AN ECONOMETRIC ANALYSIS
OF THE
FACTORS INFLUENCING
BINNED WOOL PRICES

by

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ABSTRACT

This study analyses appraisal, measurement and price data for 8,500 binned wool lots in an examination of some of the factors affecting wool valuation and price formation. The study explicitly considers:

1. The sources of binned wool price variation and the extent to which these prices are explained by appraised and measured greasy wool characteristics.

2. The relative economic importance of greasy wool characteristics.

3. Relationships between appraisals and between appraised and measured wool characteristics.

4. The effect of economic circumstances on appraisal.

5. The effect of objective measurement on total income and the equity of income distribution among growers.

The study provides evidence to support the conclusion that the present wool auction system has a number of inefficiencies and suggests that the introduction of objective measurement into wool marketing could improve this situation.

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MAJOR ABBREVIATIONS USED

ANOVA	Analysis of Variance
Aust.J.Agric.Econ.	Australian Journal of Agricultural Economics
B.A.E.	Australian Bureau of Agricultural Economics
J.Text.Inst.	Journal of the Textile Institute
Quart.Rev.Agric.Econ.	Quarterly Review of Agricultural Economics
W.M.S.G.	New Zealand Wool Marketing Study Group
Wool Tech. Sheep Breeding	Wool Technology and Sheep Breeding
W.R.O.	Wool Research Organisation of New Zealand

CHAPTER ONE

INTRODUCTION

1.1 THE NEW ZEALAND WOOL INDUSTRY:

New Zealand is the world's third largest wool producer and second only to Australia as an exporter of wool. In the 1971/72 season New Zealand wool production was 322.3 thousand metric tons greasy, 12% of the world total.[1]

The New Zealand wool clip is predominantly crossbred in character, about 84% being 50's and coarser, 14½% being 52's to 58/60's and only 1½% being 60's and finer.[2] This is a reflection of the breed composition of the New Zealand sheep flock which consists of over 80% Romney or Romney-cross. The bulk of the New Zealand clip is sold at auction in New Zealand and exported in the greasy state; local mill consumption accounts for only a small proportion of the total clip. The major use for New Zealand crossbred types is in non-apparel products such as carpets, blankets and industrial and furnishing fabrics.

In the June year 1971/72 raw wool exports, valued at $223m, comprised approximately 18% of the total value of New Zealand exports.[3] New Zealand has always depended on pastoral exports to finance its growth and development and since the 1850's wool has been its most consistent export. From 1900 to 1964 wool consistently earned one-third of New Zealand's export receipts, although its contribution has dropped in recent years to about one-fifth. Furthermore, the structure of the sheep industry in New Zealand means that wool is not only a major contributor to overseas earnings in its own right but is also a major factor in the profitability of lamb and mutton production (worth $145m in overseas earnings in 1971/72).

1.2 NEW ZEALAND WOOL MARKETING:

Prior to the establishment of the New Zealand Wool Marketing Corporation in 1972 there was no controlled marketing of New Zealand wool. The new Corporation has sought the power to acquire the total New Zealand clip and market it in the growers' best interests. However, the Corporation's marketing scheme will not be introduced until 1975 and

1. New Zealand Wool Board; 28th Annual Report, 1972.
2. New Zealand Wool Commission; Statistical Analysis of New Zealand Wool Production and Disposal, 1971/72 Season.
3. New Zealand Wool Board; op.cit.

during the 1973/74 season there will be little change in the present selling system.

Under the present system, growers market their own individual clips at auction in New Zealand or the United Kingdom, or they sell privately (see table 1). While there is no compulsion on a grower to offer his wool at auction in New Zealand, most of the clip is sold in this way. However, private selling has increased substantially in recent years.[4]

TABLE 1

Analysis of New Zealand Wool Disposal : Thousand Metric Tons Sold and Percentage of Total Sales by Method of Sale.

Method of Sale	1967-68		1968-69		1969-70		1970-71		1971-72	
	m.k.t.	%	m.k.t.	%	m.k.t.	%	m.k.t.	%	m.k.t.	%
Sold at Auction	244.1	74.4	235.8	71.0	225.3	69.1	220.6	66.0	213.9	65.8
Growers' Shipments	9.1	2.8	9.1	2.2	9.2	2.8	7.5	2.2	6.6	2.0
Private Sales	26.4	8.1	36.2	10.9	43.2	13.3	52.8	15.8	53.6	16.5
Slipe, Sheepskins	47.6	14.7	50.4	15.9	47.6	14.8	53.8	16.0	50.5	15.7
Total	327.3		331.5		325.3		334.6		324.6	

m.k.t. = metric kilo tons

Source: New Zealand Wool Commission; op.cit.

At auction, growers are assured of at least a minimum price for their clips through the operation of the floor price scheme administered by the Wool Marketing Corporation. Provision also exists for the application of floor price protection to wools sold privately, provided certain conditions are met.

The grower selling his clip at auction does so through a broker with instructions for one or more of the four methods of presentation for sale: reclassing, interlotting, binning or selling as delivered by the grower. Reclassing is the term given to the practice of classing entire clips in a broker's store rather than in the shearing shed; this is often done with large clips. Interlotting is the practice of combining different growers' lots to form large lots of the same wool. Interlotting is purely a lot building process and an important feature of it is that the original bales remain intact with the respective grower's brand on each bale.

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4. Over the last five years the percentage of private sales has doubled and in the 1971/72 season these sales represented 16.5% of all the wool sold in New Zealand. There has been a corresponding decrease in sales at auction from 74% in 1967/68 to 66% in 1971/72 and growers' shipments have also declined over the same period (see table 1).

Binning is a process whereby large numbers of fleeces or oddment lots of similar type, belonging to various growers, are classed into large, even lines. This process, which brokers specialise in, makes the composite offerings attractive to buyers. The final sale proceeds of the binned wool are distributed equitably amongst the growers whose wool was included in the binned lines.

