

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

COMPUTER SIMULATION

OF THE

WOOL SALE ROSTER

A Thesis Presented in Partial Fulfilment

of the Requirements for the Degree

of

Master of Agricultural Science

in

Agricultural Economics and Marketing

at

Massey University

by

Rodger John Mortleman

May, 1972

### ACKNOWLEDGEMENTS

Primarily, I wish to thank my supervisor, Dr. W.R. Schroder, for so willingly giving his assistance, time, and encouragement throughout the course of this study.

My gratitude extends to members of the Massey University Computer Unit for their invaluable aid, and unlimited tolerance, over the programme development stages.

Financial assistance provided by the New Zealand Wool Board for this study is gratefully acknowledged. I should like to thank Mr. J.D. Fraser, Manager of the Wool Board, for the information he provided, and his interest and suggestions, during the study.

Finally I wish to express my appreciation of the efforts of Gail Ring in typing and proof reading this thesis, and for her suggestions and encouragement over the later stages of the study,

TABLE OF CONTENTS

	Page
CHAPTER I	INTRODUCTION
1.1	New Zealand Wool Production and Disposal 1
1.2	Wool Marketing in New Zealand 1
1.3	The Auction System in New Zealand 4
1.3.1	The Auction Sale Procedure 4
1.3.2	Efficiency of the Auction System 7
1.4	The Wool Sale Roster 9
1.4.1	Drawing Up the Roster 9
1.4.2	Restrictions in Rostering 11
1.4.3	The Performance of a Wool Sale Roster 12
1.4.4	Changes to the Roster 14
1.5	The Rostering Problem 15
1.6	Objectives of the Study 16
1.7	Thesis Guide 17
CHAPTER II	THE WOOL SALE ROSTER PROBLEM AND APPROACHES TO ITS SOLUTION
2.1	The Rostering Problem 19
2.1.1	Outline 19
2.1.2	Wool Arrivals for Auction 19
2.1.3	Rostering Constraints 21
2.1.4	Performance of the Roster 25
2.1.5	Summary 34
2.2	Operations Research : A Brief Description 35
2.2.1	Conflicting Goals 37
2.3	A Mathematical Representation of the Problem 41
2.3.1	The Mathematical Model 41
2.4	Methods of Analysis 49

	Page
2.4.1	The Inventory Model Approach 49
2.4.2	The Queuing Model Approach 50
2.4.3	Dynamic Programming 51
2.4.4	Simulation 54
CHAPTER III	THE SIMULATION PROGRAMME
3.1	Contents 57
3.2	Estimation and Computer Input of Data 57
3.2.1	Estimation of Wool Arrivals 57
3.2.2	Computer Input of Wool Arrivals 59
3.2.3	The Feasible Sale Days 60
3.3	Rostering Restrictions and their Programming 61
3.3.1	The Sale Size Limits 61
3.3.2	The Between Sale Within Centre Restrictions 62
3.3.3	The Minimum Closing to Sale Date Period 63
3.3.4	The Between Sale Between Centre Restrictions 64
3.3.5	Infeasible Day Restrictions 64
3.4	Performance Parameters in the Programme 65
3.4.1	Pre-Sale Wool Storage 65
3.4.2	Bales Held Over 68
3.4.3	The Average Period Between Closing and Sale Dates 71
3.4.4	The Number of Single and Double Sales 73
3.4.5	'Monday' Sales 73
3.5	Other Features of the Computer Programme 73
3.5.1	Sale Sizes 73
3.5.2	Double Sales 74
3.5.3	More than One Feasible Sale Centre on any Day 75
3.5.4	The Single/Double Sale Decision Procedure 75
3.6	Rosters for the 1971/72 Season 78
3.6.1	Programme Rosters 79

