
<tr>
<td>Taxation</td>
<td>1.82</td>
</tr>
<tr>
<td>Reserves</td>
<td>1.86</td>
</tr>
<tr>
<td>Deferred Maintenance</td>
<td>-44.00</td>
</tr>
<tr>
<td>Total Assets</td>
<td>0.42</td>
</tr>
<tr>
<td>Equity Per Cent</td>
<td>-0.11</td>
</tr>
<tr>
<td>Borrowing</td>
<td>2.26</td>
</tr>
<tr>
<td>Investment</td>
<td>5.00</td>
</tr>
<tr>
<td>Potential Stock Units</td>
<td>0.17</td>
</tr>
<tr>
<td>Actual Stock Units</td>
<td>0.05</td>
</tr>
</tbody>
</table>
### TABLE 11.8

Five Year Annual Averages for Model Responses and Associated Standard Deviations, for Simulated Years 1986/87 to 1990/91 – Various Farm Support Policies

<table>
<thead>
<tr>
<th></th>
<th>S.M.P.s Suspended after 1984/85</th>
<th>S.M.P.s Operative 1981/82 to 1990/91</th>
<th>Output Value Subsidy (1.2 per cent)</th>
<th>Investment Subsidy (50 per cent)</th>
<th>Constant Terms of Trade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Standard Deviation</td>
<td>Mean</td>
<td>Standard Deviation</td>
<td>Mean</td>
</tr>
<tr>
<td>Gross Revenue</td>
<td>105910</td>
<td>12760</td>
<td>107180</td>
<td>11670</td>
<td>107170</td>
</tr>
<tr>
<td>Expenditure</td>
<td>80800</td>
<td>2960</td>
<td>81290</td>
<td>2780</td>
<td>81240</td>
</tr>
<tr>
<td>After tax cash surplus</td>
<td>14420</td>
<td>8660</td>
<td>14970</td>
<td>7830</td>
<td>15010</td>
</tr>
<tr>
<td>Consumption</td>
<td>14230</td>
<td>2180</td>
<td>14520</td>
<td>2020</td>
<td>14500</td>
</tr>
<tr>
<td>Tax paid</td>
<td>10690</td>
<td>2570</td>
<td>10910</td>
<td>2370</td>
<td>10920</td>
</tr>
<tr>
<td>Reserves</td>
<td>54530</td>
<td>5440</td>
<td>55440</td>
<td>4930</td>
<td>55190</td>
</tr>
<tr>
<td>Total Assets</td>
<td>811430</td>
<td>30710</td>
<td>812900</td>
<td>30580</td>
<td>814690</td>
</tr>
<tr>
<td>Equity</td>
<td>0.894</td>
<td>0.008</td>
<td>0.893</td>
<td>0.007</td>
<td>0.893</td>
</tr>
<tr>
<td>Funds Borrowed</td>
<td>10010</td>
<td>4150</td>
<td>10218</td>
<td>3833</td>
<td>10230</td>
</tr>
<tr>
<td>Deferred Maintenance</td>
<td>630</td>
<td>1530</td>
<td>380</td>
<td>1100</td>
<td>520</td>
</tr>
<tr>
<td>Investment</td>
<td>1940</td>
<td>2610</td>
<td>2150</td>
<td>2670</td>
<td>2210</td>
</tr>
<tr>
<td>Potential stock units</td>
<td>4080</td>
<td>25</td>
<td>4082</td>
<td>24</td>
<td>4082</td>
</tr>
<tr>
<td>Actual stock units</td>
<td>3986</td>
<td>111</td>
<td>3987</td>
<td>111</td>
<td>3987</td>
</tr>
</tbody>
</table>
### TABLE 11.9
**Average Model Responses, and Associated Standard Deviations, for Simulated Year 1990/91 - Various Farm Support Policies**

<table>
<thead>
<tr>
<th>S.M.P.s Suspended after 1984/85</th>
<th>S.M.P.s Operative 1981/82 to 1990/91</th>
<th>Output Value Subsidy (1.2 per cent)</th>
<th>Investment Subsidy (50 per cent)</th>
<th>Constant Terms of Trade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Gross Revenue</td>
<td>110000</td>
<td>110860</td>
<td>111320</td>
<td>110260</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>14810</td>
<td>13910</td>
<td>14710</td>
<td>14510</td>
</tr>
<tr>
<td>Mean Expenditure</td>
<td>85090</td>
<td>85590</td>
<td>85620</td>
<td>85580</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>3460</td>
<td>3370</td>
<td>3510</td>
<td>3630</td>
</tr>
<tr>
<td>Mean After tax cash surplus</td>
<td>13650</td>
<td>13900</td>
<td>14210</td>
<td>10130</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>10020</td>
<td>9360</td>
<td>14960</td>
<td>10130</td>
</tr>
<tr>
<td>Mean Consumption</td>
<td>13580</td>
<td>13800</td>
<td>13870</td>
<td>2420</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>2750</td>
<td>2390</td>
<td>11490</td>
<td>2770</td>
</tr>
<tr>
<td>Mean Tax Paid</td>
<td>11260</td>
<td>11380</td>
<td>13970</td>
<td>6100</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>6280</td>
<td>5560</td>
<td>54110</td>
<td>6340</td>
</tr>
<tr>
<td>Mean Reserves</td>
<td>53320</td>
<td>54430</td>
<td>54110</td>
<td>6340</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>38560</td>
<td>38810</td>
<td>382590</td>
<td>39680</td>
</tr>
<tr>
<td>Mean Total Assets</td>
<td>821080</td>
<td>823170</td>
<td>825090</td>
<td>826690</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>38560</td>
<td>38810</td>
<td>382590</td>
<td>39680</td>
</tr>
<tr>
<td>Mean Equity</td>
<td>0.90</td>
<td>0.90</td>
<td>0.90</td>
<td>0.90</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Mean Funds Borrowed</td>
<td>9740</td>
<td>9690</td>
<td>9910</td>
<td>4430</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>4420</td>
<td>3940</td>
<td>9910</td>
<td>4430</td>
</tr>
<tr>
<td>Mean Deferred Maintenance</td>
<td>810</td>
<td>650</td>
<td>700</td>
<td>1680</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>1810</td>
<td>1710</td>
<td>700</td>
<td>1680</td>
</tr>
<tr>
<td>Mean Investment</td>
<td>1810</td>
<td>2730</td>
<td>2010</td>
<td>2940</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>2730</td>
<td>2810</td>
<td>2010</td>
<td>2940</td>
</tr>
<tr>
<td>Mean Potential Stock Units</td>
<td>4106</td>
<td>4111</td>
<td>4112</td>
<td>4135</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>4111</td>
<td>4112</td>
<td>4112</td>
<td>4135</td>
</tr>
<tr>
<td>Mean Actual Stock Units</td>
<td>4012</td>
<td>4013</td>
<td>4014</td>
<td>4026</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>4013</td>
<td>4014</td>
<td>4014</td>
<td>4026</td>
</tr>
</tbody>
</table>
FIGURE 11.11
Gross Revenue Projections under Different Farm Support Policies

- With S.M.P.s (1982–91)
- S.M.P.s Suspended 1985 (no policy)
- Price Subsidy (1.2% on output value)
- Investment Subsidy (50% of on-farm inv.)
- Constant Terms of Trade
**FIGURE 11.12**

Consumption Projections under Different Farm Support Policies

- With S.M.P.s (1982–91)
- S.M.P.s Suspended 1985 (no policy)
- Price Subsidy (1.2% on output value)
- Investment Subsidy (50% of on-farm inv.)
- Constant Terms of Trade
FIGURE 11.13
Deferred Maintenance Projections under Different Farm Support Policies

- With S.M.P.s (1982-91)
- S.M.P.s Suspended 1985 (no policy)
- Price Subsidy (1.2% on output value)
- Investment Subsidy (50% of on-farm inv.)
- Constant Terms of Trade

FIGURE 11.14
Annual Investment Projections under Different Farm Support Policies

- With S.M.P.s (1982-91)
- S.M.P.s Suspended 1985 (no policy)
- Price Subsidy (1.2% on output value)
- Investment Subsidy (50% of on-farm inv.)
- Constant Terms of Trade
FIGURE 11.15
Potential Stock Unit Projections under Different Farm Support Policies

- With S.M.P.s (1982-91)
- S.M.P.s Suspended 1985 (no policy)
- Price Subsidy (1.2% on output value)
- Investment Subsidy (50% of on-farm inv.)
- Constant Terms of Trade

YEARS

STOCK UNITS

84 85 86 87 88 89 90 91
11.5.1 Output subsidy.

The output subsidy was simulated by increasing all product prices by 1.2 per cent. The mean responses from this policy scenario were very similar to those generated with the S.M.P. projection although both the mean level of deferred maintenance and the mean level of investment were slightly higher. This reflects the fact that the payment of such an ad valorem subsidy would be weighted in favour of high income years whereas S.M.P.s are paid in low income years. The net effect was a minimal (one extra stock unit) increase in potential and actual stock units by year 10.

The most significant differences between the policies was in the variability of the responses. Whereas S.M.P.s tended to reduce income variability associated with market price instability, the output value subsidy tended to increase it, again because subsidy payments were weighted toward high income years. Consequently, there was a slight improvement in low income year conditions but not to the same extent as occurred with S.M.P.s. In practice, this situation would be exacerbated given the range of farm sizes and incomes, with smaller farms in low income years benefiting little from the subsidy. The relative effect of this type of policy under a range of farm sizes and conditions could be more fully explored using the model.

11.5.2 Investment subsidy.

Simulating the impact of the subsidy on farm investment expenditure gave some interesting comparative results. Considering the
average response values for years 6 through 10 (Table 11.8), the resulting increase in investment led to an increase in operating expenditure, a decrease in tax paid and an increase in potential and actual stock units, compared with the "no policy" situation where S.M.P.s were discontinued after 1984/85 and no alternative policy was substituted. Other responses remained relatively unchanged. These average responses, however, mask the dynamic effects of the policy and the significant change that occurred over time. These effects are better illustrated in Figures 11.11 to 11.15.

The investment subsidy had little impact on gross revenue and consumption until the latter stages of the simulated period when the income benefits of higher stock numbers were starting to be realised (see Figures 11.11 and 11.12). Investment levels, however, were considerably enhanced by the policy (see Figure 11.14) and, by the end of the simulated period, potential stock carrying capacity was 4,135 stock units compared with 4,111 with S.M.P.s, 4,112 with the output-value subsidy and 4,106 with S.M.P.s discontinued. The full financial effect of this relatively large increase in stock numbers would occur beyond the simulated period as actual stock units followed the increase in potential stock units.

While the investment subsidy policy could be expected to lead to an increase in production and income, it did nothing to moderate the variability of income; the standard deviations for model responses tended to be similar to, if not slightly larger than, the corresponding values for the "no policy" free-market situation.
11.5.3 **Reduced price inflation.**

The third alternative was not directly comparable with the other policies. This involved a general reduction in the rate of increase in farm input prices. Such a reduction could be brought about by general economic policies or through agricultural research. For illustrative purposes it was assumed that the 2 per cent per annum decline in the terms of trade, which applied for other projections, was effectively eliminated by the "cost reduction" policy. No attempt was made to estimate the cost of such policies. As with the other policy scenarios, the continuation of S.M.P.s at nominal 1983/84 values until 1984/85 was assumed; thereafter, no other policy operated.

The reduction in expenditure, made possible by the reduced cost inflation, allowed a significant increase in after-tax cash surplus, consumption (Figure 11.12), reserves, total assets and investment (Figure 11.14). Potential stock units (Figure 11.15) increased to 4,126 by the end of the simulated period, compared with 4,106 under the comparable scenario with declining terms of trade. The variability of responses tended to be reduced under the constant terms of trade conditions.

11.6 **Alternative Stabilisation Policies**

As described in Chapter 2, two other stabilisation "schemes" are currently in place but, largely due to the operation of the Supplementary Minimum Price Scheme, their stabilisation role has been minimal since 1980/81. These schemes are the buffer fund and stock
schemes operated by the New Zealand Meat and Wool Boards, and the Income Equalisation Deposit Scheme. Several experiments were conducted with the model to assess the stabilising potential of these type of schemes and to compare their impact with that of S.M.P.s. A comparison was also made with a three year moving average price scheme. A summary of results from these projections is presented in Tables 11.10 and 11.11 and in Figures 11.17 to 11.21.

11.6.1 Buffer price scheme.

The first treatment in this experiment involved simulating the operation of a floor and trigger price scheme (referred to here as a "buffer price scheme") similar in principle to those operated by the Producer Boards. For purposes of comparison the floor prices for sheep, wool and beef were each set to match the 1983/84 value of S.M.P.s and were assumed to be maintained at that level in real terms.

Trigger prices were calculated based on the requirement that, over time, the schemes would be self-financing; administrative costs were ignored so that trigger prices were set so that expected revenue from skimming just equalled expected payouts for supplementation. Given triangular price distributions, the problem of setting an appropriate trigger price to offset a given floor price can be represented with the help of Figure 11.16 where A, B and C are the parameters of the triangular probability distribution, D is the floor price and E is the ceiling or trigger price.
TABLE 11.10

Five Year Annual Averages for Model Responses, and Associated Standard Deviations, for Simulated Years 1986/87 to 1990/91 – Various Price and Income Stabilisation Policies

<table>
<thead>
<tr>
<th></th>
<th>S.M.P.s Suspended after 1984/85</th>
<th>S.M.P.s Operative 1981/82 to 1990/91</th>
<th>Buffer Price Scheme</th>
<th>Moving Average Price Scheme</th>
<th>Income Equalisation Deposits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Standard Deviation</td>
<td>Mean</td>
<td>Standard Deviation</td>
<td>Mean</td>
</tr>
<tr>
<td>Gross Revenue</td>
<td>105910</td>
<td>12760</td>
<td>107180</td>
<td>11670</td>
<td>104800</td>
</tr>
<tr>
<td>Expenditure</td>
<td>80800</td>
<td>2960</td>
<td>81290</td>
<td>2780</td>
<td>80280</td>
</tr>
<tr>
<td>After tax cash surplus</td>
<td>14420</td>
<td>8660</td>
<td>14970</td>
<td>7830</td>
<td>13960</td>
</tr>
<tr>
<td>Consumption</td>
<td>14230</td>
<td>2180</td>
<td>14520</td>
<td>2020</td>
<td>14000</td>
</tr>
<tr>
<td>Tax Paid</td>
<td>10690</td>
<td>2570</td>
<td>10910</td>
<td>2370</td>
<td>10550</td>
</tr>
<tr>
<td>Reserves</td>
<td>54530</td>
<td>5440</td>
<td>55440</td>
<td>4930</td>
<td>54160</td>
</tr>
<tr>
<td>Total Assets</td>
<td>811430</td>
<td>30710</td>
<td>812900</td>
<td>30580</td>
<td>809370</td>
</tr>
<tr>
<td>Equity</td>
<td>0.894</td>
<td>0.008</td>
<td>0.893</td>
<td>0.007</td>
<td>0.894</td>
</tr>
<tr>
<td>Funds Borrowed</td>
<td>10010</td>
<td>4150</td>
<td>10218</td>
<td>3833</td>
<td>10020</td>
</tr>
<tr>
<td>Deferred Maintenance</td>
<td>630</td>
<td>1530</td>
<td>380</td>
<td>1100</td>
<td>430</td>
</tr>
<tr>
<td>Investment</td>
<td>1940</td>
<td>2610</td>
<td>2150</td>
<td>2670</td>
<td>1621</td>
</tr>
<tr>
<td>Potential stock units</td>
<td>4080</td>
<td>25</td>
<td>4082</td>
<td>24</td>
<td>4072</td>
</tr>
<tr>
<td>Actual stock units</td>
<td>3986</td>
<td>111</td>
<td>3987</td>
<td>111</td>
<td>3981</td>
</tr>
</tbody>
</table>
TABLE 11.11

Average Model Responses, and Associated Standard Deviations for Simulated Year 1990/91 - Various Price and Income Stabilisation Policies

<table>
<thead>
<tr>
<th>S.M.P.s Suspended after 1984/85</th>
<th>S.M.P.s Operative 1981/82 to 1990/91</th>
<th>Buffer Price Scheme</th>
<th>Moving Average Price Scheme</th>
<th>Income Equalisation Deposits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>Standard Deviation</td>
<td>Mean</td>
<td>Standard Deviation</td>
<td>Mean</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>--------------------------------------</td>
<td>---------------------</td>
<td>-----------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>Gross Revenue</td>
<td>110000</td>
<td>14810</td>
<td>110860</td>
<td>13910</td>
</tr>
<tr>
<td>Expenditure</td>
<td>85090</td>
<td>3460</td>
<td>85590</td>
<td>3370</td>
</tr>
<tr>
<td>After tax cash surplus</td>
<td>13650</td>
<td>10020</td>
<td>13900</td>
<td>9360</td>
</tr>
<tr>
<td>Consumption</td>
<td>13580</td>
<td>2400</td>
<td>13800</td>
<td>2310</td>
</tr>
<tr>
<td>Tax paid</td>
<td>11260</td>
<td>2750</td>
<td>11380</td>
<td>2390</td>
</tr>
<tr>
<td>Reserves</td>
<td>53320</td>
<td>6280</td>
<td>54430</td>
<td>5560</td>
</tr>
<tr>
<td>Total Assets</td>
<td>821080</td>
<td>38560</td>
<td>823170</td>
<td>38810</td>
</tr>
<tr>
<td>Equity</td>
<td>0.90</td>
<td>0.01</td>
<td>0.90</td>
<td>0.01</td>
</tr>
<tr>
<td>Funds Borrowed</td>
<td>9740</td>
<td>4420</td>
<td>9690</td>
<td>3940</td>
</tr>
<tr>
<td>Deferred Maintenance</td>
<td>810</td>
<td>1810</td>
<td>650</td>
<td>1710</td>
</tr>
<tr>
<td>Investment</td>
<td>1810</td>
<td>2730</td>
<td>1900</td>
<td>2810</td>
</tr>
<tr>
<td>Potential stock units</td>
<td>4106</td>
<td>41</td>
<td>4111</td>
<td>40</td>
</tr>
<tr>
<td>Actual stock units</td>
<td>4012</td>
<td>126</td>
<td>4013</td>
<td>126</td>
</tr>
</tbody>
</table>
FIGURE 11.16

Triangular Price Distribution with Floor and Ceiling Prices

The probability of the market price falling below the floor price (D) is the shaded area "d" represented mathematically as:

\[ d = \int_{A}^{D} \frac{x^2 - 2Ax}{(B-A)(C-A)} \, dx \]

Similarly, the probability of the market price exceeding the trigger price (E) is the shaded area "e" represented as:

\[ e = \int_{E}^{C} \frac{x^2 - 2Cx}{(B-C)(C-A)} \, dx \]

The appropriate ceiling price can be found by equating the two areas and solving for E to give:

\[ E = C - \sqrt{\frac{(D-A)^2}{(B-A)} \left( \frac{C-B}{B-A} \right)} \]

For comparison purposes the buffer price scheme projection was compared with the maintenance of S.M.P.s at 1983/84 levels in real terms. In both cases, the initial stages of the projections, from
1981/82 to 1983/84, simulated the actual historical conditions with the S.M.P. scheme in operation. For the buffer scheme simulation it was assumed that the scheme would be operative from the 1984/85 season.

As might be expected, the level and standard deviation of total gross revenue was lower than was the case with S.M.P.s; average annual gross revenue was approximately $2,500 or 2.3 per cent less (see Figure 11.17), while the standard deviation of gross revenue was $1,500 less. This result was indicative of other model responses such as after-tax cash surplus, consumption (Figure 11.18) and taxation. Annual average consumption, for example, was 3.5 per cent less and the standard deviation of consumption was $250 per year less; taxation was 4 per cent less and the standard deviation was $250 per year less. The average level of reserves was also slightly lower (2.5 per cent) but there was a negligible difference in the level of deferred maintenance (Figure 11.19); this latter result is logical given that the same floor price applied in each case. On the other hand, the effect on investment was more pronounced; with the buffer price scheme, average annual investment was 28 per cent less than with S.M.P.s (see Figure 11.20). As a result, by year 10, potential and actual stock units were, respectively, 17 and 12 stock units less under the buffer price scheme than the levels projected under S.M.P.s (see Figure 11.21).

As would be expected, a self-financing scheme will lead to lower levels of consumption, taxation, investment etc. than would be the case for a scheme involving significant levels of public funding. In particular, investment would be affected because the skimming effect of the ceiling price reduces available funds in high income years. A
Gross Revenue Projections under Different Stabilisation Policies

- With S.M.P.s (1982-91)
- S.M.P.s Suspended 1985 (no policy)
- Buffer Price Scheme
- Moving Average Price Scheme
- Income Equalisation Deposits
FIGURE 11.18
Consumption Projections under Different Stabilisation Policies

- With S.M.P.s (1982-91)
- S.M.P.s Suspended 1985 (no policy)
- Buffer Price Scheme
- Moving Average Price Scheme
- Income Equalisation Deposits

YEARS

84 85 86 87 88 89 90 91

CONSUMPTION (1980/81 DOLLARS)
FIGURE 11.19
Deferred Maintenance Projections under Different Stabilisation Policies

- With S.M.P.s (1988–91)
- S.M.P.s Suspended 1986 (no policy)
- Buffer Price Scheme
- Moving Average Price Scheme
- Income Equalisation Deposits

FIGURE 11.20
Annual Investment Projections under Different Stabilisation Policies

- With S.M.P.s (1988–91)
- S.M.P.s Suspended 1986 (no policy)
- Buffer Price Scheme
- Moving Average Price Scheme
- Income Equalisation Deposits
FIGURE 11.21
Potential Stock Unit Projections under Different Stabilisation Policies

- With S.M.P.s (1982–91)
- S.M.P.s Suspended 1985 (no policy)
- Buffer Price Scheme
- Moving Average Price Scheme
- Income Equalisation Deposits
relatively high proportion of those funds would normally be invested. It seems important to recognise that with a buffer price scheme, the transfer of funds from high to low income years tends to lead to a modified pattern of expenditure even if the net payments and receipts are equal over time. Investment expenditure tends to be reduced in favour of consumption and farm maintenance.

11.6.2 Moving average price scheme.

As pointed out in Chapter 2, self-financing buffer price and buffer fund schemes are inherently difficult to administer due primarily, to the problem of setting appropriate floor and ceiling prices. In recent years there appears to have been a trend toward stabilisation schemes based on automatic pricing formulas which are directly linked to the market price and which ensure (at least approximately) that the schemes are self-financing over time (Stoeckel, 1984). A typical basis for such "underwriting" schemes involves the establishment of a product price for the forthcoming season based on the weighted average of realised market returns for the two or more previous seasons. Such a scheme was advocated for the New Zealand pastoral sector by Zanetti et al. (1975).

To test the effect of such a scheme, the model was run using three-year moving average prices after 1983/84. As with the buffer price scheme simulation, the initial three years of the projection, 1981/82 to 1983/84, were deterministically generated based on historical parameters. Thereafter, prices were generated stochastically based on the historical price distribution. A moving
average price scheme would normally require a phase-in period during which the three-year moving average could be established; however, in order to generate projections which were comparable with other policy projections it was assumed that moving average prices, based on the historical price distribution, would become fully operative in 1964/65. As with the previously described experiments, the projection was replicated 25 times.

In comparison with the buffer price simulation, the mean value of most model responses were similar but the variability of those responses from year-to-year, and across replications, was significantly lower. There were, however, some notable exceptions to this general pattern. Expenditure, reserves, investment and potential stock units all exhibited a slight increase in variability. The reason for this would appear to be the carry-over effect of extremes of income which still occurred under the moving average price scheme, but which were effectively eliminated under the buffer price scheme. Although the probability of such extremes of income occurring was significantly reduced, as evidenced by the reduction in gross revenue variance (see Table 11.10), when they did occur they had a significant effect on some responses over a number of years. For example, because of lags and partial flow-on effects in the model, a high income year will tend to increase reserves and investment, and consequently, expenditure and potential stock units over the next two to four years. In this way the effect of income extremes on the variability of these responses tends to be amplified. The net effect is only small, however, and overall the policy would appear to be effective as a stabilisation measure. Significant reductions in the standard deviation of all model responses
occurred relative to those for the "no policy" treatment.

11.6.3 Reserve deposits.

The third form of stabilisation policy examined was one where farmers operate their own stabilisation fund by using Income Equalisation Deposits. To provide a basis for comparison it was assumed that the deposits in high income years would be used to maintain an available income "floor" approximately equal to that provided by S.M.P.s if they were maintained at 1983/84 levels in real terms. This floor, calculated from earlier simulation results was $85,000 in 1980/81 dollars. To calculate the appropriate income ceiling to support this floor, it was assumed, on the basis of a Shapiro-Wilk test, that the gross revenue distribution was normally distributed. Using the mean gross revenue value of $105,000 from the "no policy" simulation, the appropriate "ceiling income" level was set at $125,000. This value ensured that deposits balanced withdrawals over time. Interest payments on deposits were assumed to maintain the real value of deposits so that the real value of future income shortfalls could be covered.