1.2.1 The Place of Binning in New Zealand Wool Marketing:

A reduction in individual clip[5] size and an increase in the variation of types within a clip are situations favourable to binning. As flocks become smaller, the scope for culling and selection are reduced and farmers with small flocks tend to buy in much of their stock. For these reasons it would be expected that small flocks would be more heterogeneous and contain a wider range of wool types than larger flocks.

In New Zealand, most binned wool is sold in the South Island and this is probably due to the practice there of buying in ewes each year to produce fat lambs. These flocks would contain a larger range of wool types than in farm-bred flocks.

In general it might be expected, therefore, that binning would be prominent in areas with a high proportion of small dual purpose flocks, especially where these are run with other enterprises and may not be as effectively managed as single enterprise flocks.

There has been a steady decrease in recent years in the amount of binned wool offered at auction in New Zealand, from 44% of the total clip five years ago to 34% in 1971/72 (see table 2). This has been due to depressed prices and the growers' belief that additional costs incurred in binning would not be recouped on the sale floor, and has been paralleled by a corresponding increase in the amount of wool offered under growers' own brands.

The quantity of binned wool offered in New Zealand varies between selling centres from around a minimum of 20% at Wanganui to a maximum of 45% to 50% at Dunedin and Christchurch (see table 3). At these latter two centres approximately 40% of all the binned wool offered in New Zealand is sold. The number of binned bales sold is low in winter, rises to a maximum between October and March, then declines to the end of the season.

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5. A 'clip' is all the wool produced by a particular property at a single shearing.

TABLE 2

Analysis of Greasy Wool Sold at New Zealand Auctions by Mode of offering Expressed as a Percentage of Total Sales.

Season	Total M.Tons Sold	Reclassed	%	Binned	%	Interlotted	%	Growers	%
1967-68	244,800	26,928	11	107,712	44	14,688	6	95,472	39
1968-69	234,300	25,773	11	105,435	45	14,058	6	89,034	38
1969-70	224,100	24,651	11	98,604	44	11,205	5	91,881	41
1970-71	218,216	20,297	9	84,515	39	10,930	5	102,191	47
1971-72	209,172	12,501	6	71,682	34	9,620	5	115,371	55

Note: Weight totals do not cross add due to rounding.

Source: New Zealand Wool Commission; op.cit.

In the North Island, where growers' brands predominate, the proportion of binned wool to total sales is highest in the winter and lowest in the January/March quarter. However, in the South Island, where there is rather more binning, this proportion reaches a peak in the April/June quarter and is lowest in winter. Apart from this pattern, South Island centres generally show a rising trend in the proportion of binned wool to total sales during the year and North Island centres a declining one (see table 4).

An explanation for this situation is that most crutching wools are sold in winter and much of this wool would be binned due to its small volume. In the North Island the main clip is sold after Christmas and consequently the proportion of binned wool is low during January/March because the bulk of the fleece wool is sold as growers' lots. In the South Island a similar situation occurs in winter but, because of the popularity of fat lamb production, a large proportion of the main clip is Southdown. Most, if not all, of this Southdown wool is binned and consequently the proportion of the clip binned reaches a peak in the South Island at the time when it is at its lowest in the North Island.

1.2.2 The Auction System:

Although wool auction sales in New Zealand are legally public auctions, they are attended only by recognised wool buyers who buy wool at the sales in fulfilment of orders of their principals or on their own behalf. Teams of buyers travel from selling centre to selling centre in rotation and at each sale value the wool on display and set their 'limits'. These limits represent the maximum price the buyers are prepared to pay for each lot. At the auction sale itself

TABLE 3

Analysis of Binned Wool Sold at New Zealand Auctions Expressed as a Percentage of Total Sales in Each Centre.

Centre / Season	Auckland %	Napier %	Wanganui %	Wellington %	Christchurch %	Timaru %	Dunedin %	Invercargill %	North Island %	South Island %
1967-68	39	33	21	37	57	52	58	56	34	56
1968-69	37	36	23	36	56	53	58	59	34	57
1969-70	36	36	24	35	55	53	56	54	34	55
1970-71	34	32	21	32	54	46	51	36	31	47
1971-72	29	30	19	29	52	40	46	26	28	41

Source: New Zealand Wool Commission; op. cit.

TABLE 4

Quarterly Analysis of Binned Wool Sold at New Zealand Auctions.

		% of total binned wool sales (a)					% of sales in each quarter (b)				
	Quarter	1967-68	1968-69	1969-70	1970-71	1971-72	1967-68	1968-69	1969-70	1970-71	1971-72
North Island	Winter	2	2	2	2	2	45	45	41	41	37
	Oct-Dec	13	13	13	14	12	37	38	36	34	28
	Jan-Mar	17	17	16	16	17	30	32	31	28	25
	Apr-June	10	8	8	9	11	35	33	33	30	29
	Total	42	40	40	41	42	34	34	34	31	28
South Island	Winter	4	5	6	6	6	50	50	50	44	40
	Oct-Dec	18	21	23	21	20	50	53	51	47	40
	Jan-Mar	25	22	21	20	21	60	60	58	46	39
	Apr-June	11	12	10	12	11	65	65	59	52	51
	Total	58	60	60	59	58	56	57	55	47	41

(a) Binned wool sold in each quarter as a percentage of total binned wool sold over the season.

(b) Binned wool sold in each quarter as a percentage of total sales in the quarter.

Source: New Zealand Wool Commission; op.cit.

lots are knocked down to the highest bidder, with bids being in ½ cent per kilogram (previously ¼ cent per pound).

There are eight selling centres in New Zealand, four in each island (Auckland, Napier, Wanganui and Wellington in the north; Christchurch, Timaru, Dunedin and Invercargill in the south) and the dates for the sales and the quantities to be offered at each sale are prescribed by an auction sale roster. The normal pattern of sales is for two each week, one in the North Island and one in the South Island, with a Wednesday/Friday sequence.