	Page	
3.6.2	Adjusted Rosters	82
3.6.3	Within Centre Performance Variability	84
3.7	Summary	87
CHAPTER IV	EXPERIMENTATION WITH THE MODEL	89
4.1	The Purpose of Experimentation : Data Used	89
4.1.1	Experimental Year Data	91
4.2	Increasing the Rate of Sale of Wool at Auction	92
4.2.1	Means of Varying Sale Size Limits	93
4.2.2	Varying Sale Size Limits : Results and Conclusions	96
4.3	Alteration of Wool Handling Rates in Wool Stores	98
4.3.1	Means of Varying Handling Rates	99
4.3.2	Varying Handling Rates : Results and Conclusions	99
4.4	Simultaneous Variation of Both Sale Size Limits and Handling Rates	101
4.4.1	Means of Varying the Selling and Handling Rates Simultaneously	102
4.4.2	Varying Sale Size Limits and Handling Rates : Results and Conclusions	103
4.5	Increasing Only the Upper Sale Size Limits	107
4.5.1	Achievement of the Limit Changes	107
4.5.2	Results for the Expansion of Sale Size Limits	108
4.6	'Monday' Sales	109
4.6.1	Results of Runs	110
4.7	Reducing the Number of Auction Centres	111
4.7.1	Results of the Run for Less Centres	111
4.8	An Even Rate of Sale of Wool	112
4.8.1	Results for a Run Rostering All Single Sales	113
4.9	Experimentation with Different In-to-Store Arrivals Estimates	115
4.9.1	Results for Experimentation Using Lower In-to-Store Arrivals Data	115

4.10	Experimentation with the NETT : 100 Decision Rule	118
4.10.1	Results for the NETT : 100 and NETT : 0 Runs	119
4.11	Non-Conforming Rosters	122
4.12	Summary	123

## CHAPTER V CONCLUSIONS

5.1	Approximations and Model Validation	125
5.1.1	Approximations in the Model	125
5.1.2	Model Validation With Regard to Restrictions	126
5.1.3	Performance of Model Generated Rosters	127
5.2	Real World Applicability of Model Generated Rosters	128
5.3	Experimentation With the Model	130
5.3.1	Results	130
5.4	Value of the Study	132

BIBLIOGRAPHY		134
--------------	--	-----

## APPENDICES

A	The Computer Programme	136
A1	Alphabetic Listing of Variables	137
A2	DISKIM	142
A3	DISKMM	145
A4	Record and Retrieve Subroutines	147
A5	BEGINM	149

		Page
A6	INITNM	151
A7	STARTM	153
A8	INDMCM	155
A9	SELLEM	157
A10	PARAM	164
A11	Additional Programming	167
B	Data Used	169
B1	"Unweighted Average" Cumulative Wool Arrivals Data	170
B2	"Weighted Average" Cumulative Wool Arrivals Data	172
B3	Correction Factors for "Corrected Average" Data	174
B4	Infeasible Sale Days - 1971/72 : All Centres	175
B5	Regional Anniversaries - 1971/72	176
B6	Cumulative Wool Arrivals Data Used for Experimentation	177
C	Rosters	179
C1	Adjusted Rosters for the 1971/72 Season	180
C2	Example Programme Roster	183



LIST OF TABLES

Table		Page
1.1	The Marketing of New Zealand Wool	2
1.2	Distribution of Lot Sizes Sold at Auction - (1964/65 Season)	14
2.1	The Relationships Between Rostering Goals	38
3.1	The Between Sale Within Centre Restrictions	62
3.2	Programme Rosters for "Corrected Average" Data	80
3.3	Programme Rosters for "Unweighted Average" and "Weighted Average" Data Sets	81
3.4	Adjusted Rosters for the 1971/72 Season	82
3.5	Inconsistencies Within Centres	85
3.6	Individual Centre Performances	86
4.1	Minimum Lot Sizes and Sale Size Limits	94
4.2	Parametric Variation of Sale Size Limits	96
4.3	Parametric Variation of Between Sale Within Centre Restrictions	100
4.4	Trends in Performance Parameter Values	102
4.5	Parametric Variation of Two Restrictions	104
4.6	Parametric Increases in the Upper Sale Size Limits Only	108
4.7	The Results of Runs with Varying Restrictions on 'Monday' Sales	110
4.8	Performance with Less Centres	111
4.9	Results for a More Even Monthly Sale Rate	113
4.10	Results for Different Wool Arrivals Estimates	116
4.11	Experimental Results for NETT : 0 and NETT : 100 Decision Rules	120

LIST OF FIGURES

Figure		Page
2.1	Graphical Representation of the Mathematical Model : One Centre	42
2.2	The Inventory Approach : One Centre	49
2.3	Stages in Dynamic Programming	52
2.4	The Number of Feasible Rosters	55
3.1	Wool Storage Estimation : One Centre	66
3.2	Estimation of Bales Held Over : One Centre	69
3.3	Estimation of the Closing to Sale Date Period : One Centre	72
3.4	The Single/Double Decision Procedure	76
4.1	Rostering for an Even Rate of Sale	114

CHAPTER IINTRODUCTION1.1 New Zealand Wool Production and Disposal

New Zealand is the third largest producer, and second largest exporter, of wool in the world. Over the past thirty years New Zealand's wool production has more than doubled. Since 1967/68, however, a marked decline has occurred in the rate at which wool production was increasing. This decline may be attributed primarily to present economic and managerial advantages of expanding beef production, rather than sheep production, in many parts of the country.