Following the initial three years of the simulation, corresponding to 1981/82 to 1983/84, it was assumed that sufficient deposits were available to maintain the floor income if required. Although this is a hypothetical situation given that it is not likely to be the case in reality, it does provide for a simulated result that is comparable with that for the other policies examined.
The policy effectively reduced the variability of all model responses when compared with the "no policy" situation. The extent of the reduction was a function of the assumed band width between the floor and ceiling incomes; in this case the reduction tended to be slightly less than that achieved with the buffer price scheme and significantly less than that possible with the moving average price scheme. With respect to the average level of responses they were generally similar to the "no policy" projection. There was a reduction in the level of deferred maintenance (Figure 11.19) and a slight reduction in the level of investment (Figure 11.20). The net effect, however, was a minimal difference in the potential and actual stock units achieved (Figure 11.21).

The model projection did not show any reduction in the average level of tax paid. The main reason for this result was that the empirically estimated tax function used in the experiments did not reflect any significant change in marginal tax rate with income changes at the aggregate level (see Chapter 4). Given the potential for using farm investment and other expenditure to counteract the effects of income fluctuations, the value of, and need for, Income Equalisation Deposits to reduce the taxation effects of fluctuating incomes may have been overstated. More experiments with the model to assess the effects of Income Equalisation Deposits at the individual farm level would be useful. The specific tax schedule facing the individual farmer could be substituted for the aggregate tax function. From the current analysis, however, an indication can be gained of the level of deposits necessary to cover income shortfalls.
For a normal distribution of annual gross revenue with a mean of $105,000 and a standard deviation of approximately $12,500 (typical of the free-market "no policy" situation), the probability of a given shortfall below a given "floor income" level can be calculated. For example, for the assumed "floor income" of $85,000 the probability of any shortfall is approximately 5.5 per cent each year. For a range of shortfall levels the probability of occurrence is shown in Table 11.12.

### TABLE 11.12

<table>
<thead>
<tr>
<th>Shortfall $</th>
<th>Prob. %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5,000</td>
<td>3.2</td>
</tr>
<tr>
<td>5-10,000</td>
<td>1.5</td>
</tr>
<tr>
<td>10-15,000</td>
<td>0.5</td>
</tr>
<tr>
<td>&gt;15,000</td>
<td>0.3</td>
</tr>
</tbody>
</table>

The level of deposits regarded as appropriate by a farmer will depend on that farmer's attitude to risk. For example, under the circumstances described above, a farmer would need a deposit of approximately $10,000 to be 85 per cent certain of covering a shortfall when it occurs. If 95 per cent certainty was required then a deposit of around $15,000 would be necessary.

The deposit levels would have to be doubled to cover two successive shortfalls and trebled for three shortfalls. It would appear that farmers would have to be prepared to build up and maintain
large levels of deposits if such deposits were to play a significant income stabilising role. Even if these deposits could be held at market rates of interest, the opportunity cost could be high if profitable on-farm investment opportunities exist. Investment on the farm in high income years, with deferred maintenance and reduced operating expenditure in low income years, may be a more efficient strategy.

11.7 Conclusion

The approach taken in this Chapter has been to provide a relatively brief assessment of a range of farm support and stabilisation policies. These assessments were designed to illustrate the potential of the model as a policy analysis tool, and in each case they only represent part of what would be involved in a comprehensive policy analysis. Such an analysis could include sensitivity testing with policy-instruments and economic parameters at varying levels, various "phasing-in" scenarios could be examined and the impact of the policy on farms of varying size and financial status could be tested.

11.7.1 Some observations.

Despite the perfunctory nature of the policy analysis described in this Chapter, some observations, of relevance in the policy formulation process, can be made. Principal among these is the apparent robustness of the productive base of the pastoral farming system in the short to medium term. Production is generally insensitive to fluctuations in economic conditions, even when adverse prices prevail for three to four
years. Both the financial and physical nature of the farming system contribute to this robustness. On the financial side, the potential for using liquid reserves and reducing operating expenditure and consumption levels provides a buffer between low income and the productive base of the farm. On the physical side, well developed and maintained pastoral land would appear to be able to withstand a reduction in maintenance expenditure, including reduced maintenance fertiliser, for several years before its stock carrying capacity is seriously impaired. This means that significant short-term reductions in expenditure are possible, in response to reduced income, without leading to reduced production.

Conversely, it would appear that the buffering effect is comparable for increases in income; supply is inelastic in the short-term, and in the longer term, estimates provided in Table 11.6 with respect to the disposition of revenue from S.M.P.s, suggest that only about 15 per cent of the extra revenue finds its way into on-farm investment.

While short to medium-term stability in production appears to be a feature of average (and aggregate) farm production, there are other aspects of the situation which appear important and which could be further explored with the model. Firstly, low income may lead to low levels of consumption with associated hardship for some farmers. Secondly, farms with limited physical or financial (or managerial) resources, such as those in the early stages of development or carrying high debt loads, are likely to be much more vulnerable to adverse economic conditions than the average farm. Also, it would appear that,
given prolonged adverse economic conditions, production stability could not be expected to last much more than four years. By such time much of the financial and physical reserves of the farm are likely to have been depleted and the production effects of disinvestment could be appearing.

These observations have implications for policy design and operation. Some of these implications are discussed in the following sections.

11.7.2 Support policies.

For farm support policies operating through a subsidy on price, it must be expected that the extra revenue will be used for a variety of purposes and the effects will be diffuse. The disposition of the subsidy revenue can be expected to vary to some extent depending on whether the subsidy is applied in low income years (favouring consumption and essential expenditure) or on an ad valorem basis (probably favouring investment expenditure). The mode of application of the price subsidy will also affect the incidence of benefits among farmers; an ad valorem subsidy, for example, will provide a small benefit to a small farming operation.

With specific reference to the effects of S.M.P.s, it would appear that they may have had little impact on production levels to the end of 1983/84 but have maintained consumption levels and reduced the need for much larger levels of deferred maintenance. In this latter respect, an imminent decline in production might otherwise have been expected.
If increased investment is the aim of a support policy then a subsidy linked directly to development expenditure would appear to be effective. This policy will not provide much support in low income years or for low income farms. In fact, financial pressures may be compounded if increased operating and maintenance costs, associated with the subsidised investment, must be covered in times of low income.

Another general category of support policy that would appear worthy of closer examination, are policies which serve to reduce the level of input prices, or at least to reduce the rate of inflation for those prices. An effective policy of this type would appear to have both support and stabilisation benefits and, if achieved indirectly through research, would probably be acceptable to trading partners.

11.7.3 Stabilisation policies.

With respect to stabilisation policies, self-financing price-related schemes involving buffer-stocks or funds or a moving average price arrangement, are not likely to have much impact on the variability of production. They may tend to stabilise consumption but only indirectly. Although it could not be tested with the model, price stabilisation may encourage investment through a response to reduce risk; however, this response could well be offset by the transfer of potential investment revenue from high income years to low income years where it is likely to be used for other purposes, such as consumption.

With respect to specific types of (self-financing) price stabilisation schemes, the setting of appropriate and effective ceiling
and floor prices for buffer stock/fund schemes, remains a major difficulty. A moving average price scheme would appear much more practical and, therefore, effective. It would not, however, protect farmers from a prolonged slump in the market but this may be desirable if low prices reflect long-term market conditions.

The potential for manipulating farm expenditure and investment in the light of income fluctuations also has implications for the value of Income Equalisation Deposits. While this type of scheme would appear to be attractive as a method by which farmers can stabilise their own income, it could well be that much the same effect can be achieved, at less cost, through manipulating on-farm expenditure. For example, using "surplus" funds in high income years for tax deductible land development, farm maintenance or other expenditure can moderate the tax bill and can contribute to the potential for reducing expenditure in future low-income years without affecting production. For many farmers the return on funds invested in this way would exceed that possible from Income Equalisation Deposits (even if the market rate of interest was paid). The other aspect of the Deposit scheme highlighted in the analysis in this Chapter is the relatively large level of deposits necessary to provide an effective contingency fund. The opportunity cost of establishing and maintaining such a fund is likely to be substantial. Consequently, while Deposits may serve as another form of liquid reserves, it may be unrealistic to expect such a scheme to play a major stabilising role.

The policies examined in this Chapter largely involved manipulation of input and output prices. Experimentation with other
aspects of the modelled system is also possible. For example, policies involving variation in credit conditions, taxation provisions and production parameters would also be possible. With respect to production parameters, the model could provide a basis for assessing the financial impact of new technology and research results which bear directly on such variables as lambing and calving rates, and wool weights. A more detailed discussion of some of these options is provided in the next Chapter.
In this Chapter conclusions are drawn in relation to several aspects of this study. Firstly, consideration is given to the overall value of the study, and the resulting model. Secondly, the implementation and use of the model for the assessment of different policies in different farming situations is discussed. The scope for further model development, given existing available data, is then examined, including the possibility of adapting the model for use with other farm classes and farming systems. Finally, areas of potentially worthwhile research, highlighted by data deficiencies revealed in the system analysis process, are outlined.

12.1 Value of the Study

While the prime objective of this study was to develop a farm-level production model to assist in policy analysis, a secondary but parallel objective was to analyse and describe aspects of farmer decision making behaviour; in particular, the consumption, borrowing and investment behaviour of North Island hill country farmers. In this respect the analyses described in Chapters 5, 6 and 7 would appear to provide some useful insights into aspects of farmer behaviour and the hill country farming system. Such insights include the quantification of consumption behaviour, the isolation of some factors affecting short and long-term borrowing, the recognition of the role of liquid reserves in the financial operation of the farm, and an exploration of the
influence of climate on stock numbers.

With respect to the modelling objective, it would appear that much of the potential value attributed to farm-level production models as described in Chapter 1 has been realised. The model is detailed and flexible enough to simulate a wide range of policy scenarios within a framework which adequately represents the main dynamic and stochastic aspects of the farming system. Also, the flexibility and detail of the model provides the basis for representing a range of farm configurations and for describing policy responses in terms of a number of farm performance parameters. As such the model should provide policy makers and analysts with a useful analytical tool.

It is important, however, not to overlook the limitations associated with this type of model. In addition to the specific simplifications inherent in the North Island hill country model and described in Chapters 8, 9 and 10, there is the "aggregation" problem which must be considered when using any model of this genre. If the model is to be used to draw conclusions about the behaviour of a group of farms, then analysts should be aware of the potential for aggregation bias. As is described below, some scope may exist for combining separate representative simulations to arrive at an aggregate projection; however, in other cases, particularly where a less than perfectly elastic demand is faced, a different type of model which accounts for aggregate supply and demand behaviour may be more appropriate.
12.2 Model Implementation

Given that the model developed in this study is useful for policy analysis, further consideration is given in this section to implementing the model for different policy and other farming situations.

12.2.1 Policy analysis.

The policy experiments described in Chapter 11 basically involved the manipulation of output and input prices; however, the effects of other types of policy could also be simulated. In particular, two other policy instruments, credit and tax conditions, are often used in agricultural policy.

With respect to credit, the level of long-term borrowing in the model is determined by decision rules which take into account the farm equity level, the "farmer's" capacity to repay a loan and his willingness to borrow. For each simulated year the current interest rate and term for possible loans is specified as data. Also specified is the proportion of borrowed funds used for on-farm and off-farm investment. This range of parameters, involved in the credit component of the model, provides reasonable scope for simulating credit related policies without the need to modify the structure of the model. For example, interest rate charges can be input directly and will affect the level of borrowing possible for a given level of debt servicing expenditure. Concessional credit for farm development purposes could be represented by adjusting interest rates and the proportion of
borrowed funds used for on-farm investment. All loans simulated in the model are assumed to be in the form of table mortgages, i.e. they require regular and equal annual instalments of principal and interest to amortize the loan. If credit policies involve special repayment conditions, such as rests of principle and/or interest, some modification to the credit component of the model would be necessary.

To assess taxation policy, several approaches could be taken, depending on the nature of the policy. The effect of a general change in the marginal or average tax rates could be simulated by modifying the parameters of the tax function. Alternatively, the tax "schedule" routine, with its specific income steps and associated tax rates (described in Chapter 8), could be used instead of the tax "function" routine. The schedule routine would allow alternative schedule structures and degrees of progressiveness to be assessed.

For policies involving taxation concessions for specific expenditure, or where tax write-offs are spread over a number of years, some modification of the taxation routine would be required. In the case of specific concessions, such as accelerated depreciation allowances, these would have to be represented in the model through an adjustment in the general level of investment tax deductibility. Such a representation could only be expected to give a gross impression of the effect of the policy; for example, the effect of input substitution resulting from the policy would not be accounted for. This problem is likely to occur for any policy that affects a specific type of input; the model is a relatively blunt instrument in these situations and would need to be operated in conjunction with other analyses of input
12.2.2 Other farm situations.

The potential exists for the model to be used to represent North Island hill country farms with a wide range of different attributes. While the average and aggregate response to policy is likely to be the prime interest of policy makers, the impact of policy on certain sub-groups may also be of interest. The plight of new farmers with heavy debt commitments, for example, has traditionally been of interest in New Zealand where new, young farmers are encouraged. The effects of a high initial debt, and if necessary other attributes, on likely farm production, income and growth could be directly simulated with the model. Management and technology effects could also be represented through changes in specific lambing and calving rates, wool weights and fat lamb rates, and/or changes in the specified cost function.

The problem of aggregation bias has been referred to above; simulating the operation of disaggregated representative sub-groups within the population of farms, and then aggregating, could also provide an effective way of arriving at less biased aggregate projections. One possible basis for defining representative farms could be that used by Taylor (1984) who, for comparison purposes, divided the MWBES survey sample of North Island hill country (Class 4) farms into four groups based on gross income per stock unit (selected as an indicator of stock performance) and debt servicing costs as a percentage of gross income. Alternatively, appropriate representative farm specifications could be determined using "cluster analysis"
(Hartigan, 1975). Such an approach could reduce any aggregation bias that occurs with a single, average-farm projection, and would also provide information on sub-group effects.

12.3 Further Model Development

In accordance with the philosophy of model design outlined in Chapter 1, the model was developed to a state where it was believed that; (a) it had sufficient validity to be of value for its intended purposes, and; (b) it was still reasonably transparent and "serviceable" for the model user. However, as with most simulation models a wide range of "potential developments" would be possible. In undertaking further model development there is a danger that the added validity or apparent usefulness of the model may be more than offset by the modelling costs and the costs of added complexity; accordingly, discussion here is limited to two areas where further development may be considered worthwhile. These relate to the specification and selection procedures for investment and production options, and the adaptation of the model for other farm classes.

12.3.1 Investment and production options.

A relatively simple approach to investment was taken in the model; a priority ranking is specified for alternative investments and as the limit for investment in the highest ranking alternative is reached the next ranking option is pursued. The on-farm investment options are essentially composite in nature with land development and associated plant, machinery and building expenditure combined into investment
"profiles". While this formulation provides a basis for simulating the effect of total investment, it does not allow for the substitution between forms of investment to be represented explicitly or endogenously. This can be done to some extent exogenously by pre-budgeting the range of investment options using expected prices and production parameters (and allowing for any policy factors), and then ranking the options accordingly in the model; however, once these priorities are set they remain unchanged for each model run. In reality, the investment priorities may change from time-to-time depending on internal and external circumstances. For example, in times of high inflation the (potentially) tax free capital gains from increasing land values may induce farmers to purchase extra land rather than develop existing land.

With respect to selecting between alternative production activities, the major decision in the North Island hill country relates to setting the appropriate sheep/cattle ratio. Historically, the average sheep/cattle ratio has remained reasonably constant (see Chapter 4), and consequently a pre-specified constant ratio was used in the model; however, significant and continuing differences in the returns to sheep and cattle might be expected to change the ratio. A mechanism in the model to simulate such a change could be desirable.

Various methods can be envisaged that would facilitate the periodic selection of the best investment and production options. For example, an embedded mathematical programming sub-model could be used to determine the optimal mix of investment and production activities for the forthcoming simulated year. The programming sub-model inputs,
such as price and production parameters, capital and cash constraints, could be generated by the simulation component of the model, while the optimal solution from the sub-model would be fed back to the simulation component, perhaps in the form of an investment priority schedule and a desired sheep/cattle ratio. Such a development would result in a model structure similar to that used by Kingma and Kerridge (1977) (see Chapter 3). Alternatively, a budgeting routine could be incorporated into the model which would be used each simulated year to reassess the investment and production options and, if necessary, adjust the investment priority schedule and sheep/cattle ratio.

Conceptually, factors other than the expected money value of the investment and production options (such as risk and labour constraints) could be accounted for in both procedures (see, for example, Anderson et al. (1977), Rae (1971), Webster and Kennedy (1974), Wicks and Guise (1978), and Patrick and Eisgruber (1968)). Both programming and budgeting type procedures are essentially normative in nature and generally involve the selection of "optimal" strategies. Care would have to be taken that the positive attributes of the model were preserved, and that the descriptive and predictive validity of the model, as a representation of actual behaviour, was maintained.

For investment selection another theoretical possibility, with a stronger positive orientation, would be to build into the model an asset portfolio sub-model comprising a set of empirically estimated asset demand functions similar to those estimated by Laing and Zwart (1983) (see Chapter 7). Such a portfolio sub-model would distribute available investment funds between alternatives (such as land
development, buildings, plant and machinery and land purchase) as a function of such factors as the level and change in available funds, change in asset returns, and opening asset levels.

Unfortunately, a lack of available data on the level and composition of hill country investment is likely to render infeasible the estimation of an appropriate portfolio model. It could be possible to adapt the equations estimated by Laing and Zwart (1983), however, it is debatable how relevant these equations would be to the North Island hill country situation. Also, it could be difficult to adapt the equations to another model structure. Thus, until more comprehensive farm investment data become available, it would appear that the existing investment algorithms in the model cannot be substantially improved. Given that this is the case, the exploration of investment issues using the model should involve the careful specification and testing of alternative investment profiles.

More scope would appear to be available for adjusting the sheep/cattle ratio in the model with an empirically estimated function. Time-series data from the Meat and Wool Boards' Sheep and Beef Farm Survey could be used, together with livestock and wool price data, to test for a relationship between the sheep/cattle ratio and sheep/wool/beef price relativities. If a significant relationship was found (despite the relatively small observed variation in the sheep/beef ratio) the estimated function could be adapted for the model. To fit into the existing model structure the function would need to act through the sheep and cattle culling rates. The change in potential and actual stock units could remain a function of
investment/disinvestment and climatic conditions, but the ratio of sheep to cattle, within the new stock unit limit, would be determined using the estimated function. A required change in the sheep/beef ratio, together with a change in total stock units, could be translated into specific culling rates for the flock and herd sub-models.

Incorporating such a procedure into the model and undertaking appropriate validation testing would involve some cost. It could be worthwhile if issues related to the relative change in sheep and cattle numbers became important, in addition to an interest in overall livestock production.

12.3.2 Adapting the model for different farm classes.

The Meat and Wool Boards' Economic Service defines eight sheep and beef farm classes. The question arises as to the potential for adapting the model to simulate some or all of these other classes. The model was designed as a skeleton model so that considerable flexibility is possible through input data without the need for structural changes. There is a limit to this flexibility but farm classes involving predominantly sheep and/or beef breeding activities could be accommodated. These classes include South Island Hill Country (Class 2) and North Island Hard Hill Country (Class 3). Three other classes could be modelled with some changes to the flock and herd sub-models. These are South Island High Country (Class 1) where, due to the terrain of the country and the emphasis on wool production, wethers form a significant proportion of the flock, and both North Island Intensive Finishing Country (Class 5) and South Island Finishing/Breeding Country
(Class 6), where buying store stock, especially cattle, for fattening significantly augments the main stock breeding activities. In each of these cases, routines to represent livestock buying and selling activities, together with procedures to allow for valuing liveweight gain, would have to be added to the model.

For the remaining two farm classes, Intensive Finishing Farms (Class 7) and Mixed Cropping and Finishing Farms (Class 8), both in the South Island, extensive model development would be required to allow for the cash cropping activities which represent an important component of the farming systems involved. This would be particularly so for Class 8 farms where, on average, cropping generates over half of gross income. An added dimension of complexity could be anticipated in the resulting model, given the interactions between the livestock and cropping activities at the financial and management levels.

In addition to any changes to the model structure that might be necessary, a process of system analysis would be necessary to establish appropriate farm specifications and input data for each new farm class. Some of the necessary data would be readily available, mainly from the MWBES Survey publications, but other data, such as the parameters for the consumption, borrowing and investment components of the model, would require more detailed analysis and research. In some cases (possibly for Classes 2 and 3), some of the data derived in this study for Class 4 may be directly applicable; however, some research would still be necessary to establish that this was the case.
Ultimately, the validity of the model, when adapted to other farm classes, would have to be tested against actual historical data for that class; the possible need for further modelling effort in the light of such testing cannot be discounted.

12.4 Further Research

In the process of modelling the hill country pastoral system two major areas of data deficiency became apparent. The need for further research in these areas is discussed in the following sections.

12.4.1 Farm expenditure and investment.

The model developed in this study treats investment expenditure as a residual after allowance is made for a variety of other costs. This indirect approach to estimating investment appears to work satisfactorily but the resulting investment projections cannot be validated directly because, with most farm survey data, investment expenditure cannot be separated from general operating expenditure. For the same reason an accurate operating expenditure function cannot be estimated. This problem continues to constrain effective pastoral sector modelling in New Zealand, and as long as farm financial surveys rely primarily on accounts prepared for taxation purposes, the problem is likely to remain. While the alternative (presumably, more detailed questioning of surveyed farmers) may be impractical and excessively expensive if adopted for large samples, it could well be worthwhile for a representative sub-sample of, say, the MWBES Survey farms. The results of such a sub-survey could provide a valuable insight into the
relationships between income, operating expenditure and investment, which could then be adapted to the wider population.

Another aspect of this problem is the lack of farm-level empirical data that could be used to relate different forms of farm investment to changes in farm production and productivity. In the model, different forms of investment are linked into a composite investment "profile" or package. As described in Section 12.2.1, data do not exist to improve this formulation. In this respect a number of issues would appear worthy of further research. In the first instance, more information is needed on what proportion of investment is for replacement of depreciated existing assets, and what is genuinely new investment. Then it would be useful to know how the investment mix (land development, machinery, buildings, etc.) varies from year to year and what factors affect this mix. Also of interest would be the relationship (correlations, lags, etc.) between different forms of on-farm investment; in particular the hypothesised causal relationship between land development and other forms of investment expenditure should be examined. Finally, where a degree of independence is found between different forms of investment, more information is needed on the relative contribution of each type of investment to production, costs, capital values, etc. Such information would significantly enhance the capacity to understand and model on-farm investment behaviour in the pastoral sector.

Also important, particularly in times of depressed market conditions, is the question of the causes and effects of disinvestment. It is clear that deferred maintenance of buildings, equipment and land
improvements provides an important buffer against the effects of income fluctuations, but the circumstances under which deferred maintenance becomes true disinvestment, and the associated production and productivity effects, are not clear. As with investment, the relative effects of different forms of disinvestment are not well known, apart from some projections of the effects of suspended maintenance fertiliser.

To facilitate the further development of the investment component of the model, and/or to enhance the general standard of pastoral sector analysis, more research to describe and explain the process of pastoral sector investment would appear to be warranted.

12.4.2 The role of reserves in the pastoral farming system.

A conclusion that can be drawn from the system analysis stage of this study is that the role of savings and liquid reserves, in the financial operation of pastoral sector farms, is important but not well understood. If the impact of government policies, particularly stabilisation policies, on the operation of pastoral farming systems is to be better understood then further research examining the nature and role farm financial reserves may be worthwhile. Several aspects of the issue could be examined; as with the investment research suggested above, a detailed survey of farmers would probably be required. Firstly, a comprehensive classification and description of non-farm financial assets would be useful to determine the degree of liquidity involved and the intended or perceived purpose of maintaining the asset. For example, are some funds only held pending imminent
expenditure or investment on the farm? Are some reserves held in semi-liquid form as a hedge against risk? Are other assets held in a genuine effort to augment farm income or diversify the total investment portfolio?

Secondly, although it is likely to be difficult to determine, the nature and causes of short, medium and long-term changes in the reserve asset portfolio would be of particular value in examining the role of reserves as an internal stabilisation fund. Questions in this regard could include the following; To what extent will non-farm assets be liquidated during short and long periods of low farm income? Do farmers perceive some maximum or desired level for reserves? What priority is given to replenishing low reserves? Do reserve levels vary in response to variation in the level of risk inherent in the enterprise?