1.3 WOOL MARKETING REFORM:

Over the past decade the wool auction system has come under criticism for a number of reasons, one of these being the extent to which wool prices have fluctuated. Concern about the affects of wool price fluctuations on user demand and farm development prompted establishment of the New Zealand Wool Marketing Study Group[6] (W.M.S.G.) to investigate the situation.

The Group concluded that wool price fluctuations had an adverse affect on the growth of the sheep industry and that wool users would prefer greater price stability. To contain price fluctuations a buffer fund was recommended by the Group; this scheme to be implemented by a Central Wool Marketing Authority which would appraise and then purchase wool at fixed within-season prices and sell it through auction.

The Group also found that prices paid to growers at auction obscured market premiums and discounts, disguised trends and resulted in inequalities as between growers of comparable types. However, the Group concluded that the auction system was the preferred method of disposal for the bulk of the clip.

Other recommendations were: a market intelligence service to advise the Authority on price setting and the introduction of standard wool types backed by objective measurement.

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6. The New Zealand Wool Marketing Study Group was established in December, 1964. It consisted of members of the New Zealand Wool Board and Wool Commission assisted by academics and members of the wool trade, and was charged with the task of investigating the causes and effects of wool price fluctuations and reporting on methods of wool marketing. The findings and recommendations of the Group are contained in: Wool Marketing Study Group, Final Report, Wellington, November, 1967.

The Study Group's proposals were subsequently examined by the Wool Marketing Committee,[7] which recommended that the Group's appraisal and purchase scheme should not be implemented at that stage (1968). While the Committee agreed with the Group's proposal, it felt that heavy grower support for the scheme was lacking and that the industry should be disturbed as little as possible until the Wool Commission's stockpile was disposed of. The committee did, however, recommend the introduction of standard types, the formation of a market intelligence service and the promotion of raw wool overseas.

The emphasis of the Study Group's investigations was on price fluctuations - causes, effects on growers and users, and alternative means of control. Other aspects of wool marketing were considered, but these received much less attention than the question of price fluctuations. A much broader evaluation of the wool marketing system was conducted by the Battelle Memorial Institute, who were engaged by the Wool Board in 1970.

The critical finding of Battelle was that "Wool was being severely threatened in its market place .... was not responding to the threats and the current marketing system was mainly responsible for this lack of response."[8] The Battelle report concluded that strong changes in the marketing system were necessary to increase the competitiveness of wool as an industrial fibre. On the basis of Battelle's findings, the Wool Board proposed the establishment of a Wool Marketing Corporation with broad powers to improve the marketing of New Zealand wool. The Corporation's objective, to obtain the maximum long term returns for wool growers by developing a marketing system suited to textile industry requirements and by reducing handling and distribution costs.

The Board's original plan left several alternative methods of sale open to growers, however, a later scheme recommended by the Wool Marketing Corporation Establishment Company, and adopted by the Wool Board, proposed total acquisition of the country's wool clip. This proposal immediately sparked off a heated controversy.

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7. The Wool Marketing Committee was set up in February, 1968 and consisted of members of the Wool Board and Wool Commission. The Committee received 40 submissions from interested parties and sought additional information on all aspects of the Wool Marketing Study Group's report through a working party. The recommendations of the committee are found in: Report of the Wool Marketing Committee, Wellington, November, 1968.

8. Battelle, Comumbus, Ohio; New Zealand Marketing - A Report to the New Zealand Wool Board, August, 1971.

Many growers strongly opposed the scheme and record wool prices during the 1972/73 season did not help to persuade them otherwise. However, in the face of considerable opposition, the Labour government stood by its election promise and went ahead with legislation to give the Corporation full powers of acquisition.

1.3.1 Evolution of the Wool Measurement Programme:

Following recommendations of the W.M.S.G., a Wool Measurement and Marketing Group was established in 1967 within the Wool Research Organisation of New Zealand (W.R.O.). The purpose of the Group was to develop and test techniques and instruments for high speed wool measurement and to demonstrate the practicability of national measurement; also to advise and assist with the implementation of the Study Group's proposals.

During the 1967/68 wool selling season, objective measurement of different trading types prepared and classified by brokers began. Ten major fleece types from 33 brokers in each of six wool selling centres were measured for each sale throughout the season. As over 50% of the national clip was binned or reclassed by wool brokers, they were the logical choice at the outset. Besides, whole staple sampling of farm classed wools would have been difficult and W.R.O. also wanted to use the programme to help brokers improve their wool preparation.

In the following season, all of the 43 brokers in the eight selling centres participated in the measurement programme. Twenty different wool types (i.e. bins) per broker were sampled and measured, representing nearly 20% of all broker-classed wool. The types were selected so as to cover all quality number ranges and most staple length categories made for fleece wool. Lambs wool, crutchings, pieces, necks and bellies were also measured in limited numbers. During the two subsequent seasons the number of bins sampled per broker was reduced to approximately half the number sampled in the 1968/69 season.

For each binned lot measurements of fibre diameter, staple length and yield were made and recorded. These were used to establish tentative standards of clip preparation for fibre diameter and staple length.[9]

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9. See : Agar, M.M.; "Objective Measurement and Sale by Sample in New Zealand and Australia", <u>Wool</u>, <u>5</u>:4, p.22, 1972/73.

1.4 WOOL MARKETING EFFICIENCY:

An efficient market is one which accurately reflects the current value of individual sale lots. In an efficient market, the current value fo sale lots would be well known and any unexplained price variation would be small.[10] However, there is ample evidence that the present wool auction system frequently fails to accurately translate the wool textile industry's quality requirements into price. Furthermore, random price fluctuations occur which obscure trends and eliminate premiums paid for special qualities of wool.[11]

The effect of random price fluctuations[12] within a single season is to obscure trends in the price differences between types and therefore make it difficult to gauge trends as they develop. The lack of consistency in prices for comparable types on a single day and the degree of price fluctuation between sales over a season means the growers of comparable types do not necessarily receive the same price.