Wool provides an important source of export earnings for New Zealand. Wool exports in 1970, valued at \$204.5 million, constituted 19% of the total New Zealand earnings from export produce.<sup>1</sup> This places wool third in importance, after meat and dairy produce, as an export earner.

The bulk of the New Zealand wool clip is sold at auction in New Zealand and exported in the greasy state. The major markets for New Zealand wool are the United Kingdom, the U.S.A., Japan, Belgium, France, Italy, and the U.S.S.R. Local mill purchases take only a small proportion of the wool clip.

1.2 Wool Marketing in New Zealand

In New Zealand there is no controlled marketing of wool. Growers may market their own individual clips at auction in New Zealand or the United Kingdom, or they may sell their wool privately. The major proportion of the clip is sold at auction in New Zealand.

When growers sell their wool at New Zealand auctions they are assured

---

1. Source: Department of Statistics (3), p.567.

of at least receiving the floor price for their wool, through the operation of the floor price scheme administered by the New Zealand Wool Commission. Provision also exists for the application of floor price protection to wool sold privately, provided certain conditions are met. Growers can put their own reserves on their wool offered at auction, and they can withdraw the wool from sale and offer it later. Reasons for only a limited amount of New Zealand wool being sold by auction in London include the delay in receipt of payment, and the general convenience of supplying local sales. Private selling has developed very strongly from the 1968/69 season. The proportions of the seasonal clip sold through the various marketing channels are given in Table 1.1 below.

TABLE 1.1      THE MARKETING OF NEW ZEALAND WOOL

Method of Sale	Percentage of Total Production			
	1967/68	1968/69	1969/70	1970/71
New Zealand Auction	75.14	71.04	68.69	66.07
United Kingdom Auction	0.27	0.27	0.28	0.22
Private Sales	7.99	10.91	13.17	15.81
Others <sup>x</sup>	16.60	17.78	17.86	17.90
Total	100.00	100.00	100.00	100.00

<sup>x</sup> Composed largely of slipe wool but includes sheep skins and stock changes also.

Source: Primary data from New Zealand Wool Commission (6), p.11.

Table 1.1 above indicates that the importance of the New Zealand wool auction outlet is declining. Most of this decline is being taken up by increases in private selling. However, the auction of wool in New Zealand provides a means of sale for about two thirds of the clip. Unless private

selling, or, some other means of disposal, can accommodate this two thirds of production the New Zealand auction system will retain a major marketing role.

Because of the variability in wool offerings buyers require that wool be available for appraisal prior to auction. This appraisal function of the auction marketing system could become redundant if one (or both) of the following technological changes occurred. These are:

- i. if manufacturing techniques for wool develop such that variability in the fibre characteristics of wool become of little disadvantage, or,
- ii. if a practical means of grading wool fibres into acceptably homogenous lines becomes available (homogeneity of a degree sufficient to satisfy manufacturers).

Either, or, both, the required changes above would favour the introduction of an industrial system of marketing for wool; a system whereby samples of wool, with specified prices, would be presented to manufacturers. Otherwise, samples<sup>2</sup> could be made available to buyers for evaluation, in lieu of the present method of appraisal. In this situation the auction system could retain its function as a pricing system but lose its function as a means of wool appraisal.

These technological changes are likely to develop and effect the future of the auctioning system. The rate at which these technologies develop may determine how long the auction system remains.

At present the New Zealand Wool Marketing Corporation is being established, following recommendations made by the Wool Marketing Study Group (10), the Wool Marketing Committee (9), and, the Battelle Report (2) on wool marketing in New Zealand. The policies of the Corporation are not known as yet. To obtain wool the Corporation could buy privately, buy at auction, or operate an acquisition scheme (as does the Dairy Board). The Corporation could sell

---

2. Some wool is appraised on a sample basis at present. The situation referred to implies that all wool is appraised on the basis of samples.

wool to buyers and merchants in New Zealand, and/or, directly to overseas merchants and manufacturers, and/or, through the auction system.

In conclusion, the immediate future of the auction system cannot be assessed at this stage; the most important controlling factors are the policies decided on by the New Zealand Wool Marketing Corporation.