This last question could form the basis for an interesting econometric study of risk response if an appropriate time-series of data could be established. Conceptually, such a time-series could cover some years before and after the introduction of Supplementary Minimum Prices, which could be regarded as reducing the riskiness of pastoral production. An alternative time-series could be for the period 1965 to 1980, the first half of which saw relatively stable pastoral sector incomes compared with the wide fluctuations of the second half. If the farmer's perception of the risk involved in farming changed systematically then some risk response could be anticipated (Fisher and Hanslow, 1984), perhaps in the form of changed reserve levels and/or as changed management and stocking rate policies.
If the existence of such responses could be established and quantified then further development of the model incorporating those responses may be justified.
REFERENCES
REFERENCES


Meat and Wool Boards' Economic Service (various), *Sheep and Beef Farm Survey*, Wellington.


Ministry of Agriculture and Fisheries (1975), *Rural Credit Survey 1975*, Wellington: Economics Division, M.A.F.


New Zealand Department of Statistics (various), *Agricultural Statistics*, Wellington.


APPENDICES

APPENDIX 1  Credit Related Questions in the 1981/82 Farmer Opinion Survey

APPENDIX 2  Tabulated Results of Sensitivity Analysis

APPENDIX 3  Model Performance under Extreme Price Conditions

APPENDIX 4  Model Program Listing
APPENDIX 1

CREDIT RELATED QUESTIONS IN THE 1981/82

FARMER OPINION SURVEY
CAPITAL STRUCTURE AND INVESTMENT

(A) According to your latest Balance Sheet and/or your own estimates please enter the values of your assets as at 30 June 1982.

1. Farmland

2. Other Farm Assets

3. Off-Farm Assets

(B) At the end of the 1981-82 season how were your liabilities distributed among the following sources? Please indicate the term for which each loan was granted.

<table>
<thead>
<tr>
<th>Lender:</th>
<th>Amount</th>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Rural Banking and Finance Corp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Govt. Agency other than RBFC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Trustee Savings Bank</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Your Trading Bank</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Building Society</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Insurance Company</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Stock and Station Agent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Trust Company</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Solicitors' Trustee Funds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Family Loan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Private Source</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Local Body</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Finance Company</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Dairy Company</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Private Savings Bank</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. Other (specify) ..................</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
In the following table could you indicate approximately your new borrowings in respect to medium and long term loans during the 1981-82 production season and the rate of interest you are being charged; also please indicate whether the loan was medium or long term.

<table>
<thead>
<tr>
<th>Lender:</th>
<th>Amount</th>
<th>Int.</th>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Rural Banking and Finance Corp.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Govt. Agency other than RBFC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Trustee Savings Bank</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Your Trading Bank</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Building Society</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Insurance Company</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Stock and Station Agent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Trust Company</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Solicitors' Trustee Funds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Family Loan</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Private Source</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Local Body</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Finance Company</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Dairy Company</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Private Savings Bank</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. Other (specify)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
(D) MAIN REASONS FOR THE NEW BORROWINGS

If you were asked to state the main reasons for your additional medium and long term borrowing in 1980-81 how would you apportion them among the following?

<table>
<thead>
<tr>
<th>Reason</th>
<th>Percentage of New Borrowing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. To purchase new or additional land</td>
<td></td>
</tr>
<tr>
<td>2. To finance farm development</td>
<td></td>
</tr>
<tr>
<td>3. To purchase plant and machinery</td>
<td></td>
</tr>
<tr>
<td>4. To refinance existing loans</td>
<td></td>
</tr>
<tr>
<td>5. For personal reasons</td>
<td></td>
</tr>
<tr>
<td>6. I did not borrow additional funds</td>
<td></td>
</tr>
</tbody>
</table>

(E) If you formally applied to borrow funds during the 1981-82 season, were you able to borrow all the money you needed for your farming requirements (including development and land purchase).

Yes (1)  No (2)  Don't Know (3)  

(F) Could you please indicate the amount you were unable to borrow in the box beside the purpose for which the loan(s) were required.

<table>
<thead>
<tr>
<th>Reason</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I was not refused finance</td>
<td></td>
</tr>
<tr>
<td>2. To purchase new or additional land</td>
<td></td>
</tr>
<tr>
<td>3. To finance farm development</td>
<td></td>
</tr>
<tr>
<td>4. To purchase plant and machinery</td>
<td></td>
</tr>
<tr>
<td>5. To refinance existing loans</td>
<td></td>
</tr>
<tr>
<td>6. For personal reasons</td>
<td></td>
</tr>
<tr>
<td>7. I did not borrow additional funds</td>
<td></td>
</tr>
</tbody>
</table>
(G) What reason was given for declining your application for funds?

Insufficient Security (1)
Income not sufficient to meet repayments (2)
No funds available (3)
No reason given (4)
Other ..................... (5)
Did not seek Finance (6)
Was not refused Finance (7)

(H) During the 1981-82 season did you either:

Not borrow but believe you could have obtained finance if required

or

Borrowed finance but believed that if required could have borrowed more.

Yes (1) No (2) Don't Know (3)

(I) Why did you not borrow (more) finance during 1981-82?

Refused by lending institutions (1)
Didn't want to increase indebtedness (2)
Repayments too difficult (3)
No profitable use for additional finance (4)
Other .....................
Sensitivity elasticities are presented for the following model parameters: (see Chapter 10 for discussion of results).

<table>
<thead>
<tr>
<th>Table</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2.1</td>
<td>Total stock units, sheep/cattle ratio, culling adjustment rate</td>
</tr>
<tr>
<td>A2.2</td>
<td>Steer retention rate, lamb fattening rate</td>
</tr>
<tr>
<td>A2.3</td>
<td>Livestock and wool prices</td>
</tr>
<tr>
<td>A2.4</td>
<td>Expenditure function parameters</td>
</tr>
<tr>
<td>A2.5</td>
<td>Tax function parameters</td>
</tr>
<tr>
<td>A2.6</td>
<td>Consumption function parameters</td>
</tr>
<tr>
<td>A2.7</td>
<td>Reserve and borrowing parameters</td>
</tr>
<tr>
<td>A2.8</td>
<td>Investment parameters</td>
</tr>
</tbody>
</table>
### TABLE A2.1

**Sensitivity Elasticities for Changes in Total Stock Units, Sheep/Cattle Ratio and Culling Adjustment Rate**

<table>
<thead>
<tr>
<th></th>
<th>Total Stock Units</th>
<th>Sheep/Cattle Ratio</th>
<th>Culling Adjustment Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Yr 2 Yr 10</td>
<td>Mean Yr 2 Yr 10</td>
<td>Mean Yr 2 Yr 10</td>
</tr>
<tr>
<td></td>
<td>(E) (E2) (E10)</td>
<td>(E) (E2) (E10)</td>
<td>(E) (E2) (E10)</td>
</tr>
<tr>
<td>Gross Revenue</td>
<td>-1.02 -1.05 -1.15</td>
<td>0.08 -0.06 0.06</td>
<td>-0.05 0.001 -0.11</td>
</tr>
<tr>
<td>Expenditure</td>
<td>-0.77 -0.56 -0.92</td>
<td>0.04 -0.03 0.10</td>
<td>-0.03 0.001 -0.08</td>
</tr>
<tr>
<td>After tax Cash Surplus</td>
<td>-1.57 -1.37 -2.35</td>
<td>0.19 0.06 -0.16</td>
<td>-0.10 0.002 -0.25</td>
</tr>
<tr>
<td>Consumption</td>
<td>-0.88 -0.95 -0.83</td>
<td>0.10 -0.13 0.08</td>
<td>-0.05 0.001 -0.11</td>
</tr>
<tr>
<td>Tax Paid</td>
<td>-1.13 -1.89 -1.11</td>
<td>0.10 -0.54 0.11</td>
<td>-0.06 0.002 -0.13</td>
</tr>
<tr>
<td>Reserves</td>
<td>-0.74 -0.89 -0.90</td>
<td>0.02 -0.24 0.04</td>
<td>-0.03 0.0</td>
</tr>
<tr>
<td>Total Assets</td>
<td>-1.03 -0.93 -1.16</td>
<td>-0.12 -0.27 -0.07</td>
<td>-0.02 -0.01 -0.03</td>
</tr>
<tr>
<td>Equity</td>
<td>-0.06 -0.20 -0.02</td>
<td>-0.02 -0.05 -0.02</td>
<td>-     0.01</td>
</tr>
<tr>
<td>Funds Borrowed</td>
<td>-1.86 -10.00 -1.74</td>
<td>0.07 -4.97 -0.02</td>
<td>-0.09 0.003 -0.18</td>
</tr>
<tr>
<td>Investment</td>
<td>-5.41 -4.81 -10.00</td>
<td>0.65 -1.28 5.92</td>
<td>-0.32 0.003 -3.64</td>
</tr>
<tr>
<td>Potential Stock Units</td>
<td>-1.12 -1.00 -1.27</td>
<td>-0.004 0.03 -0.004</td>
<td>-0.01 0.001 -0.09</td>
</tr>
<tr>
<td>Actual Stock Units</td>
<td>-1.02 -1.02 -1.14</td>
<td>-0.04 -0.02 -0.06</td>
<td>-0.06 0.01 -0.09</td>
</tr>
<tr>
<td></td>
<td>Steer Retention Rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------------</td>
<td>----------------------</td>
<td>------------</td>
<td>------------</td>
</tr>
<tr>
<td></td>
<td>Mean (E)</td>
<td>Yr 2 (E2)</td>
<td>Yr 10 (E10)</td>
</tr>
<tr>
<td>Gross Revenue</td>
<td>0.001</td>
<td>0.06</td>
<td>-0.08</td>
</tr>
<tr>
<td>Expenditure</td>
<td>0.002</td>
<td>0.03</td>
<td>-0.02</td>
</tr>
<tr>
<td>After tax Cash Surplus</td>
<td>-0.003</td>
<td>0.13</td>
<td>-0.33</td>
</tr>
<tr>
<td>Consumption</td>
<td>0.002</td>
<td>0.02</td>
<td>-0.06</td>
</tr>
<tr>
<td>Tax Paid</td>
<td>-0.001</td>
<td>-0.07</td>
<td>-0.07</td>
</tr>
<tr>
<td>Reserves</td>
<td>-0.01</td>
<td>-</td>
<td>-0.07</td>
</tr>
<tr>
<td>Total Assets</td>
<td>-0.01</td>
<td>-0.02</td>
<td>-0.01</td>
</tr>
<tr>
<td>Equity</td>
<td>-0.002</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Funds Borrowed</td>
<td>-0.01</td>
<td>-0.15</td>
<td>-0.20</td>
</tr>
<tr>
<td>Investment</td>
<td>0.05</td>
<td>-</td>
<td>0.02</td>
</tr>
<tr>
<td>Potential Stock Units</td>
<td>0.002</td>
<td>-</td>
<td>0.005</td>
</tr>
<tr>
<td>Actual Stock Units</td>
<td>-0.005</td>
<td>0.01</td>
<td>-0.02</td>
</tr>
</tbody>
</table>
TABLE A2.3

Sensitivity Elasticities for Changes in Livestock and Wool Prices

<table>
<thead>
<tr>
<th></th>
<th>Sheep Prices</th>
<th>Wool Prices</th>
<th>Beef Prices</th>
<th>All Prices</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Yr 2</td>
<td>Yr 10</td>
<td>Mean Yr 2</td>
<td>Yr 10</td>
</tr>
<tr>
<td>(E) (E2) ((\text{E10}))</td>
<td>(E) (E2) ((\text{E10}))</td>
<td>(E) (E2) ((\text{E10}))</td>
<td>(E) (E2) ((\text{E10}))</td>
<td>(E) (E2) ((\text{E10}))</td>
</tr>
<tr>
<td><strong>Gross Revenue</strong></td>
<td>-0.33</td>
<td>-0.34</td>
<td>-0.42</td>
<td>-0.41</td>
</tr>
<tr>
<td></td>
<td>-0.23</td>
<td>-0.29</td>
<td>-0.28</td>
<td>-0.20</td>
</tr>
<tr>
<td><strong>After tax Cash</strong></td>
<td>-0.54</td>
<td>-0.67</td>
<td>-0.73</td>
<td>-0.51</td>
</tr>
<tr>
<td><strong>Consumption</strong></td>
<td>-0.30</td>
<td>-0.28</td>
<td>-0.41</td>
<td>-0.33</td>
</tr>
<tr>
<td></td>
<td>-0.36</td>
<td>-0.26</td>
<td>-0.48</td>
<td>-0.62</td>
</tr>
<tr>
<td><strong>Reserves</strong></td>
<td>-0.18</td>
<td>-0.24</td>
<td>-0.24</td>
<td>-0.34</td>
</tr>
<tr>
<td><strong>Total Assets</strong></td>
<td>-0.19</td>
<td>-0.19</td>
<td>-0.07</td>
<td>-0.03</td>
</tr>
<tr>
<td><strong>Equity</strong></td>
<td>-0.003</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td><strong>Funds Borrowed</strong></td>
<td>-0.45</td>
<td>-1.74</td>
<td>-0.46</td>
<td>-0.35</td>
</tr>
<tr>
<td><strong>Investment</strong></td>
<td>-1.98</td>
<td>-1.23</td>
<td>-7.68</td>
<td>-2.52</td>
</tr>
<tr>
<td><strong>Potential Stock</strong></td>
<td>-0.05</td>
<td>-0.11</td>
<td>-0.05</td>
<td>-0.14</td>
</tr>
<tr>
<td><strong>Units</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Actual Stock</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
### TABLE A2.4

**Sensitivity Elasticities for Changes in Expenditure Parameters**

<table>
<thead>
<tr>
<th>Standing Costs</th>
<th>Marginal Cost Coefficient</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Yr 2</td>
</tr>
<tr>
<td>(E)</td>
<td>(E2)</td>
<td>(E10)</td>
</tr>
<tr>
<td>Gross Revenue</td>
<td>0.25</td>
<td>0.28</td>
</tr>
<tr>
<td>Expenditure</td>
<td>-0.44</td>
<td>-0.20</td>
</tr>
<tr>
<td>After tax Cash Surplus</td>
<td>-0.24</td>
<td>-0.17</td>
</tr>
<tr>
<td>Consumption</td>
<td>-0.29</td>
<td>-0.40</td>
</tr>
<tr>
<td>Tax Paid</td>
<td>-0.14</td>
<td>-0.13</td>
</tr>
<tr>
<td>Reserves</td>
<td>-0.04</td>
<td>-0.02</td>
</tr>
<tr>
<td>Equity</td>
<td>0.01</td>
<td>0.02</td>
</tr>
<tr>
<td>Funds Borrowed</td>
<td>-0.30</td>
<td>-0.32</td>
</tr>
<tr>
<td>Investment</td>
<td>-1.48</td>
<td>-0.72</td>
</tr>
<tr>
<td>Potential Stock Units</td>
<td>-0.03</td>
<td>-0.08</td>
</tr>
<tr>
<td>Actual Stock Units</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### TABLE A2.5

**Sensitivity Elasticities for Changes in Tax Function Parameters**

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Yr 2</th>
<th>Yr 10</th>
<th>Mean</th>
<th>Yr 2</th>
<th>Yr 10</th>
<th>Mean</th>
<th>Yr 2</th>
<th>Yr 10</th>
<th>Mean</th>
<th>Yr 2</th>
<th>Yr 10</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(E)</td>
<td>(E2)</td>
<td>(E10)</td>
<td>(E)</td>
<td>(E2)</td>
<td>(E10)</td>
<td>(E)</td>
<td>(E2)</td>
<td>(E10)</td>
<td>(E)</td>
<td>(E2)</td>
<td>(E10)</td>
</tr>
<tr>
<td><strong>Gross Revenue</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expenditure</td>
<td>-0.004</td>
<td>-0.01</td>
<td>-0.02</td>
<td>-0.03</td>
<td>-0.02</td>
<td>-0.04</td>
<td>-0.03</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>After tax Cash</td>
<td>-0.06</td>
<td>-0.04</td>
<td>-0.05</td>
<td>-0.26</td>
<td>-0.22</td>
<td>-0.38</td>
<td>-0.32</td>
<td>-0.13</td>
<td>-0.59</td>
<td>-0.53</td>
<td>-0.31</td>
<td>-0.93</td>
</tr>
<tr>
<td>Surplus</td>
<td>-0.03</td>
<td>-0.03</td>
<td>-0.02</td>
<td>-0.14</td>
<td>-0.13</td>
<td>-0.16</td>
<td>-0.18</td>
<td>-0.09</td>
<td>-0.22</td>
<td>-0.29</td>
<td>-0.19</td>
<td>-0.36</td>
</tr>
<tr>
<td>Consumption</td>
<td>0.13</td>
<td>0.12</td>
<td>0.08</td>
<td>0.59</td>
<td>0.69</td>
<td>0.54</td>
<td>0.72</td>
<td>0.41</td>
<td>0.79</td>
<td>1.18</td>
<td>0.99</td>
<td>1.27</td>
</tr>
<tr>
<td>Tax Paid</td>
<td>-0.02</td>
<td>-0.02</td>
<td>-0.01</td>
<td>-0.06</td>
<td>-0.10</td>
<td>-0.09</td>
<td>-0.08</td>
<td>-0.06</td>
<td>-0.14</td>
<td>-0.13</td>
<td>-0.13</td>
<td>-0.22</td>
</tr>
<tr>
<td>Reserves</td>
<td>-0.01</td>
<td></td>
<td>-0.01</td>
<td>-0.02</td>
<td>-0.01</td>
<td>-0.04</td>
<td>-0.03</td>
<td>-0.01</td>
<td>-0.05</td>
<td>-0.04</td>
<td>-0.02</td>
<td>-0.08</td>
</tr>
<tr>
<td>Total Assets</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equity</td>
<td>-0.001</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Funds Borrowed</td>
<td>0.004</td>
<td>-0.05</td>
<td>0.02</td>
<td>0.02</td>
<td>-0.11</td>
<td>0.08</td>
<td>0.02</td>
<td>-0.10</td>
<td>0.10</td>
<td>0.04</td>
<td>-0.17</td>
<td>0.16</td>
</tr>
<tr>
<td>Investment</td>
<td>-0.16</td>
<td>-0.12</td>
<td>-0.37</td>
<td>-0.72</td>
<td>-0.49</td>
<td>-2.87</td>
<td>-0.87</td>
<td>-0.34</td>
<td>-3.90</td>
<td>-1.43</td>
<td>-0.71</td>
<td>-6.48</td>
</tr>
<tr>
<td>Potential Stock Units</td>
<td>-0.01</td>
<td>-0.01</td>
<td>-0.02</td>
<td>-0.04</td>
<td>-0.02</td>
<td>-0.05</td>
<td>-0.03</td>
<td>-0.03</td>
<td>-0.08</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actual Stock Units</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Constant</td>
<td>Marginal Propensity</td>
<td>Coefficient (lagged consumption)</td>
<td>Total Consumption</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------</td>
<td>-------------------</td>
<td>---------------------</td>
<td>----------------------------------</td>
<td>-------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>Yr 2</td>
<td>Yr 10</td>
<td>Mean</td>
<td>Yr 2</td>
<td>Yr 10</td>
<td>Mean</td>
<td>Yr 2</td>
<td>Yr 10</td>
<td>Mean</td>
<td>Yr 2</td>
<td>Yr 10</td>
</tr>
<tr>
<td></td>
<td>(E)</td>
<td>(E2)</td>
<td>(E10)</td>
<td>(E)</td>
<td>(E2)</td>
<td>(E10)</td>
<td>(E)</td>
<td>(E2)</td>
<td>(E10)</td>
<td>(E)</td>
<td>(E2)</td>
<td>(E10)</td>
</tr>
<tr>
<td>Gross Revenue</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-0.001</td>
<td>-</td>
<td>-0.02</td>
<td>-0.01</td>
<td>-</td>
<td>-0.02</td>
</tr>
<tr>
<td>Expenditure</td>
<td>-0.02</td>
<td>-0.06</td>
<td>-0.04</td>
<td>-0.08</td>
<td>-0.06</td>
<td>-0.12</td>
<td>-0.07</td>
<td>-</td>
<td>-0.12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>After tax Cash Surplus</td>
<td>-0.01</td>
<td>0.04</td>
<td>-0.02</td>
<td>0.06</td>
<td>-0.04</td>
<td>0.09</td>
<td>-0.02</td>
<td>0.16</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumption</td>
<td>0.33</td>
<td>0.22</td>
<td>0.49</td>
<td>0.47</td>
<td>0.52</td>
<td>0.46</td>
<td>1.00</td>
<td>0.58</td>
<td>1.30</td>
<td>0.98</td>
<td>1.00</td>
<td>1.06</td>
</tr>
<tr>
<td>Tax Paid</td>
<td>0.14</td>
<td>-</td>
<td>0.24</td>
<td>0.22</td>
<td>-</td>
<td>0.34</td>
<td>0.36</td>
<td>-</td>
<td>0.41</td>
<td>0.42</td>
<td>-</td>
<td>0.59</td>
</tr>
<tr>
<td>Reserves</td>
<td>-0.11</td>
<td>-0.06</td>
<td>-0.25</td>
<td>-0.16</td>
<td>-0.13</td>
<td>-0.25</td>
<td>-0.47</td>
<td>-0.17</td>
<td>-0.89</td>
<td>-0.42</td>
<td>-0.31</td>
<td>-0.61</td>
</tr>
<tr>
<td>Total Assets</td>
<td>-0.03</td>
<td>-0.01</td>
<td>-0.07</td>
<td>-0.05</td>
<td>-0.01</td>
<td>-0.10</td>
<td>-0.10</td>
<td>-0.02</td>
<td>-0.19</td>
<td>-0.11</td>
<td>-0.04</td>
<td>-0.20</td>
</tr>
<tr>
<td>Equity</td>
<td>-0.01</td>
<td>-0.01</td>
<td>-0.01</td>
<td>-0.01</td>
<td>-0.02</td>
<td>-0.01</td>
<td>-0.02</td>
<td>-0.02</td>
<td>-0.01</td>
<td>-0.03</td>
<td>-0.02</td>
<td>-0.03</td>
</tr>
<tr>
<td>Funds Borrowed</td>
<td>0.04</td>
<td>-0.10</td>
<td>0.15</td>
<td>0.06</td>
<td>-0.12</td>
<td>0.20</td>
<td>0.08</td>
<td>-0.24</td>
<td>0.25</td>
<td>0.10</td>
<td>-0.47</td>
<td>0.38</td>
</tr>
<tr>
<td>Investment</td>
<td>-1.21</td>
<td>-0.35</td>
<td>-6.94</td>
<td>-1.82</td>
<td>-0.67</td>
<td>-8.41</td>
<td>-2.90</td>
<td>-0.93</td>
<td>-10.00</td>
<td>-3.23</td>
<td>-1.69</td>
<td>-10.00</td>
</tr>
<tr>
<td>Potential Stock Units</td>
<td>-0.02</td>
<td>-0.84</td>
<td>-0.04</td>
<td>-0.10</td>
<td>-0.06</td>
<td>-0.16</td>
<td>-0.07</td>
<td>-0.18</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actual Stock Units</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-0.002</td>
<td>-0.02</td>
<td>-0.004</td>
<td>-0.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parameter</td>
<td>Upper Reserve Limit</td>
<td>Lower Reserve Limit</td>
<td>New debt Servicing Parameter</td>
<td>Minimum Equity Limit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>---------------------</td>
<td>---------------------</td>
<td>------------------------------</td>
<td>----------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean Yr 2 Yr 10</td>
<td>Mean Yr 2 Yr 10</td>
<td>Mean Yr 2 Yr 10</td>
<td>Mean Yr 2 Yr 10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(E) (E2) (E10)</td>
<td>(E) (E2) (E10)</td>
<td>(E) (E2) (E10)</td>
<td>(E) (E2) (E10)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gross Revenue</td>
<td>-0.05 -0.09</td>
<td>-0.05 -0.08</td>
<td>-0.06 -0.13</td>
<td>-0.001 -0.02</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expenditure</td>
<td>-0.01 -0.09</td>
<td>-0.03 0.02</td>
<td>0.11 0.48</td>
<td>0.93 1.92</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>After tax Cash Surplus</td>
<td>-0.01 0.004</td>
<td>-0.02 0.02</td>
<td>0.05 0.16</td>
<td>0.49 0.83</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumption</td>
<td>-0.01 0.004</td>
<td>-0.02 0.02</td>
<td>0.05 0.16</td>
<td>0.49 0.83</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumption</td>
<td>0.27 0.54</td>
<td>0.29 0.41</td>
<td>0.09 0.19</td>
<td>0.61 -0.14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tax Paid</td>
<td>0.55 0.41</td>
<td>0.84 0.86</td>
<td>-0.03 -0.004</td>
<td>-0.06 -0.23 0.61</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reserves</td>
<td>0.001 0.05</td>
<td>-0.04 0.05</td>
<td>-0.05 -0.01</td>
<td>-0.02 -0.07 -0.03</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Assets</td>
<td>-0.001 0.01</td>
<td>-0.01 -0.01</td>
<td>-0.004 0.01</td>
<td>-0.01 -0.06 0.27</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equity</td>
<td>0.06 0.23</td>
<td>0.14 0.22</td>
<td>-0.62 -0.63</td>
<td>-3.22 -10.00 0.90</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Funds Borrowed</td>
<td>-2.15 -2.21</td>
<td>-7.21 -7.32</td>
<td>-2.32 -7.32</td>
<td>-1.42 -1.38 -1.25 19.38</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Investment</td>
<td>-0.06 -0.12</td>
<td>-0.06 -0.13</td>
<td>-0.01 -0.02</td>
<td>-0.09 -0.16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actual Stock Units</td>
<td>- - -</td>
<td>- - -</td>
<td>- - -</td>
<td>-0.002 -0.02</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>Yr 2</td>
<td>Yr 10</td>
<td>Proportion of Liquid Reserves Invested</td>
<td>Mean</td>
<td>Yr 2</td>
<td>Yr 10</td>
<td>Proportion of Borrowed Funds Invested on Farm</td>
<td>Mean</td>
<td>Yr 2</td>
<td>Yr 10</td>
<td>Investment Cost</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>------</td>
<td>------</td>
<td>-------</td>
<td>---------------------------------------</td>
<td>------</td>
<td>------</td>
<td>-------</td>
<td>----------------------------------------------</td>
<td>------</td>
<td>------</td>
<td>-------</td>
<td>----------------</td>
</tr>
<tr>
<td>Gross Revenue</td>
<td></td>
<td>-0.01</td>
<td>-0.01</td>
<td>-0.02</td>
<td></td>
<td>-0.02</td>
<td>-0.05</td>
<td>-0.02</td>
<td></td>
<td>-0.03</td>
<td>-0.03</td>
<td>-0.02</td>
</tr>
<tr>
<td>Expenditure</td>
<td>-0.001</td>
<td>0.09</td>
<td>-0.01</td>
<td>0.02</td>
<td>0.03</td>
<td>0.10</td>
<td>0.003</td>
<td>0.007</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>After tax Cash Surplus</td>
<td></td>
<td>0.02</td>
<td>-0.04</td>
<td>0.11</td>
<td>0.21</td>
<td>0.02</td>
<td>0.03</td>
<td>0.003</td>
<td></td>
<td></td>
<td></td>
<td>0.003</td>
</tr>
<tr>
<td>Consumption</td>
<td>-0.001</td>
<td>0.02</td>
<td>-0.01</td>
<td>0.002</td>
<td>0.01</td>
<td>0.04</td>
<td>0.001</td>
<td>0.003</td>
<td></td>
<td></td>
<td></td>
<td>0.003</td>
</tr>
<tr>
<td>Tax Paid</td>
<td>0.06</td>
<td>-0.04</td>
<td>0.11</td>
<td>0.21</td>
<td>0.02</td>
<td>0.03</td>
<td>0.003</td>
<td>0.001</td>
<td></td>
<td></td>
<td></td>
<td>0.003</td>
</tr>
<tr>
<td>Reserves</td>
<td>0.14</td>
<td>0.18</td>
<td>0.10</td>
<td>0.09</td>
<td>-0.02</td>
<td>-0.16</td>
<td>0.01</td>
<td>0.03</td>
<td></td>
<td></td>
<td></td>
<td>0.03</td>
</tr>
<tr>
<td>Total Assets</td>
<td>-0.003</td>
<td>0.02</td>
<td>-0.01</td>
<td>-0.02</td>
<td>0.002</td>
<td>0.05</td>
<td>0.02</td>
<td>-0.04</td>
<td>-0.03</td>
<td>-0.03</td>
<td>-0.05</td>
<td></td>
</tr>
<tr>
<td>Equity</td>
<td>0.001</td>
<td>0.01</td>
<td>-0.005</td>
<td>-0.01</td>
<td>-0.002</td>
<td>-0.005</td>
<td>-0.002</td>
<td>-0.002</td>
<td>-0.002</td>
<td>-0.002</td>
<td>-0.002</td>
<td></td>
</tr>
<tr>
<td>Funds Borrowed</td>
<td>0.006</td>
<td>0.02</td>
<td>0.03</td>
<td>0.12</td>
<td>0.01</td>
<td>0.07</td>
<td>0.01</td>
<td>-0.01</td>
<td></td>
<td></td>
<td></td>
<td>0.01</td>
</tr>
<tr>
<td>Investment</td>
<td>-0.38</td>
<td>-1.00</td>
<td>1.94</td>
<td>-0.99</td>
<td>-0.12</td>
<td>-5.60</td>
<td>0.08</td>
<td>-0.01</td>
<td></td>
<td></td>
<td></td>
<td>0.06</td>
</tr>
<tr>
<td>Potential Stock Units</td>
<td>-0.02</td>
<td>-0.03</td>
<td>-0.02</td>
<td>-0.05</td>
<td>-0.03</td>
<td>-0.06</td>
<td>-0.03</td>
<td>-0.07</td>
<td></td>
<td></td>
<td></td>
<td>-0.07</td>
</tr>
<tr>
<td>Actual Stock Units</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
A3.1 Introduction