Over the course of a single sale, random movements in the prices of individual lots of the same type obscure or eliminate market premiums for both grade and quality number. Consider the situation in a market where the price premium for classing is 4.0 cents per kilogram and the random price variation is 8.0 cents per kilogram. Nearly half of the well classed wool in such a market will receive prices that are equal to or less than prices paid for unclassed wool.[13]

"Thus, a grower who is attempting to improve his clip gets a very poor guide, in terms of prices received, as to the direction in which changes should be made. What is 'good' wool one year turns out to be 'bad' wool the next, simply because of fluctuating prices."[14]

The income of both growers and buyers is subject to some risk as a result of price variations in the market. Where a grower has only a few lots in a sale the price paid may vary over a significant range. From 2% to 10% of the price paid will be determined by chance, the magnitude of this random price variation will depend on the type of wool[15] and its impact on growers' income will depend on the number of lots sold.

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10. Whan, R.B.; "Opportunities for a Marketing Authority in the Australian Wool Market", Wool Tech. Sheep Breeding, 15:2, p.65, 1968.
11. W.M.S.G.; op.cit.
12. For a definition of price fluctuations see Chapter Two, Section 2.1.
13. Whan; op.cit.
14. Schroder, W.R.; "Manawatu Evening Standard", 25/6/72.
15. Whan; op.cit.

If, for example, 4% of a grower's total wool income is determined by chance price movement and the cost of producing wool is about 60% of average wool income, then the grower's profit margin will be subject to a 10% random variation. The risk of not receiving average market price is reduced as the number of lots offered for sale is increased.[16]

Buyer income is also subject to some risk in a market having variable prices. Misdescription of wool sent to clients is more likely as price variation increases and, where the description forms a part of a guarantee, then the buyer will have to meet claims. The risk is greatest in small consignments and is progressively reduced as the number of sale lots in a consignment is increased.[17]

The W.M.S.G. established that fluctuations in prices paid for wool at auction were detrimental to both the grower and user of raw wool.[18] The Group concluded that, in the past, wide fluctuations in farm income, which had resulted from unstable wool prices, had had an adverse affect on the growth of the sheep farming industry. First, because in periods of low income there had been insufficient funds to sustain the rates of investment of high income years, and, second, because current prices for farm products had greatly influenced both farmers' willingness to invest and commercial interests' to lend, farm development proceeded on a stop/go basis. Such development is inefficient compared to the continuous planned development that stable wool prices would encourage. It was also suggested that sharp fluctuations in wool prices had caused sheep farmers to unnecessarily diversify their production patterns.

From a survey of wool users, the Group established that changes in raw wool prices are important and that most firms wanted a greater degree of stability in the price of raw wool. Substitution of wool, by other wool or other fibres, occurs when raw wool prices change by more than 10% and once such substitution occurs it will, in many cases, be permanent.

In summary, it is clear that wool price fluctuations are large and are undesirable to growers, buyers and users of raw wool. Wide unpredictable price fluctuations not only obscure trends, eliminate market premiums and subject growers' and buyers' incomes to risk but also adversely affect demand from users, who have access to stable priced substitutes, and create an uncertain environment for farm development.

16. Whan, R.B.; "Wool Selling Strategy for the Woolgrower", Wool Tech. Sheep Breeding, 19:1, p.49, 1967.

17. ________ and Fourlinnie, J.P.; "The Consistency of a Buyer's Estimates of Yield of Greasy Wool", Quart.Rev.Agric.Econ., 21:1, p.21, 1968.

18. W.M.S.G.; op.cit.

Much of the inefficiency of the wool market (i.e. between 10% and 25%)[19] is due to the fact that subjective standards are used for appraisal, and that these standards are only loosely associated with the important textile properties of wool.

For example, at present (because they receive no other form of guidance) wool buyers pay higher prices for more highly crimped wools irrespective of their mean fibre diameter. Consequently, the grower can only endeavour to increase the crimp frequency of his wool in spite of the fact that crimps are relatively unimportant in processing.

Accumulated experience has given buyers a set of indicators that can be used in estimating wool value, but mistakes must be expected when buyers look at quality number when in fact they are interested in diameter, or consider the origin of wool when they want to describe fibre substance.[20]

This situation only serves to emphasize the need for objective measurement of important processing properties in wool marketing. The introduction of objective measurement would encourage the textile trade to pay for wool properties in correct proportion to their processing importance and would result in a more efficient marketing system, since valuations would be more accurate and not partly dependent on variations in subjective appraisal.

While the average payment to growers based on objective measurement may be unaltered, assuming that appraisal errors are symmetrically distributed (this assumption is later proven untrue; see Chapter Four), the equity of payment to individual growers would be improved.

It has also been suggested[21] that pre-sale testing would overcome problems of bale weight changes due to moisture and help to remove the discrimination of buyers against binned and blended wools. It is also apparent that the rationalisation of classing on the basis of known properties of the wool in a clip will enable the classer to prepare larger sale lots and also provide the wool grower with more definite objectives in his flock selection programmes.

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19. See Chapter Two, Section 2.4.1.

20. Whan, R.B.; "Wool Price Formation"; Wool Tech. Sheep Breeding, 11:2, p.33, 1964.

21. Mackay, B.H. and David, H.G.; "Some Problems of Sampling the Australian Wool Clip for Objective Appraisal", Wool Tech. Sheep Breeding, 12:1, p.58, 1965.

1.5 THESIS OBJECTIVES:

Measurement information covering three seasons: 1968/69, 1969/70, 1970/71, was made available by W.R.O. together with the brokers' subjective appraisals of the same lots. One buying firm's appraisals of these lots were also obtained. This provided quantities of data of an hitherto unprecedented size and the opportunity to analyse appraisals, measurement and binned wool prices on a scale not previously attempted.

This thesis analyses this data in an attempt to:

1. partition the sources of short term price variability in a particular mode of offering wool, namely binned wool, and determine the extent to which binned wool prices are explained by appraised and measured fleece characteristics, and

2. to examine the efficiency of the wool auction system, in terms of its ability to reflect the current value of sale lots and as a means of communication between the grower and the ultimate end user.