### 1.3 The Auction System in New Zealand

#### 1.3.1 The Auction Sale Procedure

There are eight wool auction selling centres in New Zealand; four in the North Island (Auckland, Napier, Wanganui and Wellington) and four in the South Island (Christchurch, Timaru, Dunedin and Invercargill). A roster of wool auction sales, for each season, is drawn up by an official body called the Wool Auction Sales Committee. The roster prescribes dates for the sales at each centre and the quantity of wool to be offered at each sale. Teams of buyers in the North Island and South Island, totalling about eighty buyers, travel from selling centre to selling centre.

The roster of New Zealand wool sales covers a series of winter sales in August<sup>3</sup> as well as main sales starting at the end of September and finishing in June. At the winter sales most crutching wools are sold; also any early shorn wool available at the time; and any wool left over from the previous season.

Wool producers sort their wool into lines with some semblance of homogeneity and press it into 145 - 160 kilogram bales in the shearing shed. They may skirt, and/or, class their wool in the shearing shed, or, arrange for a wool broker to do this. Wool brokers are firms that prepare, handle, and offer producers' wool for auction (or for private sale). Growers brand their bales with their identification mark, description of contents, and bales are numbered consecutively. Transportation of wool to their broker, at the

---

3. Winter sales form part of the roster but are not considered in the roster problem. They do not effect the rostering of main sales. Main sales are rostered on the basis of estimates of new seasonal wool arrivals.

centre where their wool is to be auctioned, is arranged by the producer. At this time any instructions for the broker regarding preparation of his wool are given.

Producers usually send their wool to their broker immediately after shearing. One possible reason for this is the belief that there is a downward trend in prices over the season. The main reason is probably because producers are foregoing interest on the value of unsold wool. Because different wool types are shorn at different times of the season, the quantitative composition of wool types being offered at auction varies over the season.

On arrival at the wool brokers store, bales may be separated for specific pre-sale operations, to be carried out by the broker, as instructed by the wool producer. Pre-sale optional operations carried out are important determinants of labour and time requirements of brokers. The most important of these optional operations are binning, reclassing, skirting and interlotting. About 40% of wool offered at auction sales in New Zealand is binned or reclassified by brokers. This proportion varies between auction centres from around 20% in Wanganui to about 50% in Christchurch.<sup>4</sup>

Because the bulk of the National wool clip is shorn before Christmas, there is a rush of wool into brokers' stores between the beginning of the main selling season in October and the end of December. Brokers adopt a system of "first into store first into sale". This is necessary because of the time required to prepare wool for auction by brokers, and, because of a quantitative upper limit on the wool that can be sold at individual auction sales.

Wool brokers and wool buyers are parties to agreed regulations covering:

- i. the procedure for display of wool,
- ii. the sampling of wool by buyers,
- iii. the auction sale rules,
- iv. the after-sale procedure regarding confirmation of purchases and rebranding of bales for export,
- v. documentation,

---

4. Source: New Zealand Wool Commission (6), p.18.

- vi. shipping instructions and payment for wool purchases,
- vii. the Press market reports of each sale.

Daylight lighting is required for wool displayed for sale by auction. Bales are displayed in brokers' wool stores to which buyers are given access for valuation. A limited number of bales are opened to allow inspection. Wool brokers and buyers regulations cover the stacking of bales, and, the proportion of each lot to be opened. Bales opened for inspection must be representative of each lot, to the best of the broker's knowledge.

The rules settled between wool buyers and wool brokers provide that wool must be displayed for valuation by the buyers during an agreed number of days prior to the sale. Brokers supply buyers with catalogues in which they can mark their valuations for lots to be offered for sale. Hence buyers are ready on the sale day to compete in their bidding for lots offered. Brokers also make valuations of wool before the sale and generally communicate their valuations to the producers. Producers may then instruct brokers to place a reserve price on their wool.

Wool auction sales in New Zealand are legally public auctions but are attended only by recognised wool buyers, i.e. firm representatives resident in New Zealand, who buy wool at the sales in fulfilment of orders of their principals, or, on their own behalf. Seating is arranged suitably for the buyers at these auction sales, the seats being allocated at the beginning of the season by the Wool Brokers' Association on the basis of quantities of wool purchased during the previous three seasons.

After the sale, bales which were opened for the purpose of display are sewn up and countermarking requested by buyers is put on the bales. Space in ships is booked to ensure prompt shipment of wool overseas. Buyers pay for their purchases on or before "prompt date", that is, eighteen days after the sale.