The standard sensitivity analysis described in Chapter 10 involved relatively small perturbations in parameters away from historically based "standard" settings. It seems reasonable that a necessarily limited sensitivity analysis should concentrate on "normal" conditions because most changes in the politico-economic environment tend to be incremental rather than extreme. However, the validity and sensitivity of the model under extreme conditions will also be of interest if policies are to be assessed which are aimed at moderating the effects of adverse economic conditions, either at the sector or individual farm level.

To examine the operation of the model under atypical conditions the model was run four times with successive reductions in all product prices. The four price scenarios represented 100, 75, 50 and 25 percent of the historical price levels. The results are presented graphically for key model responses in Figures A3.1 to A3.12.
A3.2 Results and Discussion

(a) Gross Revenue

Total gross revenue (Figure A3.1) in the early years dropped in proportion to the drop in prices but in later years the fall was more than proportional for the 50% and 25% projections, as disinvestment led to significantly reduced stock numbers in these cases.

(b) Expenditure

As expected, total expenditure (Figure A3.2) exhibited less than proportional reductions due to the fixed component of costs. The result was that after-tax cash surplus (Figure A3.3), which is gross of consumption expenditure, was significantly affected by the price reductions. For example, for the 50% projection the "surplus" was negative in some years, and for the 25% projection it was negative in all years.

(c) Taxation

The progressive nature of taxation was apparent in the taxation projections (Figure A3.4), with greater than proportional reductions in tax-paid as prices were reduced. For the 25% projection virtually no tax was paid.
FIGURE A3.1
Simulated Gross Revenue under a Range of Price Conditions

FIGURE A3.2
Simulated Total Expenditure under a Range of Price Conditions
FIGURE A3.3
Simulated After-tax Cash Surplus under a
Range of Price Conditions

![Graph showing cash surplus over years for different price conditions.]

FIGURE A3.4
Simulated Tax Paid under a
Range of Price Conditions

![Graph showing tax paid over years for different price conditions.]

(d) **Consumption**

The decline in consumption (Figure A3.5) for the 75% and 50% price scenarios was slightly less than proportional to the decline in prices, reflecting the influence of the constant term in the consumption function. With the 25% projection after year 3, consumption remained at the assumed minimum level, corresponding to the value of the constant term in the consumption function. The question of whether a farmer or farming community could exist at such low levels of consumption, without another income source, is not considered explicitly in the model. It is an implied assumption in the model that the farm will continue to operate, albeit with significant rates of disinvestment, and the resulting effects in the farming system are monitored.

(e) **Reserves**

Under historical product prices the reserve level fluctuated but remained around the $60,000 level for the simulated period (see Figure A3.6). For the 75% projection, reserves declined to the minimum level in year 4, while for 50% and 25%, reserves were immediately reduced to the minimum level in year 1. In all three cases extra funds did not become available to augment reserves to maintain their real value. Consequently, the real value of reserves tended to decline over most of the projection period.

In considering the face validity of this result it seems likely that an assumed inflexible minimum reserve level is probably not
FIGURE A3.5
Simulated Consumption under a Range of Price Conditions

FIGURE A3.6
Simulated Reserve Levels under a Range of Price Conditions
realistic under extreme conditions. What might normally be regarded as fixed or non-liquid assets could well be liquidated under extreme conditions. Some consideration of this issue, perhaps to the extent of researching the nature and use of liquid and non-liquid assets, may be appropriate if the model is to be used for policy analysis under extreme conditions.

(f) Deferred Maintenance

With reserves at a minimum under conditions represented by the 75%, 50% and 25% projections, further funds to offset continued cash deficits were made available by deferring maintenance. The value of total deferred maintenance for each run is shown in Figure A3.7. Only temporary periods of deferred maintenance occurred for the 75% projection but significant and continuing deferred maintenance was necessary when prices were assumed to be 50% and 25% of historical levels.

(g) Total Assets

Total assets (Figure A3.8) tended to maintain an upward trend under the 100% and 75% price scenarios but remained relatively stable under projections for 50% and 25%. In these latter cases the reduced value of livestock, caused by reduced stock prices, and the reduced carrying capacity of the land, reflecting disinvestment, offset the increasing value per stock unit of the land which occurred historically. In the model the value of land, on a per-stock-unit basis, is regarded as exogenously determined and therefore not affected
FIGURE A3.7
Simulated Value of Deferred Maintenance under a Range of Price Conditions

FIGURE A3.8
Simulated Value of Total Assets under a Range of Price Conditions
by changes in product prices. This assumption seems appropriate for most incremental changes in politico-economic conditions; however, under extreme economic conditions land values could well be affected. Under these circumstances alternative land-value scenarios could be tested with the model in conjunction with price or policy changes.

(h) Equity and Long-term Borrowing

Equity, for all four projections, followed a similar upward trend over the test period (see Figure A3.9); however, the ranking of the projections on an equity basis changed over time. Initially, the 100% price scenario had the highest equity followed by 75%, 50% and 25%, reflecting the effect of price on the value of livestock; at year 10, however, the rankings were 50%, 75%, 100%, 25%. The rankings of projections for 100%, 75% and 50% can be explained by the effect of prices, through incomes, on new long-term borrowing (see Figure A3.10). Reduced incomes led to reduced borrowing; for the 75% and 50% scenarios the reduction in borrowing, and consequently total liabilities, was more than proportional to the reduction in total assets, with the result that equity increased slightly relative to the 100% price projection. For the 25% situation, long-term borrowing for investment purposes was effectively suspended; however, the reduction in total assets, exacerbated by the reduction in stock carrying capacity, led to a lower equity level over the period. A feature of the 25% projection for borrowing was the substantial loan ($25,000) in year 7 brought about to refinance excessive short-term debt.
FIGURE A3.9
Simulated Equity Levels under a Range of Price Conditions

FIGURE A3.10
Simulated Value of Long-term Borrowing under a Range of Price Conditions
The minor differences in equity levels are probably unrealistic under extreme price conditions due to the lack of feed-back to asset values described above. Again, asset value scenarios linked with price and policy experimentation could overcome this problem.

(i) Investment, Disinvestment and Stock Units

As was indicated by the formal sensitivity analysis discussed in Chapter 10, investment levels proved sensitive to the variation in price. Only for the 100% price projection were significant levels of investment generated (see Figure A3.11). As described above, the other projections, especially for 50% and 25%, involved disinvestment rather than investment. The effect of this investment/disinvestment situation was clearly indicated in the potential stock unit projections (Figures A3.12). Only under historical prices did potential stock units increase; for 75% little change occurred over the period, while for prices at 50% and 25% of historical values, significant reductions in potential stock-units were indicated.
FIGURE A3.11

Simulated Investment Levels under a Range of Price Conditions

FIGURE A3.12

Simulated Potential Stock Units under a Range of Price Conditions
DATA FILE REQUIREMENTS

Five main data files are used for different input parameters:

1. Flock, Herd, Production and Price Parameters

A data file, called INPUT1.DAT, is read with subroutine INPUT1 and contains livestock demographic parameters for the flock and herd, and production and price probability distribution parameters. Flock and herd data include assumed mortality rates, standard culling rates for young and old stock, ram and bull rates, the maximum proportion of young stock that can be retained as replacements, the initial total stock units, and the sheep/cattle ratio.

Production probability distribution parameters are specified as maxima, minima and modal values for lambing and calving rates, wool weights, proportion of lambs sold fat, and seasonal culling rate adjustments.

Maxima, minima and modal values are also specified for the prices of different classes of stock and for wool.
2. Capital Valuation, Farm Cost and Consumption Function Parameters

These parameters are specified in data file INPUT2.DAT and read with subroutine INPUT2. Data related to capital valuation include land value/stock unit, initial valuations for plant and machinery, homestead, financial reserves and current liabilities. Cost and consumption function parameters correspond to those described in Chapter 9 (Sections 9.3.8 and 9.3.10). Data related to inflation rates is also specified in this file.

Other data in this file relate to reserve fund limits, overdraft and deferred maintenance limits, farm maintenance cost per hectare, and the time horizon for the simulation run.

3. Land Development and Taxation Parameters

A third data file (INPUT3.DAT), read by subroutine INPUT3, includes data on land development and taxation. For each area of the farm with development potential, data arrays are specified giving the annual per hectare cost of the development programme, and the associated increases in stock carrying capacity. The number of hectares in each development area is also specified.

Taxation parameters include the coefficients of the taxation function (see Section 4.4.4) and, if required, details of the tax schedule with income increments and associated marginal tax rates. Either the tax function or the tax schedule can be used in the model (see Section 8.4.3).
4. **Long-term Borrowing Parameters**

These data are provided in *INPUT4.DAT* (read by subroutine INPUT4) and relate to the initial long-term loan status of the farm and to subsequent borrowing events. With respect to the initial loan status this is represented by a single mortgage. Data related to this mortgage include the principal, term and interest rate. Data related to subsequent borrowing include borrowing frequency, debt servicing and minimum equity limits, the proportion of borrowed funds invested on-farm, and the interest rates and repayment periods which apply.

5. **Land Development Priority Schedule**

A final input file (*INPUT5.DAT* read by subroutine INPUT5) provides the priority order for the development of different areas on the farm.
A SIMULATION MODEL OF FARM GROWTH & DEVELOPMENT

***** STOCHASTIC VERSION *****

MAIN ROUTINE

THIS IS A SIMULATION MODEL OF A N.Z. NORTH ISLAND HILL COUNTRY FARM DESIGNED TO SIMULATE THE PHYSICAL AND FINANCIAL OPERATION OF SUCH A FARM OVER A PERIOD OF UP TO 20 YEARS. BY CHANGING INPUT PARAMETER VALUES A RANGE OF FARM CONFIGURATIONS CAN BE REPRESENTED AND VARIOUS ECONOMIC, ENVIRONMENTAL AND POLICY SCENARIOS SIMULATED.

DEVELOPED FOR THE N.Z. MINISTRY OF AGRICULTURE AND FISHERIES BY TONY BECK A.E.R.U. LINCOLN COLLEGE UNIVERSITY OF CANTERBURY NEW ZEALAND; 1984

READ TAX ROUTINE SELECTION NO., RANDOM NUMBER SEED, AND NUMBER OF REPLICATIONS WANTED.

READ(16,900)CTAX,SEED,REPL

FORMAT(3(18))
---- READ IN DATA FROM FILES 11, 12, 13, 14 & 15 RESPECTIVELY -----

OPEN(11, FILE='INPUT1', STATUS='OLD', READONLY)
OPEN(12, FILE='INPUT2', STATUS='OLD', READONLY)
OPEN(13, FILE='INPUT3', STATUS='OLD', READONLY)
OPEN(14, FILE='INPUT4', STATUS='OLD', READONLY)
OPEN(15, FILE='INPUT5', STATUS='OLD', READONLY)

CALL INPUT1
CALL INPUT2(DEPREC, OTHRDCST, STANDCST, SSUCST, CONST,)
** MPCONV, MPCONC, PRECON, FYEAR, TAXINC, BRIEFOUT,
** RILIM, RFXLIM, INVRT, DMLIM, COSTINF, COSTINFLT)

CALL INPUT3
CALL INPUT4(PRINC, NTRST, TERM, STYEAR)
CALL INPUT5(BRITY)

------ SET UP POTENTIAL SHEEP AND BEEF STOCK NUMBERS ------

PTSU(O) IS POTENTIAL STOCK UNITS AT START OF YEAR 1
PSSU = PTSU(0) * PSHPROP
PBSU = PTSU(0) - PSSU

AS STARTING CONDITION ASSUME ACTUAL STOCK NUMBERS ARE A PROPORTION OF POTENTIAL
ASSU = PSSU * PROP
ABSU = PBSU * PROP

ATSU(O) IS ACTUAL STOCK UNITS AT START OF YEAR 1
ATSU(O) = ASSU + ABSU

------ DISPLAY INPUT DATA ------

IF(BRIEFOUT.EQ.2 .AND. RET.GT.1) GO TO 111

---- SET UP INITIAL DEBT SITUATION WITH RESPECT TO LOANS ALREADY TAKEN OUT BEFORE YEAR ZERO ----

CALL INLOAD(PRINC, NTRST, TERM, STYEAR)

---- SET UP SELF-SUSTAINING FLOCK AND HERD STRUCTURE ----

CALL INMOB(ABSU, ABSM, HCU, ECU, LARATE, RAMT, RCULL, DUM1,)
** EHOG, EWE2, EWE4, EWE6, EWE8, EWE5YR, DUM2, WETOT,
** ELMSL, LMTOT, RAM, RAMSLL, DUMM4, DUMM5, SEED,
** PSEED, LRMT, M, MULT, CFASLD)

CALL INMOB(ASSU, MORT, HCU2, ECU2, LARATE, RAMT, RCULL, DUM1,)
** EHOG, EWE2, EWE4, EWE6, EWE8, EWE5YR, DUM2, WETOT,
** ELMSL, LMTOT, RAM, RAMSLL, DUMM4, DUMM5, SEED,
** PSEED, LRMT, M, MULT, CFASLD)

------ DETERMINE TAX PAYABLE DURING YEAR 1 ON YEAR 0 INCOME ----- 

IF (CTAX.EQ.0) THEN CALL TAX(TAXINC, ITAXPAY, YOFLTN)
CALL TAX(TAXINC, ITAXPAY, YOFLTN)

LTAXINC = TAXINC

------ THE INFLATION IN YEAR 1 ONLY AFFECTS TAX CALCULATION FOR YEAR 0 SINCE REAL TERMS REFERS TO YEAR 1 DOLLARS -------

CNFLTN(1) = 0

------------- MAIN YEARLY LOOP -------------

CALCULATE PRICE AND COST INFLATION

INFNLTN = INFNLTN + CNFLTN

INFLTN = (1 + INFNLTN) * (1 + CNFLTN(YEAR)) - 1

COSTINF = (1 + COSTINF) * (1 + CNFLTN(YEAR)) * COSTINF - 1

TO GENERATE SHEEP AND WOOL PRICES

CALL PRICES(WOOLPR(YEAR), WLMPR(YEAR), WLMSPR, ELMSPR, ELMSPR,
** EHOPR, EWE2PR, EWE4PR, EWE6PR, EWE8PR,
** CFAPR, RAMSPR, RAMBPR, EWBPR,
** INFNLTN, SEED,
** WOLMIN, WOLMID, WOLMAX, WLMFIN, WLMFMD, WLMAX,
CALL BEEFPRIESC(WSTRPR(YEAR), WHEFPR(YEAR), FSTRPR, CLHEPR,
* COWPR, BULSPR, BULBPR, REPHEPR, INFLTN, SEED,
* WSTMIN, WSTMID, WSTMAX, WHEMIN, WHEMID, WHEMAX,
* ELMIN, ELMID, ELMAX, RMIN, RMIN, RMID, RMAX,
* E2BMIN, E2BMOD, E2BMAX,
* SMPWOL, SMPFLM, SMPFLM, YEAR)

TO GENERATE CATTLE PRICES

CALL SEASON(LRATE(YEAR), LMFTRT(YEAR), EHOGWL, EWEOL, RAMWOL,
* SEED, PSEED, ECULL, SECULL, COWCULL, SCONCULL,
* LRTMIN, LRTMID, LRTMAX, LFRMIN, LFRMID, LFRMAX,
* EHWMIN, EHWMID, EHWMAX, ELMIN, ELMID, ELMAX,
* RWLMIN, RWLMID, RWLMAX, ORMRT, ORMID, ORMAX,
* CFACTR(EAR), YEAR)

CHANGE IN POTENTIAL CARRYING CAPACITY (IN STOCK UNITS) (NETDSR)
IS DETERMINED AS THE NET EFFECT OF DEVELOPMENT (ASR(YEAR) AND
DEFERRED MAINTENANCE SITUATION (DSR).

NETDSR = ASR(YEAR) + DSR
DSR = 0
PTSU(YEAR) = PTSU(YEAR-1) + NETDSR

ALLOCATE POTENTIAL TOTAL STOCK UNITS BETWEEN SHEEP AND CATTLE.

PSSU = PTSU(YEAR) * SPPROP
PBSU = PTSU(YEAR) * (1 - SPPROP)

TO UPDATE FLOCK AND HERD COMPOSITION

CALL FLOCK(PSSU, ASSU, MORT, HCULL, ECULL, SECULL,
* LRATE(YEAR), RAMRT, RHCULL,
* EHGWL, EWEOL, RAMWOL, EMWGWL, EMWOOL, EMWHEL, EMWHEL,
* LMTOT, WLMGSL, REPS, ELMGSL, RAM, RAMSLD, RAMBGT, RMXEL, E2BGT)

CALL HERD(PBSU, ABSU, BMORT, HEFCULL, COWCULL, SCONCULL,
* CFACTR(EAR), BULRT, BULCULL, STRETT,
* HEF1, HEF2, COW3, COW4, COW5, COW6, COW7,
* COW8, STEER, STEER2, CLFTOT, HEFSLD, MACSLD, OLCSDL,
* FSTRSLD, SCFSLD, HCSLD, BPEPS, BULLS, BULDSL, BULDGT,
* NCHOFH, HEFBGT)

DETERMINE ACTUAL TOTAL STOCK UNITS

ATSU(YEAR) = ASSU + ABSU

TO CALCULATE GROSS REVENUE FROM SHEEP AND CATTLE

CALL SAW ACC(YEAR,
* WLMAT, WLMWL, LEMFAT, ELMSLD, WLMST, ELMST, GREML, GREGM,
* GREGV, EMWSLD, EMWSDL, EMWSE, EMWSE, EMWSE, EMWSE,
* CTELSL, GREAV, GREAV, RAMGRT, RAMGRT, GREVSH,
* WOLCUT, EHGWL, MORT, WETOT, RAM, GREWL, LMFTRT(YEAR),
* WLMATR(YEAR), WLMPSL, EMPLPR, LEMSPR, EMSPR, EMSPR,
* EM2PR, EM4PR, EM6PR, EM2PR, EMEPR, CMAPR, RMAPR, RMAPR,
* E2BGT, EMEWL, RAMWOL, WOLPRL(YEAR), E2BGT, E2BPR)

CALL BEEFFACC(YEAR, HEFSLD, MACSLD, OLCSDL, FSTRSLD, SCFSLD, HCSLD,
* BULSLD, HEFBGT, BULDGT, GREWOL, GREVCAF, GREVFST,
* GREWOL, GREVCAF, CLHPR, COMPR, FSTRPR, WSTRPR,
* WHEFPR, BULSPR, BULBPR, REPHEPR)

----- USE THE VALUES RETURNED BY SAWACC TO CALCULATE THE WOOL PRODUCTION
----- PER STOCK UNIT: WOLPSU FOR THIS YEAR.