Such an analysis is not purely an academic exercise, since the greater understanding of wool price formation gained would, hopefully, enable growers to make better informed responses to buyers' requirements and suggest means whereby the efficiency of the auction system could be improved.

From the grower's point of view, the general factors influencing wool prices are important but he is more particularly interested in the relative economic importance of various fleece characteristics, since he can alter these characteristics by breeding and selection. The individual grower is also interested in what affect, if any, changes in demand will have on buyers' appraisals and subsequent valuations.

With appraisal and measurement data on the same lots it is possible to compare the brokers' and the buying firm's subjective appraisals with each other and with the equivalent measurement data. Such relationships not only affect the price the grower receives and the equity of income distribution among growers, but also the value of the information about his wool on which a grower has to base his production and marketing decisions.

In Australia, a substantial amount of work has been done which examines wool price formation, the causes and effects of price fluctuations and the relationship between the various wool characteristics.
Although much of this work applies equally well to New Zealand, there are basic difference between the New Zealand and Australia clips and auction systems. The Australian clip is finer and predominantly Merino while,

at auction, big and star lots (i.e. lots of less than five bales) are sold on different floors. This means that, while the general conclusions of these Australian studies apply in New Zealand, their specific results do not. In these Australian studies it has been shown, for example, that fleece characteristics have different economic values according to the type concerned and that the magnitude of random price variation also depends on type so that differences would be expected between the Australian and New Zealand situations.

Ross[22] has studied that characteristics of New Zealand crossbred wool and detailed the relationship between some of these characteristics. In the field of prices, the Wool Marketing Study Group has investigated New Zealand wool price levels and, in particular, wool price fluctuations in some depth.[23] However, the Study Group was concerned with wool prices in aggregate, i.e. at the average price level. Thus there is a gap in New Zealand wool price investigation at the within-sale, individual lot level. This thesis aims to concentrate on this area and, while some similar work has been carried out in Australia, it has certainly not been on the scale attempted here.

In general terms, the objective of this thesis is to investigate the factors influencing binned wool prices. The specific objectives are:-

(a) To isolate the sources of binned wool price variation and to determine the extent to which these are explained by appraised and measured characteristics.

(b) To determine the relative economic importance of greasy wool characteristics.

(c) To examine the relationships between appraisals and between appraised and measured characteristics.

(d) To investigate the impact of economic circumstances on appraisal.

(e) To examine the effect of objective measurement on the equity of income distribution among growers.

1.6 THESIS OUTLINE:

This thesis may be divided into three main sections.

The first contains an introduction to wool marketing and a review of the literature concerning wool price formation (Chapters One and Two). Following this is the analysis itself, which consists of two parts:

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22. Ross, D.A.; "New Zealand 48s Count Romney Crossbred Wool", N.Z.J. Agr.Res. 2: pp.214-228, 1959.

    __________; "The Relation of Count to Other Characteristics of New Zealand Wools", N.Z.J. Agr.Res. 7: pp.666-77, 1964.

23. W.M.S.G.; Submission Papers, No's 1,3,4,6, 1966.

the first (Chapter Three) concerned with the sources of binned wool price variation and the relative economic importance of wool characteristics; the second (Chapter Four) concerned with relationships between appraisals and between appraised and measured characteristics, the impact of economic circumstances on appraisal and the effect of objective measurement on the equity of income disposal among growers. In the third section (Chapter Five) the analysis is reviewed, conclusions are drawn and their practical implications discussed.

CHAPTER TWO

WOOL PRICE FORMATION, THE CAUSES OF PRICE FLUCTUATIONS AND THE EFFECT OF OBJECTIVE MEASUREMENT ON WOOL PRICES

2.1 INTRODUCTION:

Wool prices, and commodity prices in general, tend to fluctuate about a trend. A trend relates the interaction of demand and supply of the commodity concerned and the supply and price of its competitors, and is a persistent change in prices over a long period.

Superimposed on a trend are price movements which, in the short term, often obscure the direction of the trend. These deviations of prices from a trend, or price fluctuations, occur for particular types of wool and in the margins between types. Wool price fluctuations take place within a sale, between sales within a week, between sales within a season, or over a number of seasons.

A number of articles have examined wool price formation and the causes of wool price fluctuations. This chapter discusses these questions and reviews the literature concerned with wool prices and the factors affecting them.

2.2 WOOL PRICE FLUCTUATIONS:

The Wool Marketing Study Group made a detailed examination of movements in New Zealand wool prices over a thirteen-year period as part of its enquiry.[1]

The Group concluded that wool prices had tended to fluctuate more than prices of other fibres,[2] and that there had also been considerable fluctuation in the price margins for different types of wool. Over the course of a single season movements in wool prices also showed significant fluctuations, making it difficult for farmers to accurately gauge trends in the differentials between individual types of wool.

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1. Candler. W.V.; Fluctuations in the Price of N.Z. Wool 1952-1965, Submission Paper No.1, W.M.S.G., May, 1966.

   ______; Price Movements of New Zealand Wools and Related Futures, Tops and Yarn Prices 1952-1965, Submission Paper No.6, W.M.S.G., May, 1966

2. One has to be careful when comparing wool and synthetic prices that the correct wool prices are used. Synthetic prices should be compared with the buyer's selling price to the wool user - not the price the buyer pays at auction. The former price would be a lot more stable than the auction price (unless the buyer was buying on commission).

Prices paid for individual lots of the same type were subject to random fluctuations, which obscured the premiums and discounts offered for both grade and quality number.

Payne and Whan[3] have examined within-sale price variation in a study which tests the hypothesis that wool prices fluctuate randomly about a stable mean throughout the duration of a sale.

Variations in price due to the physical characteristics and presentation of the wool were eliminated by using price series for three individual types. The hypothesis, that wool price movements within sales are random, was tested by subjecting each series to an examination for the presence of serial correlation between successive price observations. The statistic applied to each price series was the von Neuman ratio, a correlation statistic which relates the mean square of successive price differences to the variance of the entire series.