In summary the wool buyer's function consists of inspecting and valuing wool, bidding for it at auction, arranging for payment for purchases, and the



despatch of wool purchased. The wool buyer is the major link between the auction for wool and the raw wool user.

Wool Commission activities at auction effect the auction system in two ways. Firstly there is an effect on demand due to Commission bids operated on the floor price scheme. Secondly, the re-offering of any stocks of wool accumulated by the Commission effects supply.

Insofar as the roster problem is concerned Commission activities are not important. The Commission may offer stocks at any auction where these offerings do not increase the sale sizes to unmanageable levels.<sup>5</sup> Rosters are made before the season commences so little consideration can be given to demand shifts over the season.<sup>6</sup>

### 1.3.2 Efficiency of the Auction System

Two criteria which may be used to establish the efficiency of any marketing system are:

- i. efficiency as a pricing system,
- ii. efficiency as a distribution system.

A marketing method which is efficient from a pricing point of view is one in which consumers' wants are accurately transmitted to producers by the pricing mechanism. The Wool Marketing Committee (9) pointed out that the auction sale system for wool has inefficient aspects from this point of view. Short-term wool price fluctuations, and lack of consistency in the prices of individual wool types, do not give an accurate indication of consumer demand to growers.

A marketing system which is efficient from a distribution point of view

- 
5. Overrostering (see Section 1.4.1) occurs. Overrostering provides some flexibility to auction sale sizes, allowing the Commission to offer stocks if they wish.
  6. The Wool Marketing Committee (9) agreed that "the major cause of fluctuation in raw wool prices is demand for, rather than supply of, wool". The effect of the roster on wool prices, in that it supplies wool to the market, is not considered important.

is one in which goods are moved from producer to consumer at minimum cost. While the wool auction sale system effectively disposes of two thirds of the national wool clip, it forms part of the distribution system described by the Transport Department (5) as being "fragmented and costly". The Wool Marketing Study Group (10) pointed to areas in which further cost savings could be made.

However, the Wool Marketing Committee (9) observed that before the wool auction sale system could be abandoned, there must be clear evidence of a method, better suited, for the sale of some 1,600,000 bales of wool per annum.

The continuation of the auction system, in a major wool marketing function, depends on whether a more efficient marketing system can be introduced. Inefficiency of auction selling as a pricing system is the major disadvantage of this system. The floor price scheme, operated by the Wool Commission, was aimed at improving this aspect of efficiency. Partly because of the limited success of the floor price scheme, the Wool Marketing Corporation (see Section 1.2) is being set up. Insofar as the roster is concerned, proposals to improve the pricing efficiency of the auction system are not important. The reason for this lies in the belief that demand, not supply, is the important determinant of wool prices and wool price fluctuations.

Proposals aimed at improving the auction system in its distribution function do effect the roster. Most of these proposals effect the rostering constraints. Sale by sample,<sup>7</sup> dense baling,<sup>8</sup> containerisation,<sup>9</sup> and unitisation,<sup>10</sup> have implications in terms of the time constraints in rostering.

- 
7. Sale by sample involves presenting wool samples for inspection by buyers rather than stacking bales in their respective lots and opening some of them.
  8. Dense baling involves pressing wool into dense units. These bales cannot be opened for buyer inspection. Therefore dense baling must be associated with sale by sample.
  9. Containerisation involves packing and shipping wool bales in containers.
  10. Unitisation involves combining a number of bales into one unit for greater ease of handling. The bales of the unit may be held together by wire or steel straps.

The proposal that the number of selling centres be reduced would require vast changes in the roster format.

Attempts to improve the efficiency of the auction system by introducing one or more of the proposals discussed would produce associated changes in the roster format. The extent of these format changes, and the change in efficiency of the auction system, should be accurately evaluated before any proposal is implemented.

#### 1.4 The Wool Sale Roster

The wool sale roster is perhaps the most important component of the auction system. The roster affects every party involved with the auction system; therefore it affects many important performance parameters<sup>11</sup> of the system. Furthermore the roster is one of the most flexible components of the wool auction system. This flexibility makes the roster amenable to alterations and adjustments aimed at improving the performance of the auction sales procedure as a marketing system.