WOLPSU(YEAR) = WOLCUT(YEAR) / ASSU

TO CALCULATE FARM COSTS

CALL FCOST(ATXNFINC(YEAR), DEPREC, OTHERCST, SSUCST,
* STANDST, ACOST(YEAR), ASSU, ABSU, AINTP(YEAR),
* APRIPA(YEAR), GREVSH(YEAR), GREWLL(YEAR),
* GREBFW(YEAR), INFLTN, CSTINF, TAXPAY(YEAR),
* TCHEXP, TAXEXP, TAXINC, ITAXPAY, DEVEXP, DEFUNDS,
* CTAX, (TAXINC)

LTAXINC = TAXINC

----- 'FARMER' CALCULATES CONSUMPTION AND DECIDES ON BORROWING

CALL FARMER(YEAR, ATXNFINC(YEAR), CONST, MPCONY, MPCONC,
* PRECON, INFLTN, BORRYEAR, TAXPAY(YEAR),
* CTAX, LTAXINC)
* * INTR,TERM,CONSUM,
* BORRFREQ,RISK,WTP,SURPLUS,PCEQUITY)
* TO CALCULATE LOAN IF BORROWING
* IF(BORRYEAR.EQ.0) GO TO 10
* CALL LOANS(FDBRWD(YEAR),INTR(YEAR),TERM(YEAR),YEAR,LNKNT,
* BORRFREQ,WTP,PCEQUITY,0,REFLAG,
* INTPAY,PAYPAY,PAYOUT,
* APRT,AAPRT,AAPRT,APRT,
* SVAL,PLANTVAL,HSTOVAL,RACC,
* CURLIB,FARMCAP,INFLTN,TOTALIB)
* ------ LNKNT IS THE LOAN NUMBER
* ------ CALCULATE SURPLUS FUNDS AFTER TAX, CONSUM., AND BORROWING.
* PROPINV IS PROPORTION OF BORROWED FUNDS AVAILABLE FOR
* ON-FARM INVESTMENT (INCLUDING RESERVES).
* 10 FUNDS = ATXNFINCYEAR) - CONSUM(YEAR)
* + FDBRWD(YEAR) * PROPINV
* SPLFND = FUNDS
* REMAINS = 0
* DEVEXP = 0
* TO MAKE ADJUSTMENTS TO RESERVES, DEFERRED FERT., MAINT.,
* AND OVERDRAFT TO DETERMINE FUNDS REMAINING FOR
* DEVELOPMENT.
* SAVE CURRENT LEVELS FOR SUBSEQUENT MONITORING OF CHANGES
* PCURLIB = CURLIB
* PDMACC = DMACC
* PRIACC = RIACC
* IF(FUNDS.LT.0) GO TO 200
* SURPLUS FUNDS ARE AVAILABLE
* CHECK IF OVERDRAFT IS POSITIVE
* IF(CURLIB.GT.0)
* CALL OVERDRAFT(FUNDS,ODLIMIT,CURLIB,INFLTN)
* CHECK IF FUNDS REMAIN AND IF DEFERRED MAINTENANCE
* IS POSITIVE
* IF(FUNDS.GT.0.AND.DMACC.GT.0)
* CALL DEFER(FUNDS,DMACC,DLIM,MCOST,CSTINFLT,DSR,
* TSLLOSS,DEFERFLG,DEFUNDS,DMAREA)
* DMTNC(YEAR) = DMACC
* CALL RESERVE TO UPDATE RESERVE LEVEL AND DETERMINE
* FUNDS AVAILABLE FOR INVESTMENT
* CALL RESERVE(FUNDS,RLIM,RFXLM,RIACC,
* RDCINV(YEAR),INVRT,INFLTN)
* MAVAIL(YEAR) = FUNDS
* CHECK IF FUNDS ARE AVAILABLE FOR INVESTMENT
* IF(FUNDS.GT.0)
* CALL DEVELOP(YEAR,DPRTY,DEVKNT,FUNDS,DEVHA(YEAR),CSTINFLT,
* DEVEXP,REMAINS,PSU(YEAR),ATSU(YEAR))
* IF LIMIT OF DEVELOPMENT IS REACHED REMAINING SURPLUS FUNDS
* (REMAINS) IS ADDED TO RESERVES
* RIACC = RIACC + REMAINS
* RESERVE LEVEL THEN SAVED FOR OUTPUT
* RDCINV(YEAR) = RIACC
* GO TO 201
* 200 CONTINUE
* DEFICIT MUST BE COVERED
* CHECK IF SOME RESERVE IS AVAILABLE
* IF(RIACC.GT.RFSLIM*(1+INFLTN))
* CALL RESERVE(FUNDS,RLIM,RFXLM,RIACC,
* RDCINV(YEAR),INVRT,INFLTN)
* RDCINV(YEAR) = RIACC
* CHECK IF DEFICIT REMAINS AND FURTHER DEFERRED
* MAINTENANCE IS POSSIBLE
* IF(FUNDS.LT.0)
* CALL DEFER(FUNDS,DMACC,DLIM,MCOST,CSTINFLT,DSR,
* TSLLOSS,DEFERFLG,DEFUNDS,DMAREA)
* DMTNC(YEAR) = DMACC
* CHECK IF DEFICIT REMAINS
* IF(FUNDS.LT.0)
* CALL OVERDRAFT(FUNDS,ODLIMIT,CURLIB,INFLTN)
CHECK IF A DEFICIT REMAINS INDICATING THAT A TERM LOAN IS NECESSARY.

IF(FUNDS.LT.0) THEN
  CALL LOANS(-FUNDS,INTR(YEAR),TERM(YEAR),YEAR,ENKNT,
    NBPRT,QTPR,PCQT,PRE,IPRT,
    APRT,ANPRT,APRTT,TRPRT,
    SUVAL,PLANTVAL,HSTDVAL,RICA,
    C, FARMCAP, INFLN, TOTALIB)
  FDREWD(YEAR) = -FUNDS
ENDIF

FUNDS = 0
CONTINUE

CALCULATE CHANGES IN LEVELS
DCURLIB = CURLIB - PCURLIB
DMACC = DMACC - DMACC
DRAC = RICA - RICA

TO UPDATE CAPITAL VALUES
CALL CAPITAL(PTSU(YEAR), EMTOT(2), EHOG(2), RAM(2),
  EHPN, EWP, RSM, COT(2), HEP(2),
  HP(2), BULL(2), STEER(2), STEER(2),
  C0PR, C0PR, BULLSP, F0SPR,
  F0PR, F0PR, F0PR, F0PR,
  LMT(2), LMT(2), RAM(2), RAM(2),
  RAM(2), RAM(2), RAM(2),
  C, FARMCAP, INFLN, TOTALIB, RICA,
  YEAR)

RECORD INCREASE IN AREA OF LAND DEVELOPED
THADEV = THADEV + DEVHA(YEAR)

IF (BRIEFOUT .EQ. 2) GO TO 100
IF (BRIEFOUT .EQ. 1 .AND. YEAR .GT. 1 .AND. YEAR .LT. FYEAR)
  TO OUTPUT ANNUAL PRODUCTION AND FINANCIAL RESULTS
  CALL ANNUOUT(YEAR, TXNFINC(YEAR), INFLN, CNFLN(YEAR),
    NETWTH(YEAR), EWMPS, TOTALIB, TOTASSET, EQUITY(YEAR),
    GREVC, GREVW, GREVH, GREVM, GREVW, GREVH, GREVM, GREVW, GREVH,
    GREVL, C, RAMB, RAMB, RAMB, RAMB, RAMB, RAMB, RAMB, RAMB,
    CRMPS, CRMQ, CRMR, CRMV, CRMS, CRMS, CRMS, CRMPS, CRMQS,
    C, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
    LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT, LAMTOT,
SUBROUTINE INPUT1

THIS SUBROUTINE READS IN DATA RELEVANT TO THE FLOCK AND HERD:
- MAXIMUM, MINIMUM AND MODAL VALUES FOR PRICES AND SEASONAL PRODUCTION VARIABLES, SUPPLEMENTARY MINIMUM PRICES AND THE MAXIMUM PROPORTION OF EWE LAMBS/HEIFER CALVES TO BE RETAINED FOR REPLACEMENTS.

COMMON /PRIOR/ WOLMIN, WOLMID, WOLMAX, WLFMIN, WLFMID, WLFMAX, WLSMIN, WLSMID, WLSMAX, ESLMIN, ESLMID, ELMAX, EHMIN, EHMID, EHMAX, EMIN, EMID, EMAX, CFAMIN, CFAMID, CFA MMAX, RRMIMIN, RRMIMID, RRMIMAX, RRMIMID, RRMIMAX, E2BMIMIN, E2BMIMID, E2BMIMAX, LRTMIN, LRTMID, LRTMAX, LFRMIN, LFRMID, LFRMAX, EHERMIN, EHERMID, EHERMAX, ELMIN, ELMID, ELMAX, EHWMIN, EHWMID, EHWMAX, EWLMIN, EWLMID, EWLMAX, MLPMIN, MLPMID, MLPMAX, SEVPWOL, SEVPFLM, SEVPSLM, CRTMIN, CRTMID, CRTMAX
COMMON /SESNRT/ LRTMIN, LRTMID, LRTMAX, LRFLMIN, LRFLMID, LRFLMAX, EHERMIN, EHERMID, EHERMAX, ELMIN, ELMID, ELMAX, ELMAX, EWHMIN, EWHMID, EWHMAX, EWLMIN, EWLMID, EWLMAX, RWLMIN, RWLMID, RWLMAX, CRTMIN, CRTMID, CRTMAX
COMMON /SPMNPR/ SMPWOL, SMPFLM, SMPSLM
COMMON /PRODPAR/ PTSU(0:21), PROPTOT, MORT, H CULL, ECULL, RM C ULL, RAMRT, MXELH, SHPROP, SSUCST, BMORT, H EFCUL, CONCUL, BULCUL, BULRT, MXHCFH, STRE T, PROP
REAL LRTMIN, LRTMID, LRTMAX, LFRMIN, LFRMID, LFRMAX, EHERMIN, EHERMID, EHERMAX, ELMIN, ELMID, ELMAX, EHWMIN, EHWMID, EHWMAX, EWLMIN, EWLMID, EWLMAX, MLPMIN, MLPMID, MLPMAX, SEVPWOL, SEVPFLM, SEVPSLM

READ(1',100) WOLMIN, WOLMID, WOLMAX, WLFMIN, WLFMID, WLFMAX, WLSMIN, WLSMID, WLSMAX, ESLMIN, ESLMID, ELMAX, EHMIN, EHMID, EHMAX, EMIN, EMID, EMAX, CFAMIN, CFAMID, CFA MMAX, RRMIMIN, RRMIMID, RRMIMAX, RRMIMID, RRMIMAX, E2BMIMIN, E2BMIMID, E2BMIMAX
READ(1',100) SMPWOL, SMPFLM, SMPSLM

READ(1',300) MORT, H CULL, ECULL, RM C ULL, RAMRT, MXELH, SHPROP

IC FORMAT(3F6.0)
FORMAT(7F6.0)
FORMAT(16,F6.0)
RETURN END

SUBROUTINE INPUT2

A ROUTINE TO READ IN GENERAL VARIABLES SUCH AS THE SEED FOR THE PSEUDO-RANDOM NUMBERS & THE LENGTH OF THIS RUN IN YEARS, ALSO ASSETS AND LIABILITIES. ALSO COST AND CONSUMPTION FUNCTION PARAMETERS.

COMMON /CPTLRT/ SUVALLPLANTVAL, HSTDVAL, RIACC, CULIB, FARMCAP, INFITN, TOTALIB
COMMON /ACCINF/ CNFLTN(20)
INTEGER SEED, DEPREC, OTHRDCT, STANDCST, SPECREV, SUVAL, PLANTVAL,
     HSTDVAL, RIAACC, CURLIB, FYEAR, TAXINC,
     BRIEFOUT, RILIM, RFXLIM, DMLIM, ODLIMIT, MCOST
REAL CNFLTN, CONST, MPCONY, MPCONC, PRECON, INFLTN, RIMP, COSTINF,
     INVRT, SSUCST

READ(12,100) FYEAR, BRIEFOUT
READ(12,100) SUVAL, PLANTVAL, HSTDVAL, RIAACC
READ(12,150) RILIM, RFXLIM, INVRT, TAXINC
READ(12,100) CURLIB, ODLIMIT, DEPREC, OTHRDCT
READ(12,110) STANDCST, SSUCST, DMLIM, MCOST
READ(12,300) CNFLTN(1), I = 1, 20
READ(12,300) COSTINF

FORMAT(4IS) FORMAT((IS), (FS.0, 6F2.1), (IS))
FORMAT((6FS.0), (10FS.2, 10FS.2))
RETURN END

SUBROUTINE INPUT3
A ROUTINE FOR READING IN THE COST OF LAND DEVELOPMENT (DCOST),
THE DEVELOPMENT RETURN IN TERMS OF INCREASED STOCK UNIT CARRYING CAPACITY OF
THE FARM FOR EACH HECTARE DEVELOPED (SRADD),
THE TAX FUNCTION AND THE TAXRATE ARRAY USED IN THE TAX SCHEDULE ROUTINE.
COMMONT/ATAX/TAXCONST, TAXRAT, LTAXRAT, TAXRATE(8, 3)
COMMON /DVLPRT/ DCOST(5, 20), SRADD(5, 20), COST(5, 20), SR(25, 20),
     ACOOST(20), ASR(20), PEA(5)
INTEGER DOOST, COST, ACOOST, AREA
REAL TAXCONST, TAXRAT, LTAXRAT
READ(13, 100) (WCOST(I, J), J = 1, 20), I = 1, 5,
     (SRADD(I, J), J = 1, 20), I = 1, 5)
READ(13, 8000) (AREA(I), I = 1, 5)
READ(13, 1400) TAXCONST, TAXRAT, LTAXRAT
DO 10 I = 1, 8
READ(13, 14000) (TAXRATE(I, J), J = 1, 3)
CONTINUE
10 FORMAT(5(2014/), 5(20F4.1/))
FORMAT(3IS/) FORMAT(2IS/) FORMAT(3FS.O)
RETURN ENO

SUBROUTINE INPUT4(PRINC, NTRST, TERM, STYEAR)
A ROUTINE FOR READING IN LOAN DATA :
THE CHARACTERISTICS OF AN INITIAL LOAN WHICH SIMULATES THE CURRENT EFFECT OF ALL THE BORROWING ACTIVITY BEFORE THE START OF THE MODEL'S SIMULATION PERIOD;
AND THE LOANS TO BE TAKEN OUT OVER THE SIMULATION PERIOD.
COMMON/AFARMR/FDBRWD(20), INTR(20), LTERM(20), SPLFND, CONSUM(20),
     BORRFREQ, RISK, WP, SURPLUS(20), PCEQUITY, PROPINV
INTEGER FDBRWD, PRINC, LTERM, STYEAR, TERM, SPLFND, BORRFREQ, WP
REAL INTR, RISK, PCEQUITY, CONSUM, PROPINV
READ(14, 100) PRINC, TERM, STYEAR, NTRST
READ(14, 200) BORRFREQ, RISK, PCEQUITY, PROPINV
DO 10 I = 1, 20
READ(14, 300) (INTR(I), LTERM(I))
CONTINUE
10 FORMAT(20F6.0)
FORMAT(16, F6.0)
FORMAT(16, F6.0)
FORMAT(16, F6.0)
RETURN END

SUBROUTINE INPUT5(DPRTY)
A ROUTINE TO READ DATA IN FROM A FILE CREATED PRIOR TO THE
MODEL RUN (PERHAPS BY ANOTHER PROGRAM) OF THE ORDER OF DEVELOPMENT PRIORITIES.
INTEGER DPRTY(5)
READ(15, 100) DPRTY
FORMAT (5(7X, 11))

RETURN
CHECK VALIDITY OF INPUT SINCE RNDATA REQUIRES PRIORITY NUMBERS
IN THE RANGE 1 TO 5.

DO 10 I=1,5
   IF (OPRTY(I).GT.5) OPRTY(I) = 5
   IF (OPRTY(I).LT.1) OPRTY(I) = 1
CONTINUE
RETURN
END

SUBROUTINE INMOB (SU,MORT,CULYNG,CULOLD,BTHRAT,MALRT,MALCUL,
* STRRET,AGE1,AGE2,AGE3,AGE4,AGE5,AGE6,AGE7,BRDTOT,FYNGSLD,
* YNGTOT,MALES,MALSLD STEER1,STEER2,SEED,PSEED,
* BRTMID,TYPE,MULT,CFASLD)

THIS SUBROUTINE DETERMINES A STABLE INITIAL FLOCK OR HERD
STRUCTURE GIVEN INITIAL SHEEP OR CATTLE STOCK UNITS
(SHEEP:TYPE=1; CATTLE:TYPE=2)

INTEGER AGE1(2),AGE2(2),AGE3(2),AGE4(2),AGE5(2),AGE6(2),
* AGE7(2),STEER1(2),STEER2(2),SEED,PSEED,
* BRDTOT(2),FYNGSLD(2),YNGTOT,MALES(2),MALSLOD(2),SU,CFASLD,
* REPS,TYPE
REAL MORT,BTHRAT,MULT,BRTMID,MALRT,MALCUL
BTHRAT=BRTMID
PSEED=SEED
R=RAN(SEED)

CALCULATE THE PROPORTION OF ADULT STOCK THAT WILL SURVIVE UNTIL
NEXT YEAR

SURVS=1-CULOLD-MORT

CALCULATE NUMBER OF HEIFERS OR EWE HOGGETS NEEDED TO MAINTAIN
THE FLOCK OR HERD AT CONSTANT NUMBER

FOR SHEEP
   IF(TYPE.EQ.1)MULT=.7+(1-CULYNG-MORT)*(SURVS**4+
      SURVS**3+SURVS**2+SURVS+1)*(1+MALRT*.8)
   FOR CATTLE
   IF(TYPE.EQ.2)MULT=3.5+(1-CULYNG-MORT)*
      (4.5+(MALRT*.5)+(BTHRAT/2*STRRET*.5)+
      (BTHRAT/2*STRRET*(1-MORT)*4.5)+
      (1-CULYNG-MORT)*(SURVS**5+SURVS**4+SURVS**3+
      SURVS**2+SURVS)*6.0+(MALRT*.5)+(BTHRAT/2*STRRET*.5)+
      (BTHRAT/2*STRRET*(1-MORT)*4.5)

   AGE1(2) = JNINT(SU/MULT)
   FROM THIS, CALCULATE THE NUMBER OF STOCK IN EACH AGE GROUP
   ADJUST TO AVOID ERROR ACCUMULATION

   AGE2(2) = JNINT(AGE1(2) * (1-CULYNG-MORT))
   AGE3(2) = (AGE2(2) * SURVS)*1000
   AGE4(2) = (AGE3(2) * SURVS)
   AGE5(2) = (AGE4(2) * SURVS)
   AGE6(2) = (AGE5(2) * SURVS)
   AGE7(2) = (AGE6(2) * SURVS)

   NOW CONVERT BACK TO ACTUAL VALUES

   AGE3(2) = JNINT(AGE3(2)/1000.0)
   AGE4(2) = JNINT(AGE4(2)/1000.0)
   AGE5(2) = JNINT(AGE5(2)/1000.0)
   AGE6(2) = JNINT(AGE6(2)/1000.0)
   AGE7(2) = JNINT(AGE7(2)/1000.0)

   CALCULATE BREEDING STOCK AND LAMB/CALF TOTALS

   IF(TYPE.EQ.2) GO TO 10
   FOR SHEEP
   BRDTOT(2) = AGE2(2)+AGE3(2)+AGE4(2)+AGE5(2)+AGE6(2)+AGE7(2)
   YNGTOT = JNINT(BRDTOT(2)*BTHRAT)
   CFASLD = JNINT((AGE2(2)-STRRET))
   REPS = JNINT((AGE2(2)+AGE3(2)+AGE4(2)+AGE5(2)+AGE6(2)+AGE7(2))
      + (BTHRAT/2)*SURVS)
   BTRAT=2*STRRET
   CONTINUE

   FOR CATTLE
   BRDTOT(2) = AGE2(2)+AGE3(2)+AGE4(2)+AGE5(2)+AGE6(2)+AGE7(2)
   YNGTOT = JNINT((BRDTOT(2)+BTHRAT)
   CFASLD = JNINT((AGE2(2)-STRRET))
   REPS = JNINT((AGE2(2)+AGE3(2)){(CULYNG+MORT)+BRDTOT(2)}
      *(MALSLD+MORT)
      *(MALRT)*SURVS)
   STEER1(2) = JNINT((YNGTOT/2)*BRDTOT)
   STEER2(2) = JNINT(STEER1(2)*(1-MORT))
   CONTINUE

   CALCULATE THE NUMBER OF EWE SALEABLE EWE LAMBS OR HEIFER CALVES

   FYNGSLD(2) = JNINT(YNGTOT/2.0)-REPS
   MALES(2) = JNINT(BRDTOT(2)*MALRT)
   MALSLD(2) = JNINT(MALES(2)*MALCUL)
RETURN
SUBROUTINE FLOCK(PSSU,ASSU,MORT,HCULL,ECULL,SECULL,LRATE,
RAMRT,RMCULL,EHOG,EWE2,EWE4,EWE6,
EMBSS,EMWS,EMGLD,EMASLD,EMBSLD,
EMASLD,EMASLD,EMWS,EMGLD,EMBSLD,EMRT,
MREPS,EMRSLD,EMBRT,EMBRT,EMRT,
MXELH,EM2BGT)

A SUBROUTINE TO SIMULATE THE DYNAMIC COMPOSITION OF
A SELF-REPLACING FLOCK

NOTE: ACTUAL STOCK NUMBERS ARE CHANGED BY VARYING
EWE CULLING RATES WHICH ARE DETERMINED MAINLY
BY SEASONAL CONDITIONS. ACTUAL STOCK UNITS (ASSU)
CAN INCREASE BUT ONLY TO THE LEVEL OF
POTENTIAL STOCK UNITS (PSSU) WHICH IS DETERMINED
BY FARM INVESTMENT AND DISINVESTMENT.

INTEGER EHOG(2),EWE2(2),EWE4(2),EWE6(2),EWE5YR(2)
EMETOT(2),EMBSLD,EMASLD,EMASLD,EMBSLD,EMGLD,EMASLD,EMWS,
EMGLD,EMRT,EMRSLD,EMBRT,EMBRT,EMRT,
MAEWE,PSSU,ASSU
REAL MRT,LRATE,ECULL,SECULL,MXELH,ASSU

STORE LAST YEAR'S FIGURES
"1" IS THE PAST YEAR, "2" IS THE PRESENT YEAR

EHOG(1)=EHOG(2) EWE2(1)=EWE2(2) EWE4(1)=EWE4(2) EWE6(1)=EWE6(2)
EMETOT(1)=EMETOT(2) ELMSLD(1)=ELMSLD(2) RAM(1)=RAM(2)
RAMSLD(1)=RAMSLD(2)

CALCULATE LAMBS SOLD AND RETAINED AS REPLACEMENTS BASED
ON STANDARD HOGETT AND EWE CULLING RATES (HCULL AND ECULL)

REPS=JNINT(EHOG(1)*(HCULL+MORT)+EMETOT(1)*(ECULL+MORT)
+EWE5YR(1)*(1-ECULL-MORT))

LAMTOT=JNINT(EMETOT(1)*LRATE*(1-MORT))

WLMST=JNINT(LAMTOT/2.)

CHECK THAT THERE ARE ENOUGH EWE LAMBS FOR REPLACEMENTS
IF(REPS.LE.MXELH*LAMTOT/2) GO TO 10

TWO TOOTHS MUST BE BOUGHT TO MAKE UP STOCK NUMBERS
ELMSLD(2)=JNINT((MXELH-LAMTOT/2)*)
EW2BGT = JNINT(REPS*MXELH*LAMTOT/2)

 THESE SHEEP PURCHASED TO MAKE UP STOCK NUMBERS FOR NEXT YEAR
ARE BOUGHT TO LAMB AS TWO-TOOTHS NEXT YEAR, NOT AFFECTING THIS YEAR'S LAMBING.
GO TO 20

SUFFICIENT EWE LAMBS ARE AVAILABLE.

ELMSLD(2)=JNINT((LAMTOT/2.-REPS)
EW2BGT = 0

CALCULATE THE NUMBER OF EWES THIS YEAR
NOTE ADJUSTMENTS MADE TO MINIMISE ERROR ACCUMULATION

HOGETT CULLING RATE ASSUMED TO REMAIN CONSTANT

EHOG(2)=JNINT((LAMTOT/2.-ELMSLD(2)))+W2BGT)
EWE2(2)= (EHOG(2)-EHOG(1)*HCULL-(EHOG(1)*MORT)*10000
EWE2(2) = JNINT(EWE2(2)/1000.)

NOW DETERMINE IF THE EWE CULLING RATE SPECIFIED FOR
THIS YEAR WILL LEAD TO ACTUAL STOCK UNITS (ASSU)
EXCEEDING POTENTIAL Stock UNITS (PSSU)

-DETERMINE MINIMUM CULL RATE POSSIBLE (MINECUL)
(I.E. THE CULL RATE THAT WOULD LEAD TO PSSU)

MAEWE = EWE2(1)+EWE4(1)+EWE6(1)+EW5YR(1)
MINECUL = (0.7*EHOG(2)+EWE2(2)+MAEWE-(MAEWE*MORT)+
0.6*RAM(2)-PSSU)/MAEWE

IF MINIMUM CULL RATE IS GREATER THAN SEASONAL CULL
RATE THEN SUBSTITUTE

IF(MINECUL.GT.SECULL)SECULL=MINECUL

NOW CALCULATE REMAINDER OF FLOCK USING APPROPRIATE
EWE CULL RATE.