The results indicate that it is unusual to find significant serial correlation between prices during a single sale. This suggests that the factors responsible for within-sale price movements behave in a random fashion.

If it is accepted that the price behaviour of the three types examined in this study are representative of other wool types, then the results have a significant bearing on statistical analysis of wool prices. A random movement of prices throughout a sale suggests that probabilistic models of an auction market, such as that developed by Whan and Richardson,[4] which are based on the assumption of randomness, have a practical application. Furthermore, these results support the use of regression and analysis of variance techniques in the examination of price variation within sales.

This study, in common with a number of wool price studies, assumes individual type classifications are homogeneous so that the variation in physical properties between lots is removed from price analyses. In fact, because wool classing is subjective and wool is so variable, wool types are not homogenous and there will always be an appraisal component in the price relationship between different types.

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3. Payne, R.A. and Whan, R.B.; "The Nature of Price Movements During Single Sales for Three Individual Wool Types Sold in Sydney," Aust.J.Agric.Econ., 15:2, p.95, 1971.

4. Whan, R.B. and Richardson, R.A.; "A Simulated Study of an Auction Market", Aust.J.Agric.Econ., 13:2, p.91, 1969.

To overcome this problem some researchers have split the lots of one classer's line in an effort to achieve experimental control by randomisation.

2.3 WOOL PRICE FORMATION AND THE CAUSES OF PRICE FLUCTUATIONS:

The price of raw wool is basically determined by its supply and demand conditions, but wool price formation is not the simple result of changes in the retail demand and the available supply of wool. The factors responsible for raw wool prices are numerous and varied; many are related to political and economic decisions that affect wool prices only indirectly while others are the direct expression of demand for wool products.

2.3.1 Long Term Trends:

The dominant part in wool price formation is played by macro - economic factors since they set the general, long term price trend, around which prices for individual lots vary according to other price formation factors.

Ultimately long term trends are the result of the interaction of these macro - economic influences, which are largely beyond the control of buyers and sellers and include: the level of world wool stocks, the level of consumer demand for woollen goods, competition from synthetic fibres, the bank rate, the availability of credit, and the many other unpredictable political and economic actions that affect the sale of wool.

In a background paper, submitted to the Wool Marketing Study Group, Philpott[5] suggested that long term trends in average wool prices were explained by changes in per capita real incomes in consuming countries relative to changes in per capita supplies of wool and wool type fibres.

The basic concept underlying Philpott's long term model[6] is that a period of from one to three years is too short for growers to adjust their production to the price of raw wool, but is long enough for final consumers to adjust their consumption of wool clothing.

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5. Philpott, B.P.; Analysis of Trends and Fluctuations in Wool Prices, Submission Paper No.3, W.M.S.G., May, 1966.

6. A full description of Philpott's long (and short) term model and its derivation is given in: Philpott, B.P.; Fluctuations in Wool Prices 1810-1963, Lincoln College A.E.R.U. Publication No.13, 1965.

Despite its limitations, the most serious of which is the use of moving averages on his data, Philpott's long term model does give some indication of the forces that had operated on wool price trends up until 1963/64. However, as Whan[7] points out, the factors that influence the general level of wool prices are numerous and varied, consequently a complete understanding of long run wool prices is a complex task.

2.3.2 Short Term Fluctuations:

In the short term, that is over periods of a single day up to a month or quarter, fluctuations in average wool prices are the result of changes in demand for raw wool by buyers[8] in relation to the supply of wool.

The essential difference between 'short' term and 'long' term with respect to wool prices lies in the demand for speculative stocks. In the short term the demand for wool is influenced by buyers' demand for speculative stocks which in turn is influenced by their expectations about future prices. For example, if wool prices are expected to rise in the immediate future, or if a rise in orders for textiles is expected, the trade would want to acquire and hold stocks of wool larger than those immediately necessary for current mill requirements. Any time period which is long enough to eliminate this speculative element from the demand for wool is considered long term.

Philpott[9] has suggested that, in the short run, average wool prices are determined by the supplies of wool placed on the market, in conjunction with the current rate of mill consumption and the state of the wool trade's expectations about the future.

Philpott's short run model assumes that both supply and mill consumption of wool in a period not longer than one year are independent of the price of raw wool. Rather it is the demand for speculative stocks which is responsible for most of the elasticity of demand for wool.

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7. Whan, R.B.; "Wool Price Formation", Wool Tech. Sheep Breeding, 11:2, p.29, 1964.

8. It should be pointed out that the wool buyer is not a perfect proxy for the processors he represents. What the buyer wants at an auction and what his principals, the processors, want is not necessarily the same thing. Buyers may blend or sort their auction lots, for example, to make up the processing lots that go to their principals. Thus buyers may hinder effective communication between wool growers and wool users.

9. Philpott; op.cit., 1965.

Philpott assumes that manufacturers' speculation regarding future movements in wool prices will be determined by expectations regarding future rate of mill consumption and supply of wool, and that these two variables are largely influenced by the present state of supply and demand for wool.

A serious defect of Philpott's model is the failure to define an equation for demand for speculative stocks. Although he repeatedly suggests that it is changes in stock policies which cause most of the variation in short term prices, all Philpott does is to reason some of the variables which could affect price in the short run and to argue that they can be regarded as exogenous.

Philpott's short run analysis was extended by McKenzie's[10] quarterly model of wool price formation, which applied Philpott's hypothesis to quarterly data. McKenzie also considered the possibility of seasonal shifts in demand for stocks and the influence of expected changes in mill consumption and supply.

Despite its limitations and the oversimplification inherent in any model of the formulation of expectations regarding future price levels, McKenzie's model was capable of explaining 90% of the variance in quarterly wool prices.

A survey of manufacturer's stock policies by the Wool Marketing Study Group[11] indicated that the level of orders and sales was a much more important determinant of the demand for stocks of raw wool than expectation of a change in raw wool prices.