##### 1.4.1 Drawing Up the Roster

The wool sale roster is drawn up by an official body named the Wool Auction Sales Committee. The composition of the Committee is:

- Three members nominated by the N.Z. Woolbuyers' Association
- Three members nominated by the N.Z. Woolbrokers' Association
- Two members nominated by the N.Z. Wool Board
- One member nominated by the N.Z. Wool Commission
- One member (without vote) to be Chairman of the Committee

A Sub-Committee, (composed of representatives of the wool brokers, the wool buyers, the Wool Board and the Wool Commission), has the function of

---

11. Performance parameters represent goals, or, objectives, of individuals or parties. Measurement of performance parameters measures the extent to which these goals are fulfilled, (see Section 1.4.3).

drawing up tentative rosters for submission to the Wool Auction Sales Committee. This Sub-Committee has six members.

Before a roster can be formulated, estimates of expected wool arrivals for each centre must be made. The auction sales roster for the 1969/70 season, originally drawn up by the Wool Auction Sales Committee in November 1968, was revised by the Committee in May 1969 in the light of amended estimates of the quantities of new clip wool likely to be available in the eight selling centres throughout the season. Due to inaccuracy in the quantities offered for sale, compared to new clip wool actually available for sale, the system for rostering has been altered. Future rosters will set firm quantities for the first half of the season only. Tentative quantities will be given for the remainder of the season, and will be reviewed in mid-season.

The estimates of quantities of wool rostered for sale, when the roster is drawn up, need to be reasonably close to what will actually be offered at sale because:

- i. shipping space for wool is made available (booked) according to the wool sale roster. Hence inaccuracies in estimates result in excess, or, deficits in, shipping capacity for each sale,
- ii. buyer inconvenience is caused by inaccurate rostering.

Generally the Wool Auction Sales Committee overrosters in most centres. i.e. the amount of wool rostered for sale exceeds total seasonal arrivals.<sup>12</sup> Overrostering provides both brokers, and the Wool Commission, some flexibility in their operations.

The current sales programme is known in the trade as a two-island roster. It requires buying firms to have buyers for each island. This type of roster has proved flexible in meeting current demands and, particularly,

---

12. The 1970/71 roster (as amended August, 1970) rostered 1,435,000 bales for auction from September. Total arrivals for that season (excluding winter sales) numbered 1,305,000 bales. Total rostered/total arrivals equals approximately 1.1. i.e. overrostering by about 10% occurred.

in ensuring that there is no undue delay in the early part of the season in scheduling sales where there is wool awaiting sale.

#### 1.4.2 Restrictions in Rostering

Five basic restrictions must be considered when rostering wool sales. These restrictions are required in the roster by buyers and brokers so as they may fulfill their functions in the auction system without undue hardship.

Lower sale size limits are required to give a full days auctioning. Upper sale size limits keep the sale to a manageable size. The sale size limits are determined by the rate of selling wool and the length of the sale. The auction selling rate is generally between 300 - 350 lots per hour. Sales commence at 8.00 a.m. and finish at about 6.00 p.m. Wool auction sales may be either single or double sales. Single sales comprise one auction day; double sales are held over two auction days.

There are time restrictions on the minimum period between sales in a centre. A minimum period is required to allow brokers to break down the previous sale and prepare for the next sale. The sizes of these periods depend on the sizes of the two sales and the amount of preparation required for wool that is arriving in brokers' stores.

Brokers give notice of closing dates for sales. The closing date is the last day that new wool arrivals will be included in the next sale. A minimum value for the closing to sale date period is required to allow late arrivals to be processed and presented for appraisal by buyers prior to auction.

Buyers require minimum periods between sale dates in the same and different Islands. The within Island restriction allows buyers to organise shipping arrangements for purchases, to communicate with principals and associates, and, to evaluate wool being offered at the following sale. The between Island restriction is required by buyers for similar purposes though they seldom attend sales in different Islands.

The fifth basic restriction is that sales must be held only on trading

days. This excludes weekends and public holidays. A Christmas break is included in this restriction.

#### 1.4.3 The Performance of a Wool Sale Roster

The performance of a roster is some measure of the degree to which the roster fulfils the goals of parties involved. Due to areas of conflicting interest, however, a roster considered to have a high performance by one party may be considered of low performance by another party. Furthermore, a roster may be regarded as having high performance with respect to one goal of an individual (or party) and low performance in terms of another of his goals. Generally it is easier for an individual (or individual party) to compromise his (or its) conflicting goals, and arrive at a decision, than it is for more than one individual (or party). The problem of compromise, between the conflicting goals of parties devising the roster, detracts from the use of optimising analytical techniques for the roster system.<sup>13</sup>

The wool producer would consider a high performance roster as one which sold his wool as soon as possible and at a good price. For some producers the wool cheque is the first source of revenue after winter, and may be required to meet operational expenses.