EWE4(2)= (EWE2(1)-EWE2(1)*SECULL-(EWE2(1)*MORT))*1000
EWE6(2)= (EWE4(1)-EWE4(1)*SECULL-(EWE4(1)*MORT))*1000
EWE2(2)= (EWE6(1)-EWE6(1)*SECULL-(EWE6(1)*MORT))*1000
EWE5YR(2)= (EWE2(1)-EWE2(1)*SECULL-(EWE2(1)*MORT))*1000

NOW CONVERT BACK TO ACTUAL VALUES

EWE4(2) = JNINT(EWE4(2)/1000.)
EWE6(2) = JNINT(EWE6(2)/1000.)
EWE2(2) = JNINT(EWE2(2)/1000.)
EWE5YR(2) = JNINT(EWE5YR(2)/1000.)
EMETOT(2)=EWE2(2)+EWE4(2)+EWE6(2)+EWE5YR(2)+EWE5YR(2)
CALCULATE STOCK SALES FROM CURRENT FLOCK

\[
\begin{align*}
\text{EHGSLD} &= \text{JNINT}(\text{EHOG}(1) \times \text{HEFCUL}) \\
\text{EWSLD} &= \text{JNINT}(\text{EWE}(2) \times \text{HEFCUL}) \\
\text{EWSL} &= \text{JNINT}(\text{EWE}(4) \times \text{HEFCUL}) \\
\text{EWBSLD} &= \text{JNINT}(\text{EWE}(8) \times \text{HEFCUL}) \\
\text{CFASLD} &= \text{JNINT}(\text{EWE}5YR(I) - (\text{EWE}5YR(I) \times \text{MORT}))
\end{align*}
\]

CALCULATE RAMS HELD, BOUGHT AND SOLD

\[
\begin{align*}
\text{RAM}(2) &= \text{JNINT}(\text{EWETOT}(2) \times \text{RAMRT}) \\
\text{RAMSLD}(2) &= \text{JNINT}(\text{RAM}(I) \times \text{RMCIlLL}) \\
\text{RAMBGT} &= \text{JNINT}(\text{RAM}(2) - \text{RAM}(1) \times (1 - \text{MORT} - \text{RCULL}))
\end{align*}
\]

CALCULATE ACTUAL SHEEP STOCK UNITS AT END OF YEAR.

\[
\text{ASSU} = 0.7 \times \text{EHQG}(2) + \text{EWETOT}(2) + 0.8 \times \text{RAM}(2)
\]

RETURN

END

SUBROUTINE HERD(PBSU, ABSU, BMORT, HEFCUL, 
* COWCUL, COWCUL6SCOWCUL, COWCUL, COWCUL, STEER1, STEER2, 
* CLFTOT, HEFSLD, MACSLD, OLCSDL, FSTRSLD, SCFSLD, HCFSLD, 
* BREPS, BULLS, BULLSLD, BULBGT, MXHCFH, HEFBGT)

A SUBROUTINE TO SIMULATE THE DYNAMIC COMPOSITION OF A SELF-REPLACING BEEF HERD

NOTE: ACTUAL STOCK NUMBERS ARE CHANGED BY VARYING COW CULLING RATES WHICH ARE DETERMINED MAINLY BY SEASONAL CONDITIONS. ACTUAL STOCK UNITS (ABSU) CAN ONLY INCREASE TO THE LEVEL OF POTENTIAL STOCK UNITS (PBSU) WHICH IS DETERMINED BY FARM INVESTMENT AND DISINVESTMENT.

INTEGER HEFI(2), HEF2(2), COW3(2), COW4(2), COW5(2), COW6(2), COW7(2), 
* COWTOT(2), HEFSLD, MACSLD, OLCSDL, FSTRSLD, SCFSLD, HCFSLD, 
* BREPS, BULLS, BULLSLD, BULBGT, MXHCFH, HEFBGT

STORE LAST YEAR'S FIGURES
"1" IS THE PAST YEAR, "2" IS THE PRESENT YEAR

\[
\begin{align*}
\text{HEFI}(1) &= \text{HEFI}(2) \\
\text{HEF2}(1) &= \text{HEF2}(2) \\
\text{COW3}(1) &= \text{COW3}(2) \\
\text{COW4}(1) &= \text{COW4}(2) \\
\text{COW5}(1) &= \text{COW5}(2) \\
\text{COW6}(1) &= \text{COW6}(2) \\
\text{COW7}(1) &= \text{COW7}(2) \\
\text{COWTOT}(1) &= \text{COWTOT}(2) \\
\text{BULLS}(1) &= \text{BULLS}(2) \\
\text{BULLSLD}(1) &= \text{BULLSLD}(2) \\
\text{STEER1}(1) &= \text{STEER1}(2) \\
\text{STEER2}(1) &= \text{STEER2}(2) \\
\text{SCFSLD}(1) &= \text{SCFSLD}(2) \\
\text{HCFSLD}(1) &= \text{HCFSLD}(2)
\end{align*}
\]

IN CALCULATING THE VALUES OF ACTIVITIES REQUIRED TO KEEP THE HERD IN A STABLE STATE ROUNDING ERRORS CAN ACCUMULATE DUE TO THE 'BOOTSTRAPPING' METHOD OF DERIVATION. I.E ONE HERD COMPONENT DERIVED USING THE VALUE OF A PREVIOUSLY CALCULATED ONE. TO OVERCOME THIS ALL VALUES HAVE BEEN CALCULATED EXACTLY (BY CONVERTING ALL FRACTIONAL PARAMETERS TO WHOLE NUMBERS) THEN THE ACTIVITIES HAVE BEEN ROUNDED TO THEIR CLOSEST INTEGER VALUE.

CALCULATE HEIFER CALVES NEEDED AS REPLACEMENTS USING STANDARD HEIFER AND COW CULLING RATES (HEFCUL AND CONCUL)

\[
\begin{align*}
\text{BREPS} &= \text{JNINT}(\text{HEFI}(1) \times (\text{HEFCUL} - \text{BMORT}) + \text{COWTOT}(1) \times (\text{COWCUL} + \text{BMORT})) \\
\text{CLFTOT} &= \text{COWTOT}(1) \times \text{CRATE} \times (1 - \text{BMORT})
\end{align*}
\]

CALCULATE STEER CALVES SOLD AS WEANERS: BALANCE IS RETAINED FOR FATTENING

\[
\begin{align*}
\text{SCFSLD} &= \text{JNINT}(\text{CLFTOT}/2 \times (1 - \text{STRRET})) \\
\text{USE ABOVE STATEMENT WHEN NO. OF STEERS RETAINED FOR FATTENING IS BASED ON PROP. OF STEER CALVES (STRRET)}
\end{align*}
\]

SCFSLD = CLFTOT/2 - STEER1(1) USE ABOVE STATEMENT WHEN STEERS RETAINED IS MAINTAINED AT CONSTANT LEVEL
CHECK THAT THERE ARE ENOUGH HEIFER CALVES AVAILABLE FOR REPLACEMENTS.

IF(BREPS.LE.MXHCFH*CLFTOT/2)GO TO 10

IF INSUFFICIENT CALVES, 2 YEAR HEIFERS ARE BOUGHT IN TO MAKE UP STOCK NUMBERS.

{HEFSLD(2) = JNINT((1-MXHCFH)*CLFTOT/2)
  HFBGT = JNINT(BREPS - MXHCFH * CLFTOT/2)

HEIFERS BOUGHT CALVE AS 3 YEAR OLD COWS

NEXT YEAR, NOT AFFECTING THIS YEARS CALVING

GO TO 20

IF SUFFICIENT HEIFER CALVES ARE AVAILABLE:

{HCFSLD(2) = JNINT(CLFTOT/2. - BREPS)
  HFBGT = 0

CALCULATE THE NUMBER OF COWS THIS YEAR.

20  

HEIFER CULLING RATE ASSUMED TO REMAIN CONSTANT

{HEF1(2) = JNINT(CLFTOT/2. - HCFSLD(2) + HFBGT)
  HEF2(2) = (HEF1(1) * (1-HEF1CUL-BMORT)*1000)

NOW DETERMINE IF THE COW CULLING RATE SPECIFIED FOR THIS YEAR WILL LEAD TO ACTUAL STOCK UNIT (ABSU) EXCEEDING POTENTIAL STOCK UNITS (PBSU)

- DETERMINE MINIMUM CULL RATE POSSIBLE(MINCCUL)

{MACOW = HEF2(1)+COW3(1)+COW4(1)+COW5(1)+COW6(1)

MINCCUL = (3.5*HEF1(2)+4.5*HEF2(2)+6.0*MACOW)* 5.5*BMORT*MACOW+3.5*STEER1(1)+4.5*STEER2(1)+ 5.5*BULLS(1) - PBSU/(6.0*MACOW)

IF MINIMUM CULL RATE IS GREATER THAN SEASONAL CULL RATE THEN SUBSTITUTE IF (MINCCUL.GT.SCOWCUL) SCOWCUL = MINCCUL

NOW CALCULATE REMAINDER OF HERD USING APPROPRIATE COW CULL RATE.

{COW3(2) = JNINT(COW3(1))/1000.
  COW4(2) = JNINT(COW4(1))/1000.
  COW5(2) = JNINT(COW5(1))/1000.
  COW6(2) = JNINT(COW6(1))/1000.
  COW7(2) = JNINT(COW7(1))/1000.

NOW CONVERT THE VALUES BACK TO ACTUAL VALUES

{COW3(2) = JNINT(COW3(2)/1000.)
  COW4(2) = JNINT(COW4(2)/1000.)
  COW5(2) = JNINT(COW5(2)/1000.)
  COW6(2) = JNINT(COW6(2)/1000.)
  COW7(2) = JNINT(COW7(2)/1000.)

CALCULATE THE NUMBER OF STEERS ON HAND

{STEER1(2) = JNINT((CLFTOT/2.) * STRRET).

USE ABOVE STATEMENT WHEN USING STRRET(SEE COMMENT ABOVE)

STEER1(2) = STEER1(1)

USE ABOVE STATEMENT WHEN STEERS RETAINED IS CONSTANT

{STEER2(2) = JNINT(STEER1(1) * (1-BMORT))

CALCULATE STOCK SALES FROM CURRENT HERD

{HEFSLD = JNINT(HEF1(1) * HEFCUL)
  MACSLD = JNINT((HEF2(1)+COW5(1)+COW4(1)+COW3(1)+ COW6(1).*SCOWCUL)
  OLCSLD = JNINT(COW7(1) * (1-BMORT))
  FSTRSLD = JNINT(STEER2(1) * (1-BMORT))

CALCULATE BULLS HELD, BOUGHT AND SOLD

{BULLS(2) = JNINT(COWTOT(2) * BULRT)

BULLSLD(2) = JNINT(BULLS(1) * BULCUL)

BULBG = JNINT(BULLS(2)-BULLS(1) * (1-BMORT-BULCUL))

CALCULATE ACTUAL BEEF STOCK UNITS AT END OF YEAR.

{ABSU = 3.5*HEF1(2) + 4.5*HEF2(2) + 6.0*(COWTOT(2)-HEF2(2)) + 3.5*STEER1(2) + 4.5*STEER2(2) + 5.5*BULLS(2)

RETURN
SUBROUTINE PRICES(Woolpr, WLMFPR, WLMSPR, ELMFPR, ELMSPR, EHGP, EW2PR, 
   * EMPR, EMSPR, EWMFPR, EFAPR, RAMP, RAMBPR, EwLBPR, INFLTN, SEED, 
   * Wollmin, Wollmid, Wollmax, WLMFmin, WLMFmid, WLMFmax, 
   * WLMSPmin, WLMSPmid, WLMSPmax, ELMSmin, ELMSmid, ELMSmax, 
   * ELMSmin, ELMSmid, ELMSmax, EHGMin, EHGMid, EHGmax, 
   * WEMin, WEMid, WEMax, CFAMiMin, CFAMiMid, CFAMiMax, 
   * RMSmin, RMSmid, RMSmax, RAMBmin, RAMBmid, RAMBmax, 
   * EwLBmin, EwLBmid, EwLBmax, 
   * SMPWOL, SMPFLM, SMPFLM, YR) 
A SUBROUTINE TO RANDOMLY DETERMINE THE PRICES OF SHEEP AND WOOL 
INTEGER SEED 
REAL INFLTN 

TRIDST  IS  TRIANGULAR  PROBABILITY DISTRIBUTION ROUTINE 
CALL TRIDST(SEED, Wollmin, Wollmid, Wollmax, Wollpr) 
CHANGE THE SEED SO THAT WOOL  PRICE  IS  GENERATED FROM A DIFFERENT SEED 
R = RAND(SEED) 

CALL TRIDST(SEED, WLMFmin, WLMFmid, WLMFmax, WLMFpr) 
CALL TRIDST(SEED, ELMSmin, ELMSmid, ELMSmax, ELMFpr) 
CALL TRIDST(SEED, EHGmin, EHGmid, EHGmax, EHGP) 
CALL TRIDST(SEED, WEMin, WEMid, WEMax, EW2PR) 
CALL TRIDST(SEED, RMSmin, RMSmid, RMSmax, RMSpr) 
CALL TRIDST(SEED, EwLBmin, EwLBmid, EwLBmax, EwLBpr) 

CHANGE THE SEED 
R = RAND(SEED) 
RETURN 
END 

SUBROUTINE BEEFPRICES(WSTRPR, WHEFPR, FSTRPR, CLHEPR, COMPR, BULSPR, 
   * BULBPR, REPHER, INFLTN, SEED, 
   * WSTMmin, WSTMid, WSTMAX, WHEFmin, WHEFmid, WHEFmax, 
   * FSTRmin, FSTRmid, FSTMAX, COHMIN, COHmid, COHmax, 
   * BLSmin, BLSmid, BLSmax, BULmin, BULmid, BULBOX, 
   * RHEmin, RHEmid, RHEmax, CHEMIN, CHEmid, CHEmax, SMPBEF, YR) 
A SUBROUTINE TO RANDOMLY DETERMINE BEEF CATTLE PRICES 
INTEGER SEED 
REAL INFLTN 
CALL TRIDST(SEED, WSTMmin, WSTMid, WSTMAX, WSTRPR) 
CALL TRIDST(SEED, WHEFmin, WHEFmid, WHEFmax, WHEFPR) 
CALL TRIDST(SEED, FSTRmin, FSTRmid, FSTMAX, FSTRPR) 
CALL TRIDST(SEED, COHMIN, COHmid, COHmax, COMPR) 
CALL TRIDST(SEED, BLSmin, BLSmid, BLSmax, BULSPR) 
CALL TRIDST(SEED, BULmin, BULmid, BULBOX, BULBPR) 
CALL TRIDST(SEED, RHEmin, RHEmid, RHEmax, REPHER) 
CALL TRIDST(SEED, CHEMIN, CHEmid, CHEmax, CLHEPR) 

INFLATE PRICES 
WSTRPR = WSTRPR * (1+INFLTN) 
WHEFPR = WHEFPR * (1+INFLTN) 
FSTRPR = FSTRPR * (1+INFLTN) 
COMPR = COMPR * (1+INFLTN) 
BULSPR = BULSPR * (1+INFLTN) 
BULBPR = BULBPR * (1+INFLTN) 
REPHER = REPHER * (1+INFLTN) 
CLHEPR = CLHEPR * (1+INFLTN) 

CHANGE SEED 
R = RAND(SEED) 
RETURN 
END
SUBROUTINE SEASON(LRATE, LMFTRT, EHOGWL, EWEWOL, RAMWOL, SEED, PSEED, 
* ECULL, CONCUL, COWCUL, 
* LRTMIN, LRTMID, LRTMAX, LFRMIN, LFRMID, LFRMAX, 
* EHWMIN, EHWMID, EHWMAX, EWLMIN, EWLMAX, 
* RWLMIN, RWLMID, RWLMAX, CRTMIN, CRTMID, CRTMAX, CULATE, YR)

A SUBROUTINE TO RANDOMLY DETERMINE SEASONAL VARIABLES

INTEGER SEED, PSEED
REAL LRTMIN, LRTMID, LRTMAX, LFRMIN, LFRMID, LFRMAX, LRATE, 
* LMFTRT, CULATE

NOTE THAT THE LRATE AND CULATE I.E. LAMING RATE AND CALVING RATE 
ARE DETERMINED USING THE SEASONAL 
SEED SAVED FROM LAST YEARS CALCULATIONS (PSEED)

CALL TRIDST(PSEED, CRTMIN, CRTMID, CRTMAX, CULATE)
CALL TRIDST(SEED, LFRMIN, LFRMID, LFRMAX, LMFTRT)
CALL TRIDST(SEED, EHWMIN, EHWMID, EHWMAX, EHOGWL)
CALL TRIDST(SEED, EWLMIN, EWLMAX, EWEWOL)
CALL TRIDST(SEED, RWLMIN, RWLMAX, RAMWOL)
CALL TRIDST(SEED, -0.05, 0.0, 0.1, CULATE)

MAKE SEASONAL ADJUSTMENT TO CULLING RATES

SECULL = ECULL - CULATE 
SCOWCUL = CONCUL - CULATE

CHANGE THE SEED

PSEED = SEED
R = RAN(SEED)
RETURN END

SUBROUTINE TRIDST(SEED, MIN, MODE, MAX, X)

A SUBROUTINE TO GENERATE A RANDOM VARIATE FROM A TRIANGULAR PROB. 
DISTRIBUTION. THE TRIANGLE CUTS THE X-AXIS AT 'MIN' AND 'MAX', 
THE Y-AXIS IS THE PROBABILITY, AND 'MODE' IS THE X-VALUE WHICH 
GIVES THE HIGHEST Y-VALUE, IE. THE GREATEST PROBABILITY, 
OR MOST LIKELY X-VALUE.

INTEGER SEED
REAL MIN, MODE, MAX

INPUT = SEED
R = RAN(INPUT)
IF(R > 0.0) GO TO 1
FM = (MAX-MIN)/(MAX-MIN)
IF(R .LT. FM) GO TO 1
X = MAX - SQRT((1-R)*(MAX-MIN)*(MAX-MODE))
GO TO 2
1 X = MIN + SQRT((FM)*CULATE)
2 RETURN END
SUBROUTINE SAWACC(I)
  REAL WLMFAT, WLMSLD, ELMFAT, ELMSLD, WLMSTR, ELMSTR
  REAL GREVLM, GREVHG, ELGSLD, GREVWM, ELGMWT, ELGSMT, GREVSH, GREVEW, EW2SMR, EW4SMR, EW6SMR, EWBSMR, CFAWMR, GREVCF, GREVRM, RAMSLD, RAMBGT, GREWSH, WOLCUT
  WLMFAT = WLMSLD * WLMSTR
  ELMFAT = ELMSLD(2) * ELMSTR
  WLMSTR = WLMSLD - WLMFAT
  ELMSTR = ELMSLD(2) - ELMFAT

  REAL MORT, LMFTRT
  GREVLM(I) = WLMFAT * WLMMPR + WLMSTR * WLMSPR
  GREVHG(I) = ELGSLD * ELGMPR + EW4SMR * EW4MPR + EW6SMR * EW6MPR + EWBSMR * EWBSMPR
  GREVCF(I) = CFAWMR * CFAPR + GREVSH(I) + GREVEW(I) + GREVCF(I) + GREVRM(I)

  CALCULATE THE GROSS REVENUE FOR WOOL
  GREWL(I) = WOLCUT(1) * WOOLPR
  RETURN
END

SUBROUTINE TO CALCULATE THE REVENUE FROM THE FLOCK

INTEGER WLMFAT, ELMFAT, GREVLM(20), GREVHG(20), WOLCUT(20), GREVWM(20), ELGMWT(20), ELGSMT(20), GREWSH(20), GREVEW(20), EW2SMR, EW4SMR, EW6SMR, EWBSMR, CFAWMR, GREVCF, GREVRM, RAMSLD(2), RAMBGT, GREWSH, WOLCUT

REAL MORT, LMFTRT
GREVLM(I) = WLMFAT * WLMMPR + WLMSTR * WLMSPR + ELMFAT * ELMMPR + ELMSTR * ELMSPR
GREVHG(I) = ELGSLD * ELGMPR + EW4SMR * EW4MPR + EW6SMR * EW6MPR + EWBSMR * EWBSMPR
GREVCF(I) = CFAWMR * CFAPR + GREVSH(I) + GREVEW(I) + GREVCF(I) + GREVRM(I)
GREVSH(I) = GREVLM(I) + GREVHG(I) + GREVEW(I) + GREVCF(I) + GREVRM(I)
GREWOL(I) = WOLCUT(I) * WOOLPR
RETURN
END

SUBROUTINE BEEFACC(I)

INTEGER HEFSLD, MACSLD, OLCSLD, FSTRSLD, SCFSLD, HCFSLD, HEBFSLD, BULSLD, HEBGT, BULGT, GREVCUL, GREVCAF, GREVFST, GREVBUL

REAL CLHEPR, COWPR, WSTRPR, WHEFPR, BULSPR, BULBGT

GREVCUL(I) = HEFSLD * CLHEPR + CMACSLD + OLCSLD) * COWPR
GREVCAF(I) = (SCFSLD * WSTRPR) + (HCFSLD(I) * WHEFPR)
GREVFST(I) = FSTRSLD * FSTRPR
GREVBUL(I) = BULSLD(2) * BULSPR - BULBGT * BULBPR

TO CALCULATE TOTAL BEEF GROSS REVENUE ALLOW FOR REPLACEMENT HEIFERS BOUGHT
GREBF(I) = GREVCUL(I) + GREVCAF(I) + GREVFST(I) + GREVBUL(I) - (HEBFSLD * REPHPR)
RETURN
END

SUBROUTINE FCOST(AXTNFINC, DEPREC, OTHRDCT, SSUCST, STANDCST, ACOST, SSU, BSL, AINTPA, APRIPA, GREWS, GREWLN, GREWBF, INFLN, CST1NFT, TAXPAY, TCSHEX, TAXEX, ITAXPAY, DEVEXP, DEFUNDS, CTAX, LAXINC)

THIS ROUTINE BRINGS TOGETHER COSTS FROM VARIOUS PARTS OF THE MODEL. IT CALCULATES THE AFTER TAX NET FARM SURPLUS FROM GROSS WOOL, SHEEP AND BEEF REVENUE, LOAN REPAYMENTS, STOCKING COSTS, DEVELOPMENT EXPENSES AND STANDING CHARGES. TAX IS DEDUCTED ALLOWING FOR DEPRECIATION, INTEREST REPAYMENTS ON LOANS AND OTHER DEDUCTIONS.
REAL INFLTN,CSTINFLT,TAXCONST,TAXRAT,LTAXRAT
INTEGER ATXNFINC,OTHRDCT,STANDCST,ACOST,SSU,BSU,AINTPA,
  APRIA,GREVSH,GREVWL,GREVF,TAXEXP,TCHEXP,TAXPAY,
  TAXINC,DEPREC,ITAXPAY,DEVEXP,DEFUNDS,CTAX

DEVEXP = FUNDS CARRIED FORWARD TO COVER DEVELOPMENT EXPENDITURE
DEFUNDS = (IF NEGATIVE) REPRESENTS REDUCED MAINTENANCE FERTILISER
  EXPENDITURE TO COVER PREVIOUS YEARS DEFICIT.
  (IF POSITIVE) REPRESENTS CATCH UP EXPENDITURE FOR
  PREVIOUSLY DEFERRED FERTILISER FOR WHICH FUNDS ARE CARRIED FORWARD.

TOTAL CASH EXPENDITURE (ACOST IS DEVELOPMENT EXPENSES),
(DEPRECIATION VALUE ASSUMED TO REPRESENT NORMAL CASH
EXPENDITURE ON REPAIRS AND MAINTENANCE AS WELL AS
BOOK VALUE FOR TAX PURPOSES)
TCHEXP = (1 + CSTINFLT)*(STANDCST+DEPREC+ACOST)
* + (GREVSH+GREVWL+GREVF)*SSUCST
* + APRIA + AINTPA + DEFUNDS

TAX DEDUCTIBLE EXPENDITURE
TAXEXP = TCHEXP - APRIA + (1 + CSTINFLT)*(OTHRDCT)

TAXBLE INCOME IS CALCULATED FROM GROSS SHEEP AND WOOL REVENUE AND
TAX DEDUCTIBLE EXPENSES
TAXINC=GREVSH+GREVWL+GREVF-TAXEXP

IF "TAX" SCHEDULE ROUTINE IS USED TO CALCULATE TAX THEN THEN TAX
TO BE PAID THIS YEAR IS BASED ON LAST YEAR'S INCOME:
TAXPAY = ITAXPAY

Determine tax payable from taxable income.
IF "AVTAX" FUNCTION ROUTINE IS USED TAX TO BE PAID THIS YEAR
(TAXPAY) IS CALCULATED DIRECTLY
IF(CTAX.EQ.1)CALL AVTAX(TAXINC,LTAXPAY,INFLTN)
IF(CTAX.EQ.2)CALL TAX(TAXINC,ITAXPAY,INFLTN)

CALCULATE NET FARM INCOME AFTER TAX
(DEVEXP IS FUNDS CARRIED FORWARD FROM PREVIOUS YEAR
TO COVER DEVELOPMENT EXPENDITURE IN CURRENT YEAR)
ATXNFINC=GREVWL+GREVSH+GREVF-TCHEXP-TAXPAY+DEVEXP+DEFUNDS
DEVEXP = 0
DEFUNDS = 0
RETURN

SUBROUTINE TAX(TAXINC,TAXPAY,INFLTN)
A ROUTINE TO DETERMINE THE TAX PAYABLE (TAXPAY) USING A TYPICAL
TAX SCHEDULE.
N.B. A PARTNERSHIP IS ASSUMED. TO ACCOUNT FOR THIS TAXINC IS
DIVIDED BY TWO TO DETERMINE APPROPRIATE TAX RATE-
RESULTING TAX PAYABLE IS THEN MULTIPLIED BY TWO.