The Group concluded that short term fluctuations in wool prices originate primarily from fluctuations in demand. Furthermore, fluctuations in demand are associated with cyclical changes in the level of consumption of raw wool by textile mills. These changes were a reflection of similar, but very much smaller, fluctuations in retail demand which were greatly magnified as they were transmitted back down the marketing chain to the mills.[12]

The Group was unable to specify how the changes in retail sales were transmitted to the changes in auction demand for wool. However, the general conclusion of their studies was that fluctuations in raw wool prices in the short run are related, in a complex way, to fluctuations in mill consumption, which in turn are determined by factors further up the marketing chain.

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10. McKenzie, C.J.; An Analysis of Short Term Fluctuations in Wool Prices, M.Agr.Sc.Thesis, Lincoln College, 1966.
11. New Zealand Wool Marketing Study Group; Final Report of the Wool Marketing Study Group, Wellington, November, 1967.
12. Philpott, B.P., Beggs, D.M. and Calder, M.W.; Cycles in British Wool Consumption, Submission Paper No.2, W.M.S.G., May, 1966.

The Wool Marketing Study Group's conclusion, that fluctuations in demand rather than changes in supply are responsible for fluctuations in short term wool prices, was supported by the results of a study by Yap.[13] Yap estimated the proportion of the total variability in wool prices which could be attributed to changes in demand for wool and concluded that this proportion ranged between 78% and 98%, depending on the elasticity of demand assumed.

Most short term models of price formation in the raw wool market have assumed that wool prices are a function of mill consumption, stocks and/or trade expectations. An alternative approach is that adopted by Hussey,[14] who has investigated the usefulness of leading indicator models in projecting short term movements in wool prices.

Hussey postulated that the general level of economic activity in the major wool consuming countries has some delayed effect on average Australian wool prices at auction. Accordingly a model was formulated which related quarterly wool prices and interest rates in seven major wool consuming countries. This model was able to account for over 90% of the variation in the wool price index over the past nine years and also to project this index four quarters ahead of the fitted period.

However, essentially Hussey's research has only quantified an interesting association between average Australian wool prices and interest rates in the main consuming countries. The largely heuristic approach adopted in the study has meant that, while it has been possible to formulate a reasonably strong statistical relationship, the structural nature of the relationship is unclear and further research in this direction is required.[15]

2.4 WITHIN-SALE PRICE FLUCTUATIONS:

The price of a single lot at an auction sale is affected first by general economic influences, which include those responsible for changes in short term supply and demand. However, assuming that these factors remain constant throughout any one particular sale, the price paid for a lot depends largely on the technical and physical properties of the lot.

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13. Yap, C.B.; A Study of Supply and Demand Effects on the Instability of Wool Price and Income, M.Agr.Sc. Thesis, Massey University, 1968.

14. Hussey, D.D.; "An Alternative Approach to Projecting Short Term Wool Prices", Quart.Rev.Agric.Econ., 25:2, p.175, 1972.

15. In fact this article is only an introductory report on one aspect of the econometric analysis being carried out by the B.A.E. at the time.

In addition, factors which have no direct connection with the technical or physical properties of the lot will also influence its price. These factors include those relating to wool presentation and are:-

(i) lot size;

(ii) method of classing;

(iii) district of origin;

(iv) time of selling.

Even when all these factors have been considered a small component of price still remains unexplained. It has been suggested that the factors which may account for this apparently unexplained residual are:

(i) the inconsistency of buyers' estimates of value;

(ii) differences in price limits between buyers;

(iii) variations in demand throughout the sale period.

2.4.1. Price Variation Due to Physical Differences Between Lots.

Wool buyers value lots by subjectively estimating the yield and type of each lot. Yield expresses the proportion of clean wool in a greasy sample; the type number given to a lot indicates its style,[16] fineness, length, vegetable matter fault and colour. Because of differences in the technical properties of different wool types, different prices are paid for them at auction.

Skinner[17] has demonstrated that the physical characteristics of wool which affect its processing performance have a significant bearing on the prices paid for different lots. Of the variation in clean prices within sales, he has shown that between 80%-90% is controlled by three variables : crimps per inch, colour and staple length. Crimps per inch is over three times more important in affecting prices than staple length or colour, which are approximately equal in this respect. These results confirm the conclusions drawn in an earlier analysis,[18] which showed that the price paid for Merino wools is overwhelmingly dependant on crimp frequency and, that staple length and colour have real, though very much smaller, effects in determining prices paid; and that soundness, handle and character give no additional information concerning price.

16. Style is a term used to categorise wool in relation to character (i.e. crimp definition), degree of vegetable matter contamination, weathering and degree of dust contamination.

17. Skinner, J.N.; "Some Factors Affecting the Clean Price of Greasy Wool", Aust.J.Agric.Econ., 9:2, p.176, 1965.

18. Dunlop, A.A. and Young, S.S.Y.; "Selection of Merino Sheep : An Analysis of the Relative Economic Weights Applicable to Some Wool Traits", Empire J.Exp.Agric., 28:111, p.201, 1960.

Similar conclusions were expressed by Paynter[19] who noted that the impact of fibre fineness on wool values is much more pronounced in the superior styles and between the finer counts. Although agreeing that colour and staple length are also important price determinants, Paynter contends that there is only a small clean price difference associated with length. Paynter also suggests that because of the yield advantage of coarser wools the influence of fibre fineness on greasy wool values is much less marked than in the instance of clean prices.

An important point to note about these studies is the failure of character (or crimp regularity and definition) to influence the price paid by the buyer. This is surprising considering the importance placed on this trait by breeders and wool classers. This finding supports earlier suggestions[20] that character may be unimportant.

It should also be pointed out that the conclusions of Skinner and Dunlop and Young's studies may have been influenced by the fact that the wools used did not show soundness or length abnormalities. Further, the conclusions reached in these studies are based on fleece wool only. It seems more than likely that similar differences in non-fleece wools would be reflected in smaller price changes.