The wool broker wishes to shift as much wool as possible without extensive peak handling periods. Peak handling periods entail high costs of overtime work. They are caused by pre-sale rushes of wool arrivals and post sale shipping rushes.

Wool buyers need time to evaluate potential purchases and attend sales. Their main costs are in travelling and accommodation. Time is required after sales to organise the disposal of purchases.

The roster effects the activities of the Wool Commission in two ways. Firstly the roster effectively supplies wool to the market, and therefore has

---

13. The problem of conflicting goals is expanded in Section 2.2.1.

implications to the floor price scheme. Secondly, stock offerings by the Commission must fit in with the roster. Stock offerings at a sale must be such that the resulting sale size is within prescribed limits.

The Wool Board acts in a co-ordinating function. Their aim, as representatives of producers, is to co-ordinate the system so as to minimize costs due to peak handling periods, yet sell wool at a rapid rate over the season. Shipping must be well organised to keep shipping and wool handling costs down.

In attempting to fulfil these objectives, the Wool Auction Sales Committee devises rosters which tend to have a monthly pattern of single sales. i.e. a single sale is held each month in each centre. The pattern cannot be rigidly adhered to because of holidays and differences in wool arrivals in different centres; smaller centres may not have enough wool for monthly single sales, whereas in larger centres so much wool may accumulate that a double sale must be held.

From the goals of the parties involved, a list of performance parameters for the roster can be drawn. The performance parameters are:

- i. the accuracy of the forecasts of quantities offered at sales,
- ii. the length of time bales are held in store prior to being sold,
- iii. the storage requirements for wool,
- iv. the extent of peak handling periods caused by the roster,
- v. the time buyers have for wool appraisal, and disposal of purchases,
- vi. the ease with which shipping can be made available.

In the list above many of the performance parameters are seen to be interrelated. The length of time bales are held in store prior to sale, obviously determines pre-sale storage requirements. The ease of organising shipping is related to sale size forecasts, and peak handling periods. Further in the study these performance parameters are made more specific to remove some of these interrelationships. Performance parameters relating to wool prices are not included in the list. The reason for this is the belief that the roster plays only a limited role



insofar as wool prices are concerned.<sup>14</sup>

#### 1.4.4 Changes to the Roster

Proposed changes to the auction system could produce significant changes in rostering. Most of these changes would be reflected in alteration of the rostering constraints.

Proposals that would improve the distribution efficiency of the auction system would often allow the minimum period between two sales to be reduced; less time may be required to set up and break down sales.

A study conducted by Peirse and Beggs (7) indicated that advantages would accrue in terms of wool handling and wool prices if smaller lot sizes were abolished from the auction system. The average lot size at auction is important in that the rate of selling wool (in bales per day) is limited by the rate of selling lots. If the rate of selling lots of wool was constant, then the rate of sale of wool at auction would be directly dependent on the average lot size.

Peirse and Beggs give a broad distribution of lot sizes over the 1964/65 season in the following table.

TABLE 1.2      DISTRIBUTION OF LOT SIZES SOLD AT AUCTION - (1964/65 SEASON)

Lot Size	Number of Lots	Percentage of Total Lots	Number of Bales	Percentage of Total Bales
1 - 6	64,360	48.8	287,747	21.8
7 - 10	31,618	23.9	260,368	19.9
11 - 15	16,166	12.3	204,714	15.8
16 - 20	7,313	5.5	129,705	9.8
21 - 25	4,949	3.8	114,805	8.7
26 & over	7,610	5.8	315,036	24.0
TOTALS	132,016		1,312,375	

Source: Peirse and Beggs (7), p.1.

<sup>14</sup>. For further discussion on this point see Section 2.1.4.



Assuming that the rate of selling lots is independent of lot size it can be seen from Table 1.2 that 48.8% of the selling time is taken to sell 21.3% of the wool offered at auction by the 1 - 6 lot size class. At the other extreme only 5.8% of the selling time was required to sell 24% of the bales. Abolishing smaller lots would probably increase the average lot size. This would mean that more wool could be sold in a days auctioning. The result on the roster would be to increase the sale size limit restrictions.