INTEGER TAXINC,TAXPAY
COMMON/TAX/TAXCONST,TAXRAT,LTAXRAT,TAXRATE(8,3)

REAL INFLTN

TAXINC = TAXINC/2

CHECK THAT TAXABLE INCOME IS POSITIVE
IF(TAXINC.LT.0)GOTO40

TAXBLE INCOME NON-NEGATIVE
LSTBR=0
DO 10 I=1,8
10 IF(TAXINC.LT.TAXRATE(I,1)*(1 + INFLTN))GOTO20
IF(TAXRATE(I,1).EQ.0)GOTO20
LSTBR=TAXRATE(I,1)

GOTO30

TAXPAY=TAXRATE(1,2)*(1 + INFLTN)
  + TAXRATE(1,3)*(TAXINC - LSTBR*(1 + INFLTN))/100
TAXPAY = TAXPAY+2
GOTO30

CONTINUE
NEGATIVE TAXABLE INCOME

RETURN
END
SUBROUTINE AVTAX(TAXINC, LTAXINC, TAXPAY, INFLTN)
A SUBROUTINE TO CALCULATE TAX PAYABLE USING A TAX FUNCTION

COMMON /ATAX/TAXCONST, TAXRAT, LTAXRAT, TAXRATE(8,3)
INTEGER TAXINC, LTAXINC, TAXPAY
REAL INFLTN, TAXCONST, TAXRAT, LTAXRAT

TAXPAY = TAXCONST + TAXRAT * TAXINC + LTAXRAT * LTAXINC

IF (TAXPAY, LT, 0) TAXPAY = 0
RETURN END

SUBROUTINE CAPITAL(TSU, EWETOT, EHOG, RAM, 
* EHOGR, EWEPR, RAMPR, FARMCAP, INFLTN, TOTALIB, 
* COWT, HEF1, HEF2, RIACC, YR)
A SUBROUTINE TO EVALUATE THE NET WORTH AND EQUITY OF THE FARM THIS YEAR

INTEGER TSU, EWETOT, EHOG, RAM, EHOGR, EWEPR, RAMPR, FARMCAP, INFLTN, TOTALIB, 
* COWT, HEF1, HEF2, RIACC, YR
REAL NETWTH, INFLTN, RAMPR, RAMSR, EWR, EW2PR

CALCULATE THE FARM CAPITAL THIS YEAR
- FOR VALUE OF FLOCK NEED SALE PRICE OF RAMS AND EWES.
- IF 2 TO 8 TOOTH EWES ARE ALL THE SAME PRICE.
- FOR VALUE OF HEIFERS NEED SALE PRICE FOR HEIFERS, COWS, BULLS AND STEERS, STEERS ARE VALUED AT 75% OF FAT STEER PRICE.
- VALUATION OF STOCK IS 80% OF TOTAL MARKET VALUE

RAMPR = RAMSR
EWR = EW2PR

FARMCAP = (SUVAL * TSU + PLANTVAL) + (EWETOT * EWEPR + EHOGR * EWEPR + RAMPR * (EWEPR + EWEPR)) * 
* (EWEPR * EWEPR) * COMP + BULLS * BULS + (COWT + HEF1) + (HEF2 + HEF2) + RIACC,
* + (COWT1 + STEER2) * FSTRPR + 0.75

CALCULATE THE TOTAL ASSETS THIS YEAR
TOTASSET = FARMCAP + (1 + INFLTN) * HSTDVAL + RIACC

CALCULATE THE TOTAL LIABILITIES THIS YEAR
TOTALIB = APROUT + CURLIB

IF OVERDRAFT IS REFINANCED THIS YEAR SET CURRENT LIABILITIES TO ZERO AND RESET REFINANCE FLAG TO ZERO
IF (REFLAG.EQ.1) CURLIB = 0
REFLAG = 0

CALCULATE THE NET WORTH OF THE FARM
NETWTH = TOTASSET - TOTALIB

CALCULATE THE EQUITY (AS A PERCENTAGE)
EQUITY = (FARMCAP + RIACC - TOTALIB) / (FARMCAP + RIACC)
RETURN END

SUBROUTINE INLOAN(PRINC, INTR, LTERM, STYEAR)
A SUBROUTINE TO ESTIMATE THE REPAYMENT SCHEDULE (OVER THE SIMULATION PERIOD) FOR LONG-TERM LOANS WHICH WERE TAKEN OUT BEFORE THE FIRST YEAR OF THE SIMULATION. ONE MORTGAGE IS ASSUMED TAKEN OUT 'STYEAR' YEARS BEFORE START OF SIMULATION.

COMMON /LOANRT/ INTPAY(20,20), PRIPAY(20,20), APROUT(20,20), AINTPA(20,20), APRIPA(20,20), TREPAY(20)
COMMON /CPTLRT/ SUVAL, PLANTVAL, HSTDVAL, RIACC,
* CURLIB, FARMCAP, INFLTN, TOTALIB
INTEGER PRIPAY, APROUT, TREPAY, APROUT, AINTPA, APRIPA, STYEAR,
* REPAY, SUVAL, PLANTVAL, HSTDVAL, RIACC, CURLIB
REAL INTR

CALCULATE THE TOTAL AMOUNT REPAYED EACH YEAR
NTREPAY = PRINC*(INTR*(1+INTR)**LTERM)/((1+INTR)**LTERM-1)
INITIALISE PRINCIPAL OUTSTANDING
NPROUT=PRINC

RUN UNTIL THE FIRST YEAR OF THE SIMULATION

DO 1 K=1,(STYEAR-2)
   NINTPAY=NPROUT*INTR
   NPRIPAY=NTREPAY-NINTPAY
   NPROUT=NPROUT-NPRIPAY
   CONTINUE

NOW RUN FOR THE LENGTH OF THE SIMULATION

LKNTA IS USED TO IDENTIFY THIS AS THE FIRST LOAN

CALL LOANS(NPROUT,INTR,(LTERM-STYEAR+1),0,LKNTA,
   0,0,0,0,REFLAG,
   INTPay,PRIPAY,PROUT,
   APROUT,AINTPA,APRIPA,TREPAY,
   SUVAL,PLANTVAL,HSTOVAL,RIACC,
   CURLIB,FARMCAP,INFLTN,TOTALI6)
RETURN

END

SUBROUTINE LOANS(PRINC,INTR,LTERM,KYR,J,BORRFREQ,
   REPAY,PCEQUITY,REFIN,REFLAG,
   INTPAY,PRIPAY,PROUT,
   APROUT,AINTPA,APRIPA,TREPAY,
   SUVAL,PLANTVAL,HSTOVAL,RIACC,
   CURLIB,FARMCAP,INFLTN,TOTALI6)

A SUBROUTINE TO CALCULATE THE REPAYMENT SCHEDULE FOR EACH
TABLE MORTGAGE OVER A PERIOD OF TWENTY YEARS.

DIMENSION INTPAY(20,20),PRIPAY(20,20),PROUT(20,20),APROUT(20),
   AINTPA(20),APRIPA(20),TREPAY(20)

INTEGER PRIPAY,PROUT,PRINClTREPAY,APROUT,AINTPA,APRIPA,TREPAY
INTEGER SUVAL,PLANTVAL,HSTOVAL,RIACC,BORRFREQ
REAL INTER,PRIC,APRIPA,EQUTY,INFLTN

SET REFINANCING FLAG

REFLAG = REFIN

LAST=18
IF((KYR + 1 + LTERM).LE.18) LAST = KYR + LTERM
IF(J .NE. 1 .AND. REFIN .NE. 1) GO TO 1
IF FIRST YEAR OR REFINANCING OVERDRAFT REQUIRED
CALCULATE THE TOTAL AMOUNT REPAID EACH YEAR ON MAIN LOAN

TREPAY(J)=PRINC*(INTR*(1+INTR)**LTERM)/((1+INTR)**LTERM-1)
IF REFINANCING INCLUDE LOAN THIS YEARS TOTAL LIABILITIES
IF(REFIN.EQ.1)TOTALI6=TOTALI6+PRINC
GO TO 3

FOR NEW LOANS, GIVEN THE ANNUAL INTEREST AND PRINCIPAL
ABLE TO BE PAID, CALCULATE THE PRINCIPAL OF THE LOAN
AND CHECK THE EQUITY LEVEL AFTER THIS LOAN HAS BEEN TAKEN OUT

TREPAY(J)=REPAY
PRINC=(TREPAY(J)*((1+INTR)**LTERM-1))/((1+INTR)**LTERM)
CONVERT AMT.BORROWED FROM ANNUAL TO PERIODIC BASIS

PRINC=PRINC*BORRFREQ

CHECK EQUITY LEVEL AGAINST PCEQUITY, MINIMUM EQUITY ALLOWED

EQUITY=(FARMCAP+RIACC-TOTALIB-PRINC)/
   (FARMCAP+RIACC)
IF(EQUITY.GE.PCEQUITY) GO TO 3

IF EQUITY BELOW MINIMUM LEVEL, THEN REDUCE THE PRINCIPAL
OF THE LOAN TO THE REQUIRED LEVEL

PRINC=(FARMCAP+RIACC)*(1-PCEQUITY)-TOTALIB
TREPAY(J)=PRINC*(INTR*(1+INTR)**LTERM)/((1+INTR)**LTERM-1)
IF(PRINC.GE.0) GO TO 3
PRINC=0
TREPAY(J)=0
RETURN

INITIALISE PRINCIPAL OUTSTANDING

3 PROUT(J,KYR + 1)=PRINC
   APROUT(KYR + 1)=APROUT(KYR + 1)+PROUT(J,KYR + 1)
   IF(KYR + 1.GT.18) GO TO 4

SIMULATE FOR THE MIDDLE YEARS

DO 100 K=KYR + 1,LAST
   INTPAY(J,K)=PROUT(J,K)*INTR
   PRIPAY(J,K)=TREPAY(J)-INTPAY(J,K)
   IF(PRIPAY(J,K).GT.PROUT(J,K))PRIPAY(J,K)=PROUT(J,K)
   CONTINUE
SUBROUTINE FARMERCYR(INTR,ATXNFINC,CONST,MPCONY,MPCONC,PRECON,INFLTN,BORRFREQ,TAXPAY)

A subroutine to calculate consumption and determine borrowing behaviour.

DIMENSION INTR(20),ATXNFINC,CONSUM(20)

REAL INRFLTN,MPCONY,MPCONC,PRECON,CONSUM,RISK,PCEQUITY

CALCULATE CONSUMPTION AND SET PREVIOUS CONSUMPTION (PRECON) FOR NEXT YEARS CALCULATION.

CONSUM(YR) = CONST*(1+INFLTN) + MPCONY*ATXNFINC + MPCONC*PRECON

IF(CONSUM(YR)<=CONST*(1+INFLTN)) CONSUM(YR) = CONST*(1+INFLTN) PRECON = CONSUM(YR)

IF YEAR IS A BORROWING YEAR, THEN DETERMINE THE AMOUNT OF INTEREST AND PRINCIPAL FARMER IS WILLING AND ABLE TO PAY AS THE RISK COEFFICIENT TIMES THE SURPLUS OVER THE LAST N YEARS, WHERE N IS SPECIFIED AT INPUT TIME AS THE FREQUENCY OF BORROWING (YEAR 1 LOAN SITUATION HANDLED BY 'INLOAN')

SURPLUS IS REGARDED AS PRE-TAX NET INCOME

SURPLUS(YR) = ATXNFINC + TAXPAY

BORRYEAR = 0

$ N = Y R / B O R R F R E Q$

IF(YR.EQ.1 .OR. YR.GT.N*BORRFREQ) GO TO 1

BORRYEAR = 1

SUM = 0

BEGIN = YR - BORRFREQ + 1

DO 100 I = BEGIN, YR

SUM = SUM + SURPLUS(I)

100 CONTINUE

FIND AVERAGE ANNUAL SURPLUS

SUM = SUM/BORRFREQ

FIND WILLINGNESS TO REPAY (WTP) AS PROP. OF ANNUAL SURPLUS

WTP = SUM*RISK

IF CURRENT SURPLUS OR AMOUNT WILLING TO PAY IS NEGATIVE CANCEL BORROWING EVENT

IF(SURPLUS(YR).LT.0 .OR. WTP.LT.0)BORRYEAR = 0

CONTINUE

RETURN

END
N.B. DCOST, COST & ACOST ARE IN TERMS OF YEAR 1 (UNINFLATED) DOLLARS
THADEV = 0
SFUNDS = FUNDS

******** START OF DEVELOPMENT CALCULATION ********

4 CHANGE=0
L=1
TYPE=DPRTY(1)

------------------------ ------------------------ ------------------------
EXIT ROUTINE IF:

THERE IS NO MONEY AVAILABLE FOR DEVELOPMENT THIS YEAR
IF(FUNDS.LE.0) GO TO 30
OR IF THERE IS NO MORE LAND TO BE DEVELOPED ('REMAINS' EQUALS FUNDS REMAINING AFTER DEVELOPMENT POTENTIAL EXHAUSTED)
IF(TYPE.EQ.0) GO TO 30
OR IF POTENTIAL STOCK CARRYING CAPACITY EXCEEDS ACTUAL STOCK CARRIED BY MORE THAN 20 PERCENT
IF(PTSU.GT.ATSU*I.20) GO TO 30

CALCULATE THE NUMBER OF HECTARES IT IS POSSIBLE TO DEVELOP
HADEV=FUNDS / (((1 + CSTINFLT)*DCOST(TYPE,L))
IF(HADEV.LT.AREA(TYPE)) THEN
FUNDS = 0
GO TO 1
ENDIF
THERE IS ENOUGH MONEY TO COMPLETE DEVELOPMENT OF THIS LAND TYPE AND MOVE ON TO THE NEXT TYPE
HADEV=AREA(TYPE)
CHANGE=1
PROJECT THE COST OF DEVELOPMENT AND MAINTENANCE OF THIS LAND AND THE INCREASE TO STOCKING RATE FROM NEXT YEAR TO YEAR 20

1 DO 2 K=YEAR+1,20
C COST(DEVKNT,K)=DCOST(TYPE,L) * HADEV
SR (DEVKNT,K)=SRADD(TYPE,L) * HADEV
UPDATE THE TOTALS
ACOST(K)=ACOST(K) + COST(DEVKNT,K)
ASR(K)=ASR(K) + SR(DEVKNT,K)
L=L+1
2 CONTINUE

UPDATE THE AREA OF THIS TYPE LEFT TO BE DEVELOPED
AREA(TYPE)=AREA(TYPE) - HADEV
THADEV=THADEV+HADEV
THADEV HOLDS THE TOTAL AREA OF LAND DEVELOPED EACH TIME SO THAT IF MORE THAN ONE LAND TYPE IS DEVELOPED AN ACCURATE TOTAL WILL STILL BE KEPT.
THADEV = THADEV + HADEV
IF(CHANGE.EQ.0) GO TO 30
MOVE ON TO THE NEXT TYPE OF LAND AND CALCULATE HOW MUCH MONEY IS LEFT FOR FURTHER DEVELOPMENT OF THIS NEW LAND TYPE

30 CONTINUE C DETERMINE TOTAL DEVELOPMENT EXPENDITURE AND REMAINING FUNDS
DEVEXP = SFUNDS - FUNDS
RETURN

END

SUBROUTINE DEFER(FUNDS,DMACC,DMLIM,MCOST,CSTINFLT,DSR,TSRLOSS,DEPERFLAG,DEFUNDS,DMAREA)

THIS ROUTINE CALCULATES THE AMOUNT OF LAND NOT RECEIVING FERTILISER MAINTENANCE IN A GIVEN YEAR, HOW LONG MAINTENANCE IS DEFERRED ON EACH BLOCK OF LAND IS ALSO MEASURED AND UPDATED. ASSOCIATED DROPS IN STOCKING RATES ARE ALSO CALCULATED AND UPDATED.
INTEGER DMVALU(20), DMAREA(20), TSRLoss, AREA, DEFICIT, FUNDS
INTEGER DMACC, DCOST, DSR, DMLIM, DEFERFLAG, DFUNDS
REAL CSTINFLT

Glossary:
- FUNDS = FUNDS SURPLUS OR DEFICIT
- DMACC = CURRENT VALUE OF DEFERRED MAINTENANCE
- DMLIM = LIMIT OF ANNUAL VALUE OF DEFERRED MAINTENANCE (REAL)
- DCOST = REAL COST OF MAINTENANCE
- DSR = CHANGE (+ OR -) IN IN SR
- DEFERFLAG = INDICATES DEFERRED LIMIT HAS BEEN REACHED
- DEFUNDS = EXTENT OF COST SAVED BY DEFERRED FERTILISER IN THIS PERIOD (-) OR EXTENT OF EXPENDITURE TO CATCH UP ON DEFERRED FERTILISER
- LSTRLoss = TSRLoss
- SAVE TOTAL ACCUMULATED STOCKING RATE LOSS TO DATE
- SAVE CURRENT LEVEL OF FUNDS TO DETERMINE EXTENT OF EXPENDITURE CHANGE DUE TO DEFERRING OR CATCHING UP ON MAINTENANCE APPLICATIONS
- DEFUNDS = FUNDS
- DETERMINE CURRENT VALUE OF PREVIOUSLY DEFERRED MAINTENANCE
  DMACC = DMACC * (1 + CSTINFLT)
  IF(FUNDS.GT.O) GO TO 100
  DEFICIT = -FUNDS
  DETERMINE IF ANNUAL DEFERRED LIMIT WILL BE REACHED
  IF(DEFICIT.LT.DMLIM*(1 + CSTINFLT)) GO TO 5
  DEFICIT = DMLIM * (1 + CSTINFLT)
  DMACC = DMACC + DEFICIT
  FUNDS = FUNDS + DEFICIT
  DEFERFLAG = 1
  GO TO 8
  FUNDS = 0
  DMACC = DMACC + DEFICIT
  DETERMINE AREA EQUIVALENT FOR DEFERRED MAINTENANCE.
  FIND MOST UNDER-MAINTAINED AREA
  AREA = JNINT(DEFICIT/DCOST * (1 + CSTINFLT))
  DO 10 J = 20, 1, -1
  IF(DMAREA(J).GT.0) GO TO 20
  CONTINUE
  IF NO AREA UNMAINTAINED DEFER MAINTENANCE ON AREA FOR FIRST TIME
  DMAREA(1) = AREA
  GO TO 200
  IF(DMAREA(J).LT. AREA)GO TO 30
  DMAREA(J+1) = AREA
  DMAREA(J) = DMAREA(J) - AREA
  GO TO 200
  DO 40K = J, 1, -1
  IF(DMAREA(K).GE. AREA) GO TO 50
  DMAREA(K+1) = DMAREA(K)
  AREA = AREA - DMAREA(K+1)
  CONTINUE
  IF(AREA.NE.0) GO TO 70
  DMAREA(1) = AREA
  GO TO 200
  DMAREA(K+1) = AREA
  DMAREA(K) = DMAREA(K) - AREA
  GO TO 200
  CONTINUE
  DEFERRED MAINTENANCE CAUGHT UP
  SURPLUS = FUNDS
  IF(SURPLUS.LT.DMACC) GO TO 110
  FUNDS = SURPLUS - DMACC
  DMACC = 0
  DO 105 J = 20, 1, -1
  IF(DMAREA(J).GT.0) GO TO 130
  CONTINUE
  DMACC = DMACC - SURPLUS
  FUNDS = 0
  DO 120 J = 20, 1, -1
  IF(DMAREA(J).GT.0) GO TO 130
  CONTINUE
  AREA = JNINT(SURPLUS/(DCOST * (1 + CSTINFLT)))
C DETERMINE AREA REMAINING IN DEFICIT
C DO 150 JJ=1,J-1
     TDMAREA = 0
     DO 140 K=1, JJ
           TDMAREA = TDMAREA + DMAREA(K)
     CONTINUE
140
C CHECK IF ENOUGH LEFT TO COVER ALL AREAS
C SHIFTS ALL AREAS TO THE LEFT AS THEY ALL GET EXTRA DRESSING
C IF(AREA.LT.TDMAREA) GO TO 160
     DO 150 I=1,J
           DMAREA(I) = DMAREA(I+1)
     CONTINUE
C AREA = AREA - TDMAREA
150 CONTINUE
C CHECK IF AREA IN GREATEST DEFICIT IS GREATER THAN AREA TO BE FERTILISED
C IF(DMAREA(JJ).GT.AREA) GO TO 170
C TOPDRESS ALL OF MOST DEFICIT AREA
   JJ = JJ - 1
   DMAREA(JJ) = DMAREA(JJ) + DMAREA(JJ+1)
   AREA = AREA - DMAREA(JJ+1)
   DMAREA(JJ+1) = 0
   GO TO 160
C TOPDRESS AS MUCH AS POSSIBLE OF MOST DEFICIT AREA
C IF(JJ.EQ.1) GO TO 200
   DMAREA(JJ) = DMAREA(JJ) - AREA
   DMAREA(JJ-1) = DMAREA(JJ-1) + AREA
200
C CALCULATE CHANGE IN TOTAL STOCK RATE LOSS FROM PREVIOUS PERIOD
C DSR = LTSRLOSS - TSRLOSS
C CONVERT VALUE OF DEFERRED MAINTENANCE TO REAL TERMS
C DMACC = DMAACC/(1+CSTINFLT)
C DETERMINE NET EXPENDITURE
C DEFUNDS = FUNDS - FUNDS
C NEGATIVE VALUE INDICATES EXTENT OF COST REDUCTION DUE TO DEFERRED FERTILISING.
C POSITIVE VALUE INDICATES EXTENT OF INCREASED EXPENDITURE TO CATCH UP ON FERTILISING.
C RETURN END

SUBROUTINE RESERVE(FUNDS,RILIM,RFXLIM,RIACC, RDCINV,INVRT,INFLTN)
SUBROUTINE TO MONITOR AND UPDATE THE LEVEL OF LIQUID RESERVE FUNDS USED AS THE FIRST SOURCE OF FUNDS TO FINANCE A DEFICIT.
INTEGER FUNDS,RILIM,RFXLIM,RIACC,RDCINV
REAL INFLTN,INVRT
RILIM = REAL VALUE OF RESERVE LEVEL ABOVE WHICH 'INVRT' PROPORTION OF FUNDS ARE AVAILABLE FOR INVESTMENT
RFXLIM = MINIMUM LEVEL FOR LIQUID RESERVES - FUNDS UP TO THIS LEVEL ASSUMED TO BE ILLIQUID(FIXED)
RIACC = NOMINAL VALUE OF CURRENT RESERVE LEVEL
FUNDS = NOMINAL SURPLUS OR DEFICIT
RDCINV = RIACC (SAVED FOR OUTPUT)

C DETERMINE IF DEFICIT OR SURPLUS
C IF(FUNDS.GE.0) GO TO 30
C FOR DEFICIT DETERMINE IF LIQUID RESERVE WILL COVER DEFICIT (NOTE: 'FUNDS' WILL BE NEGATIVE)
C IF(RIACC+FUNDS.GT.RFXLIM*(1+INFLTN)) GO TO 20
C LIQUID RESERVES WILL NOT COVER DEFICIT
C FUNDS = FUNDS + RIACC - RFXLIM*(1+INFLTN)
C RIACC = RFXLIM*(1+INFLTN)
C CONTINUE
RESERVE COVERS DEFICIT
RIACC = RIACC + FUNDS
FUNDS = 0
GO TO 50
30 CONTINUE
FOR SURPLUS DETERMINE IF FUNDS WILL PAY BACK ALL RESERVE ALLOWING FOR INCREASE IN NOMINAL VALUE OF RESERVE WITH INFLATION.
IF(RIACC+FUNDS.GT.RILIM*(1+INFLTN)) GO TO 40
C IF FUNDS WILL NOT COVER RESERVE DEFICIT
RIACC = RIACC + FUNDS
FUNDS = 0
GO TO 50
40 CONTINUE
IF FUNDS WILL COVER RESERVE DEFICIT
(Note: DIFF can be negative if RIACC is already greater than inflated reserve limit)
DIFF = RILIM * (1+INFLTN) - RIACC
RIACC = RILIM * (1+INFLTN) + (1-INVRT) * (FUNDS - DIFF)
FUNDS AVAILABLE FOR INVESTMENT ASSUMED TO BE 'INVRT' OF FUNDS IN EXCESS OF RESERVE LIMIT
FUNDS = (FUNDS - DIFF) * INVRT
C FUNDS AVAILABLE FOR INVESTMENT ASSUMED TO BE INVRT OF FUNDS IN EXCESS OF RESERVE LIMIT
C 50 CONTINUE
RDINV = RIACC
RETURN
END

SUBROUTINE OVERDRAFT(FUNDS,ODLIMIT,ODLEVEL, INFLTN)
SUBROUTINE TO MONITOR AND UPDATE THE LEVEL OF OVERDRAFT.
IF OVERDRAFT LIMIT IS EXCEEDED FOR TWO YEARS A TERM LOAN IS TAKEN OUT TO COVER THE OVERDRAFT.
INTEGER FUNDS,ODLIMIT,ODLEVEL
REAL INFLTN
ODLIMIT = REAL VALUE OF OVERDRAFT LIMIT
ODLEVEL = CURRENT LEVEL OF OVERDRAFT
FUNDS = NOMINAL SURPLUS OR DEFICIT
ODLO,ODL1,ODL2 = REAL VALUE OF PREVIOUS OVERDRAFT LEVELS.
Determine if Deficit or Surplus
IF(FUNDS.GT.0) GO TO 20
FOR DEFICIT
ODLEVEL = ODLEVEL - FUNDS
FUNDS = 0
GO TO 50
20 CONTINUE
FOR SURPLUS DETERMINE IF FUNDS WILL COVER OVERDRAFT.
IF(ODLEVEL.FUNDS.LT.0) GO TO 30
FUNDS WILL NOT COVER OVERDRAFT
ODLEVEL = ODLEVEL - FUNDS
FUNDS = 0
30 CONTINUE
ODLEVEL REMAINS UNCHANGED AT THIS POINT AND IS COUNTED IN TOTAL LIABILITIES IN THIS YEAR (SEE SUBROUTINE CAPITAL). TERM LOAN TAKES EFFECT FROM NEXT YEAR.
ODLO = 0
60 RETURN
END
SUBROUTINE RNDATA(FYEAR, STANCST, OTHRDCT, DEPREC, SEED, 
PRINC, INTRST, TERM, SYEYAR, CONST, MPCONY, 
MPCONC, PRECON, DFRY, RILIM, RXFLIM, INVR, DMLIM, 
OOLT OT, MCOST, PSSU, PBSSU, COSTINF, CTAX) 

A SUBROUTINE FOR PRINTING OUT THE INITIAL VALUES OBTAINED FROM INPUT 
DATA FILES BY THE PROGRAM TO CHECK THE DATA INPUT AND TO IDENTIFY 
EACH RUN WITH THE PARAMETERS IT HAS USED. 