At present there are eight selling centres in the roster. It has been argued that this number could be decreased, to economic advantage, by removing some of the smaller centres. Such a proposal has important implications for parties effected by the roster. Producers in areas where centres were abolished would incur higher transport costs for their wool. Average brokerage costs may decrease due to economies of scale. Wool buyers would have less centres to attend sales in. Shipping could probably be organised more easily. However, as the quantity of wool channelled through a centre increases, more peak handling periods, and higher storage costs, are likely to occur. Because of all these factors, a full investigation into the performance of the auction system with less centres is required before such a proposal is implemented.

To facilitate the organisation of shipping an even monthly disposal pattern for wool could be introduced. This proposal could improve the operational efficiency of wool brokers and buyers but may incur higher wool storage costs. The roster would change in format, from tendencies to maximise monthly wool disposals, to a format promoting an even monthly disposal rate.

### 1.5 The Rostering Problem

Devising feasible wool sale rosters is time consuming, due to the restrictions that must be observed. Furthermore, rosters may be feasible but not acceptable. An acceptable roster must satisfactorily fulfil the goals of parties effected by it. It is difficult to devise acceptable rosters due to the problem of conflicting goals (see Section 1.4.3).

Different feasible rosters vary in their performance for different goals. It would be desirable to devise a great range of feasible rosters from which one can be chosen by the Wool Auction Sales Committee. At present, rosters are devised by a Sub-Committee of six members. The time required to draw up feasible rosters limits the range that can be produced. Consequently only a limited range of rosters can be studied and modified to find one which is satisfactory. Because of this limited range much time may be used to modify rosters. If a wider range of rosters was made available, then it is likely that one of these would be acceptable with little modification.

Due to the time required to draw up feasible rosters, and additional time that would be needed to measure performance parameters of the roster, no measures of performance parameters are made. In accepting a roster the Wool Auction Sales Committee must appraise the performance of the roster; but this appraisal is not in quantitative measures of performance parameters. However, quantitative measures would improve the appraisal function.

Furthermore, the present system of devising and evaluating rosters makes it very difficult, and, time consuming, to evaluate the performance of the roster sub-system for new roster formats; formats which would result from the introduction of proposed changes to the auction system.

#### 1.6 Objectives of the Study

The main aim of the study was to devise a means of generating a wide range of feasible rosters. It was imperative to observe the rostering restrictions, and, desirable to measure the performance parameters of each roster quantitatively. The advantages of producing a wide range of feasible rosters, each with a measured set of performance parameters, have been explained in the previous section.

Because of the number of restrictions and performance parameters in the rostering problem, and the number of rosters required, it was felt necessary to use a computer. Consequently a representative mathematical model of

the roster sub-system had to be devised. Formulation of a representative mathematical model of the roster sub-system requires that all components of the system be included in the model. Variation of the action of the system's components, or the relationships between components, makes experimentation with the model possible. Consequently, in fulfilling the main aim of the study, a means is provided by which the performance of the roster sub-system can be studied for proposed changes to the auction system.

### 1.7 Thesis Guide

In Chapter II a full description of the rostering problem is given in the broad categories of wool arrivals, constraints and performance parameters. Within these categories assumptions and refinements are made to establish components and relationships of the roster system. A description of operations research is given with special emphasis on the problem of conflicting goals. Following this a mathematical model of the roster sub-system is devised, and techniques of analysing the roster problem, by means of the mathematical model, follow.

Chapter III presents the computer simulation model and its validation. The estimation and computer input of wool arrivals is described initially. This is followed by the specifications for rostering restrictions, and their inclusion in the programme. Performance parameters measured by the model, and decision making processes of the model, are described next. Finally, a range of rosters, based on three sets of wool arrivals estimates, and varying model decision rules, are presented. These rosters are for the 1971/72 season; they are compared to the actual roster devised by the Wool Auction Sales Committee for that season.

In Chapter IV experimentation with the model is carried out to evaluate the effect of proposed changes to the auction system on the performance parameters of the model. The layout for each experiment conducted is as follows. Firstly, the implication of the experiment, in terms of proposed changes to the auction system, is discussed. Then the results for the experiment are

presented and conclusions drawn. Further in the Chapter the sensitivity of the experimental results under conditions of changing wool arrivals and decision processes is studied. Inconsistent rosters are discussed, and finally a summary of the experimental results is presented.

Chapter V presents the conclusions drawn from the study. Initially the validity of the model, and model produced rosters, is discussed. Experimental results and policy suggestions are presented next. Finally a summary of the usefulness of the study in view of future changes to the wool marketing system is presented.