COMMON /AFARM/ FDBRW(D(20), INTR(20), LTERM(20), SPLND, CONSUM(20), 
BORRREQ, RISK, WTP, SURPLUS(20), PEQUITY, PROPINV 
COMMON /DPVT/ DCOST(5, 20), ERADD(5, 20), COST(25, 20), SR(25, 20), 
ACOST(20), ASR(20), AREA(5) 
COMMON /ATAX/ TAXCONST, TAXRAT, TLTAXRAT, TAXRATE(8, 3) 
COMMON /CPLR/ SUVAL, PLANTVAL, HSTDVAL, RIAACC, 
CURLIB 
COMMON /CESRT/ LRTMIN, LRTMD, LRTMA, LRMIN, LRMD, LRMA, EHMIN, 
EHMAX, ELMIN, ELMID, ELMAX, RNLM, RNMD, RNMA, 
CTMIN, CTMD, CTMA 
COMMON /PRECT/ WOLMIN, WOLMD, WOLMA, WLMIN, WLMID, WLMA, WLSMIN, 
WLSMD, WLSMD, ELFMIN, ELFMD, ELFMA, ELMIN, ELMID, ELMAX, 
EHMIN, EHMD, EHMID, EHAMAX, EFMIN, EFMD, EFMA, CFIN, CFINMD, 
CFRAM, CFRA, CFINMD, CFINMA, RFIN, RFINMD, RFINMA, RFINB, 
E2BMIN, E2BMD, E2BMA, E2BMIN, E2BMD, E2BMA, RMIN, RMD, RMA, 
SLMIN, SLMD, SLMA, SLMIN, SLMD, SLMA, BLSMIN, BLSMD, BLSMA, 
BLMIN, BLMD, BLMA, BLMIN, BLMD, BLMA, BLMIN, BLMID, BLMAX, 
RMHMIN, RMHMD, RMHAMAX, CHEMIN, CHEMD, CHEMA, SMPEBF 

COMMON /SMPNR/ SMWOL, SMFMLM, SMPSLM 
COMMON /ACCINF/ CNFLTN ZO) 
COMMON /PRODPAR/ PTSU(O:Z11), PROP, MORT, HCU1, ECU1, RMCUL, RAMRT, 
MCREL, SHFPR, SSUCST, BMORT, HECUL, CONCUL, BULCUL, BULT, 
MXCHF, STRET 

REAL MORT, HCU1, ECU1, RMCUL, RAMRT, LRTMIN, LRTMD, LRTMA, 
LRMIN, LRMD, LRMA, SSUCST, INTR, INTRSH, MXELH, CONST, 
MPCON, MPCONC, PRECON, RISK, PEQUITY, PROPIN, INVR, BMORT, 
HECU1, BULCUL, BULT, MXCHF, STRET, 
TAXCONST, TAXRAT, TLTAXRAT 
INTEGER DCOST, COST, AREAP, PSSU, BORRREQ, WTP, 
SURPLUS, SPLYND, PSSU, PBSSU 
INTEGER SEED, FYEAR, DEPREC, OTHRDCT, STANCST, SYEYAR, 
PLANTVAL, HSTDVAL, RIAACC, CURLIB, MCOST, OOLT OT 
INTEGER FDBRW, LTERM, DEPREC, ATAX, SYEYAR, DFRY(5), RILIM, RXFLIM, 
DMLIM, OOLT OT, CTAX 

FYEAR IS THE LENGTH OF THIS RUN IN YEARS 
WRITE(6,201) FYEAR, SEED 

TABULATE ASSETS (& TOTAL ASSETS) STANDING COSTS AND TAX DEDUCTIONS 
WRITE(6,202) HSTDVAL, STANCST, DEPREC, 
OTHRDCT, RIAACC 
WRITE(6,203) PLANTVAL, SUVAL, CURLIB 
WRITE(6,210) RILIM, INVRT*100, RXFLIM, DMLIM, MCOST, OOLT OT 

TABULATION OF TRIANGULAR DISTRIBUTION PARAMETERS FOR PRICES 
AND RATES, ETC. 
WRITE(6,511) SSUCST 
WRITE(6,520) CONST, MPCON, MPCONC, PRECON 
WRITE(6,99) 
WRITE(6,177) 
WRITE(6,121) PSSU 
WRITE(6,100) 
WRITE(6,101) WOLMIN, WOLMD, WOLMA 
WRITE(6,102) WLMIN, WLMID, WLMAX 
WRITE(6,103) WLSMIN, WLSMD, WLSMA, MORT*100 
WRITE(6,104) ELMIN, ELFMD, ELFMA 
WRITE(6,105) ELMIN, ELMID, ELMAX, HCU1*100 
WRITE(6,106) EHMIN, EHMID, EHAMAX 
WRITE(6,107) EWMIN, EWE, EWEA, RMCUL*100 
WRITE(6,108) CFMIN, CFMD, CFMA 
WRITE(6,109) RFIN, RFINMD, RFINMA, ECU1*100 
WRITE(6,110) RMIN, RMINMD, RMAX 
WRITE(6,111) E2BMIN, E2BMD, E2BMA, RAMRT*100 
WRITE(6,99) 
WRITE(6,112) LRTMIN, LRTMD, LRTMA 
WRITE(6,113) LRMIN, LRMD, LRMA 
WRITE(6,114) EHMIN, EHMID, EHAMAX 
WRITE(6,115) ELMIN, ELMID, ELMAX 
WRITE(6,116) RLMIN, RLMID, RLMAX 
WRITE(6,117) SMWOL, SMFMLM, SMPSLM 
WRITE(6,118) MXELH*100 
WRITE(6,99) 
WRITE(6,178) 
WRITE(6,99) 
WRITE(6,98) 
WRITE(6,179) PSSU 
WRITE(6,100) 

BEEF PARAMETERS 
WRITE(6,501) WSMIN, WSTMID, WSTMA 
WRITE(6,502) HEMIN, HEMID, HEMAX 
WRITE(6,503) FSMIN, FSMID, FSMAX, BMORT*100 
WRITE(6,504) CNM, CNMID, CNMA 
WRITE(6,505) BMIN, BMID, BMAX, HECUL*100 
WRITE(6,506) BMIN, BMINMD, BMAX, BULCUL*100 
WRITE(6,507) RMIN, RMINMD, RMAX, BULCUL*100
WRITE(6,98)
WRITE(6,208)CHEM1,CHEM2,CHEM3,CWACU*100
WRITE(6,98)
WRITE(6,209)BULL1*100
WRITE(6,99)
WRITE(6,310)CRTL1,CRTL2,CRTL3
WRITE(6,311)SPDEF
WRITE(6,312)MXHCPH*100
WRITE(6,99)
WRITE(6,600)PTSU(0)

C
IF (CTAX.NE.1) THEN
WRITE(6,204)
DO 10 J=1,8
WRITE(6,209)(TAXRAT(J),J=1,8)
CONTINUE ENDIF

C
IF (CTAX.EQ.1) WRITE(6,2041)TAXCONST,TAXRAT,LTAXRAT
WRITE(6,99) WRITE(6,207)(J, J=1,10)
WRITE(6,99)(J, J=1,10)
WRITE(6,99)
WRITE(6,206) WRITE(6,300)
WRITE(6,301)(DPRTY(I),I=1,5)
WRITE(6,302)(DPRTY(J)$,J=I,5)
DO
WRITE(6,303)
WRITE(6,304)
WRITE(6,305)
WRITE(6,306)
WRITE(6,307)
WRITE(6,308)
WRITE(6,309)
WRITE(6,310)
WRITE(6,311)
WRITE(6,312)
WRITE(6,313)
WRITE(6,314)
WRITE(6,315)
WRITE(6,316)
WRITE(6,317)
WRITE(6,318)
WRITE(6,319)
WRITE(6,320)
WRITE(6,321)
WRITE(6,322)
WRITE(6,323)
WRITE(6,324)
WRITE(6,325)
WRITE(6,326)
WRITE(6,327)
WRITE(6,328)
WRITE(6,329)
WRITE(6,330)
WRITE(6,331)
WRITE(6,332)
WRITE(6,333)
WRITE(6,334)
WRITE(6,335)
WRITE(6,336)
WRITE(6,337)
WRITE(6,338)
WRITE(6,339)
WRITE(6,340)
WRITE(6,341)
WRITE(6,342)
WRITE(6,343)
WRITE(6,344)
WRITE(6,345)
WRITE(6,346)
WRITE(6,347)
WRITE(6,348)
WRITE(6,349)
WRITE(6,350)
WRITE(6,351)
WRITE(6,352)
WRITE(6,353)
WRITE(6,354)
WRITE(6,355)
WRITE(6,356)
WRITE(6,357)
WRITE(6,358)
WRITE(6,359)
WRITE(6,360)
WRITE(6,361)
WRITE(6,362)
WRITE(6,363)
WRITE(6,364)
WRITE(6,365)
WRITE(6,366)
WRITE(6,367)
WRITE(6,368)
WRITE(6,369)
WRITE(6,370)
WRITE(6,371)
WRITE(6,372)
WRITE(6,373)
WRITE(6,374)
WRITE(6,375)
WRITE(6,376)
WRITE(6,377)
WRITE(6,378)
WRITE(6,379)
WRITE(6,380)
WRITE(6,381)
WRITE(6,382)
WRITE(6,383)
WRITE(6,384)
WRITE(6,385)
WRITE(6,386)
WRITE(6,387)
WRITE(6,388)
WRITE(6,389)
WRITE(6,390)
WRITE(6,391)
WRITE(6,392)
WRITE(6,393)
WRITE(6,394)
WRITE(6,395)
WRITE(6,396)
WRITE(6,397)
WRITE(6,398)
WRITE(6,399)
WRITE(6,400)
WRITE(6,401)
WRITE(6,402)
WRITE(6,403)BORSFREQ,RISK,PEQUITY,PRININV
FORMAT(/)

C
FORMAT(/)
177 FORMAT(2IX,'SHEEP PARAMETERS !21X,')
178 FORMAT(2IX,'BEEF PARAMETERS !21X,')
179 FORMAT(1X,'INITIAL POT.HERD SIZE: !6.2X,STOCK UNITS')
180 FORMAT(1X,'PRICES & SEASONAL VARIABLES!21X,MINT,5X,MID,5X,MAX')
181 FORMAT(1X,'WOL!,1X,3(2X,F6.2))
182 FORMAT(1X,'NEL!,1X,3(2X,F6.2))
183 FORMAT(1X,'WLS!,1X,3(2X,F6.2),5X,MORTALITY RATE!,2X,F4.1)
184 FORMAT(1X,'TEL!,1X,3(2X,F6.2))
185 FORMAT(1X,'ELS!,1X,3(2X,F6.2),4X,HOGG CULLING!,3X,F4.1)
186 FORMAT(1X,'PRICES!3X,EH!,1X,3(2X,F6.2))
187 FORMAT(1X,'WE!,1X,3(2X,F6.2),6X,RAM CULLING !2X,F4.1)
188 FORMAT(1X,'CFA!,1X,3(2X,F6.2))
189 FORMAT(1X,'RM!,1X,3(2X,F6.2),6X,EWE CULLING !2X,F4.1)
190 FORMAT(1X,'RMB!,1X,3(2X,F6.2))
191 FORMAT(1X,'EWEB!,1X,3(2X,F6.2),6X,RAM RATE !2X,F4.1)
192 FORMAT(1X,'LRT!,1X,3(2X,F6.2))
193 FORMAT(1X,'PRICES!4X,COW!,1X,3(2X,F6.2))
194 FORMAT(1X,'E!1X,3(2X,F6.2))
195 FORMAT(1X,'HEIF CULLING!2X,F4.1)
196 FORMAT(1X,'BLB!,1X,2X,F6.1)
197 FORMAT(1X,'RHE!,1X,3(2X,F6.2),5X,BULL CULLING !2X,F4.1)
198 FORMAT(1X,'CHE!1X,3(2X,F6.2),5X,COW CULLING !2X,F4.1)
199 FORMAT(1X,'BULL RATE !2X,F4.1)
200 FORMAT(1X,SEASONAL !2X,HEIF!,1X,3(2X,F6.2))
201 FORMAT(1X,'PRICES!10X,BEEF!,1X,3(2X,F6.2))
202 FORMAT(1X,'DEPRECIATION !16.8X)
203 FORMAT(1X,'LICT RESERVES !16.8X)
204 FORMAT(1X,'OTHER DEDUCTIONS !16.8X)
205 FORMAT(1X,'STANDING COSTS !16.8X)
206 FORMAT(1X,'PREV. YEARS CONSUME !16.8X)
207 FORMAT(1X,'CURRENT LIABILITIES !16.8X)
SAVE DEVEXP AND DEFUNDS FOR NEXT YEAR'S OUTPUT

LDEVEXP = DEVEXP
LDEFUNDS = DEFUNDS

50 FORMAT (T2B '---FINANCIAL---', T2B, '---------------', T2B)
T50 'NOM I
T60 'REAL r

10 20 C
C

WRITE(6,103) NETWTH, NETWTH/INFNFC, FARMCAP,
FARMCAP/INFNFC, TOTAL, TOTAL/INFNFC,
TOTAL/INFNFC, TOTASSE!, TOTAS~ET/INFNFC,
DMACC, DMACC/INFNFC, CURLIB, CURLIB/INFNFC.


105 FORMAT (3X 'DEFERRED FERTILIZER LIMIT REACHED ****')

201 FORMAT (3X 'NO LOAN TAKEN OUT THIS YEAR')

202 FORMAT (3X 'BORROWING $', 15, ' AT', F4.1, '% FOR', 12, 'YEAR TERM N.B. THIS IS THE AMOUNT BORROWED IN', F4.2)

203 FORMAT (1X, 'ACCUMULATED PRINCIPAL OUTSTANDING', 1X, '$', 16, '//')

401 FORMAT (5X '--- SEASONAL VARIABLES ---', 3X, 'LAMBING RATE', F5.1, ' %', 5X, 'EWE HOGGET', F5.2, ' $', 5X, 'EWE PRICE', F6.2)

SUBROUTINE OUTPUT

SUBROUTINE TO OUTPUT DETAILS OF COMPLETE BORROWING AND DEVELOPMENT PROGRAMME AT END OF SIMULATED PERIOD

COMMON /LOANRT/ INTPAY(20,20), PRIPAY(20,20), PROUT(20,20), APROUT(20,20), APRIPA(20,20), TREPAY(20,20)
COMMON /OUTRT/ DEVHA(20), DCOST(5,20), SRADD(5,20), COST(25,20), SR(25,20), ACOST(20), ASR(20), AREA(5)
COMMON /ACCINF/ CNLTN(20)
INTEGER DCOST, COST, ACOST, AREA
REAL NFLTN -

WRITE(6,707) 'PRIN', 'CIPA', 'L', 'OUT', 'TSTA', 'NDIN', 'G'
WRITE(6,708) WRITE(6,705) APROUT WRITE(6,707) 'REST', 'PAL', '0', '0'

SUBROUTINE TO OUTPUT INFORMATION

WRITE(6,707) 'PRIN', 'CIPA', 'L', 'OUT', 'TSTA', 'NDIN', 'G'
WRITE(6,708) WRITE(6,705) APROUT WRITE(6,707) 'REST', 'PAL', '0', '0'

RETURN
END
SUBROUTINE OUTSUM(WOOLPR, WLMFP, LRATE, LMFRT,
* WOLPSU, WOLCUT, GREYH, GREYLM, GREYLG, GREYHG,
* GREYV, GREYCF, GREYRM, WHEFPR, GREYBF,
* WHEFPR, GREYBF, CRATE, ATSU,
* MAVAIL, RCINV, DINV, ACOST,
* MAVAL, RDCINV, ACOST, ASR,
* NYEAR, RE, REPL)

SUBROUTINE TO OUTPUT RESULT SUMMARY OF MAIN MODEL RESPONSES FOR EACH REPLICATION

COMMON/AFRING, FDBRWD(20), INTR(20), LTERM(20), SPLFND, CONSUM(20),
* BORREREO, RISK, WTP, SURPLUS(20), PEOEQUI, PROPINV
* /APRPT /APRPT, APRPT, APRPT, APRPT, APRPT, APRPT, APRPT, APRPT, APRPT, APRPT,
* /DOST /DOST, DOST, DOST, DOST, DOST, DOST, DOST, DOST, DOST, DOST,
* /ACOST /ACOST, ACOST, ACOST, ACOST, ACOST, ACOST, ACOST, ACOST, ACOST, ACOST,
* /DEVHA /DEVHA

COMMON /OUTRT/ MCXEL, SHPROP, SSCOST, BMORT, HEFCUL, CONCUL, BULCUL, BULRT,
* MCHCUL, STRETT

COMMON /GVAR/ EQUITY, NETWTH, TAXPAY, ATXNFNC

COMMON /ACCINF/ CNFLTN(20)

COMMON /PTSU/ ATSU(20), ATXNFNC(20), TAXPAY(20), SURPLUS,
* MAVAIL(20), RCINV(20), WOLCUT(20),
* GREYH(20), GREYLM(20), GREYLG(20), GREYHG(20), GREYV(20),
* GREYBF(20), GREYBM(20), GREYBF(20),
* DINV(20), DINV(20), DINV(20), DINV(20), DINV(20), DINV(20), DINV(20), DINV(20), DINV(20), DINV(20),
* ACOST(20), ACOST(20), ACOST(20), ACOST(20), ACOST(20), ACOST(20), ACOST(20), ACOST(20), ACOST(20), ACOST(20),
* DEVHA, NTERM, RE, REPL

REAL WOLPR(20), WLMFP(20), LRATE(20), LMFRT(20), WOLPSU(20),
* CRATE(20), WHEFPR(20), WHEFPR(20), NETWTH(20), INTR

REAL CNFLTN, INDEX(20), EQUITY(20), CONSUM, ASR
IF REPLICATION NO. IS ONE WRITE SIMULATION PERIOD AND TOTAL REPS.

INFDEX(1) = INFDEX(1) * (1 + CNFLTN(1))

DO I = 2, NYEAR
    INFDEX(I) = INFDEX(I-1) * (1 + CNFLTN(I))
END DO

IF USED AS ABOVE INFDEX WILL DISCOUNT BACK TO YEAR 1
TO 'INFLATE' FORWARD APPLY ADJUSTMENT BELOW

DO I = 1, NYEAR
    INFDEX(I) = INFDEX(I) / INFDEX(NYEAR)
END DO

WRITE(S, 100) (INFOEX(I), I = 1, NYEAR)
WRITE(S, 100) (WOOLPR(I) / INFOEX(I), I = 1, NYEAR)
WRITE(S, 100) (LMFTRT(I), I = 1, NYEAR)
WRITE(S, 100) (WOLCUT(I), I = 1, NYEAR)
WRITE(S, 150) (GREVSH(I) / INFOEX(I), I = 1, NYEAR)
WRITE(S, 150) (GREVMV(I) / INFOEX(I), I = 1, NYEAR)
WRITE(S, 150) (GREVHG(I) / INFOEX(I), I = 1, NYEAR)
WRITE(S, 150) (GREVQM(I) / INFOEX(I), I = 1, NYEAR)
WRITE(S, 150) (GREVFQ(I) / INFOEX(I), I = 1, NYEAR)
WRITE(S, 150) (GREVRM(I) / INFOEX(I), I = 1, NYEAR)
WRITE(S, 150) (WSTRPR(I) / INFOEX(I), I = 1, NYEAR)
WRITE(S, 150) (GREYBF(I) / INFOEX(I), I = 1, NYEAR)
WRITE(S, 150) (CRATE(I), I = 1, NYEAR)
WRITE(S, 120) (ATSU(I), I = 0, NYEAR)
WRITE(S, 150) (ATXNFNC(I) / INFOEX(I), I = 1, NYEAR)
WRITE(S, 150) (CONSUM(I) / INFOEX(I), I = 1, NYEAR)
WRITE(S, 150) (TAXPAY(I) / INFOEX(I), I = 1, NYEAR)
WRITE(S, 150) (SURPLUS(I) / INFOEX(I), I = 1, NYEAR)
WRITE(S, 150) (ROCFIN(I) / INFOEX(I), I = 1, NYEAR)
WRITE(S, 150) (MAVAIL(I) / INFOEX(I), I = 1, NYEAR)
WRITE(S, 150) (ROCINV(I) / INFOEX(I), I = 1, NYEAR)
WRITE(S, 150) (OMTNC(I) / INFOEX(I), I = 1, NYEAR)
WRITE(S, 150) (NETWTH(I) / INFOEX(I), I = 1, NYEAR)
WRITE(S, 150) (EQUITY(I) / INFOEX(I), I = 1, NYEAR)
WRITE(S, 150) (FBRNO(I) / INFOEX(I), I = 1, NYEAR)
WRITE(S, 150) (TLTERM(I), I = 1, NYEAR)
WRITE(S, 150) (APROUT(I) / INFOEX(I), I = 1, NYEAR)
WRITE(S, 150) (APRIPAI(I) / INFOEX(I), I = 1, NYEAR)
WRITE(S, 150) (TREPAY(I) / INFOEX(I), I = 1, NYEAR)
WRITE(S, 150) (AQOQT(I) / INFOEX(I), I = 1, NYEAR)
WRITE(S, 150) (ASR(I), I = 1, NYEAR)
WRITE(S, 120) (DEVHA(I), I = 1, NYEAR)

101 FORMAT(5X, <NYEAR> F8.3)
120 FORMAT(5X, <NYEAR> F8.2)
140 FORMAT(5X, <NYEAR> F8.1)
150 FORMAT(5X, <NYEAR> F8.0)
RETURN
END