In a later analysis[21] it was shown that no significant differences in clean price existed between free Merino fleeces and equivalent types containing up to 3% vegetable fault, although higher degrees of fault appeared to draw a discount.

These results suggest that buyers do not discount fleece wools containing up to 3% of fault, or that the additional processing costs they incur - and therefore the discount associated with these wools - are too small to be detected in the data analysed. However, for wools containing higher levels of fault the increased processing costs will be reflected in price discounts as compared to free skirting types.

It was also shown that price variation was higher for faulty wool Two factors are thought to be involved in this price variability. The first is buyer discrimination against some species of vegetable fault.

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19. Paynter, J.R.; "The Importance of Wool Style and Physical Fleece Characters as Determinants of Greasy Wool Values", Wool Tech. Sheep Breeding, 11:1, p.69, 1964.

20. Dunlop and Young; op.cit., p.204.

21. Webster, I.D. and Whan, R.B.; "The Effect of Vegetable Fault on the Clean Price Paid for Wool", Quart.Rev.Agric.Econ., 21:2, p.73, 1968.

Some species of fault are more expensive to remove than others (for example, long, thin grass seeds are more objectionable than small round seeds that fall out of the wool in the early stages of processing) but this analysis does not distinguish between the various species of fault and, therefore, any changes in species over a season would be reflected in additional price variability for the faulty types.

The second factor influencing the variability of prices paid for faulty types is the fact that the error associated with buyers' estimates of yield, and consequently the variability of their price limits, increases with increasing fault.

While clean price variation is dominated by fibre fineness (measured by count or crimp frequency) greasy wool prices are markedly influence by yield. According to Paynter,[22] for a sound, 3½ inch, 64's Merino, a buyer's estimate of an additional per cent of yield means an increase of approximately ¼ pence per pound geasy. (It should be clear, however, that this value is related to the general price level at the time of Paynter's study. For a higher price level, for example, an additional percent of yield would be worth more than ¼ pence per pound).

The contention, that most of the variation between prices paid for individual lots could be ascribed to yield, was tested by the Wool Marketing Study Group.[23] The percentage of the variance explained by yield differences varied from as little as 9% to as much as 53%. However, for most types, variation in yield accounted for 20%, but in only four instances was more than 33% of the variance in prices attributable to yield.

Although there is only a small clean price difference associated with length, length has a significant effect on greasy prices because of the strong association between yield and length.[24] McMahon[25] concludes that the small clean price disadvantage of longer wools is too small to compensate for the very strong effect which extra length has in giving greater fleece weights.

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22. Paynter; op.cit.

23. W.M.S.G.; op.cit.

24. In Chapter Four, Section 4.2.1, p.86 the correlation coefficient for the relationship between length and yield is calculated as, $r = 0.286$.

25. McMahon, P.R.; "A New Look at Wool Classing", Wool Tech. Sheep Breeding, 16:2, p.104, 1969.

To summarise: between 75% and 90% of the variation in prices for individual lots within a sale can be explained by the physical fleece characteristics yield, crimps per inch (quality number) staple length and colour.[26] The remaining 10% to 25% reflects the magnitude of the price variation between 'identical' lots (i.e. lots with the same appraised physical characteristics) in the same sale. This variation arises because factors other than the technical properties of wool determine the price paid at auction.

2.4.2 Price Variation Due to Factors Other Than the Physical Differences Between Lots:

The within-sale price variation for lots of the same type has been examined in some detail by several authors and a number of significant sources have been defined and isolated. These are:

(a) Lot size
(b) District of origin
(c) Time of selling
(d) Method of classing

(a) Lot size

Pierse and Beggs[27] have shown that small lots, and some very large lots, show a perceptible discount when sold at auction, They found that, irrespective of the mode of offering, very small lots (i.e. five bales or less) sold at a discount below the average price received for similar types sold in lots within the six to 25 bale range. Bins and interlots below eight bales showed a similar discount while, at the other end of the scale, lots of 26 bales and higher sold at a discount if offered binned, and a premium if offered reclassed or under a grower's own brand, Interlots showed a discount for lots of 51 bales and over.

Similar conclusions were expressed in a study by Whan,[28] which showed that big lots sold at auction in Australia bring a higher price than star lots.

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26. Assuming that the percentage of price variation explained by yield varies from 25% to 30%, and the percentage of clean price variation controlled by crimps per inch, colour and length from 80% to 90%, then the range of greasy price variation explained by these four fleece characters is 76% to 92%.

27. Pierse, H.L.M. and Beggs, D.M.; Analysis of the Distribution of Lot Sizes at New Zealand Greasy Wool Auctions, Submission Paper No.4, W.M.S.G., May, 1966.

28. Whan, R.B.; "Differences in the Prices Paid at Auction for Big and Star Lots of Wool Sold in Sydney", Quart.Rev.Agric.Econ., 19:4, p.186, 1966

(In Australia big lots contain five or more bales and star lots four bales or less). Like Pierse and Beggs, Whan could find no continuous relationship between the size of lots and the prices paid for them.

The magnitude of the discount for star lots estimated by Whan varied from year to year, however, and further evidence[29] suggested that it also varied from selling centre to selling centre. In a subsequent analysis[30] Whan confirmed that the magnitude of the price discounts on growers' brand star lots of the same type varied according to the centre in which the wool was sold. In some centres the size of the discount varied significantly from sale to sale; Whan suggested that this was due to differences in the proportion of star lots in the total offering but was unable to prove this contention.

Several attempts have been made to establish the factors determining the magnitude of the discount on star lots. Fourlinnie and Whan[31] demonstrated that unit marketing costs associated with both the buying and selling of wool at auction vary inversely with the number of bales in a sale lot. Some of the factors leading to higher buying costs per bale for small lots are: the longer inspection time required to value small lots; higher invoicing costs, increased sampling and the fact that small lots take longer to buy. It is for such reasons that star lots are claimed to be more expensive to buy and hence receive a discount compared to big lots.

In Australia, the most important distinction between big lots and star lots is that they are displayed on separate floors and sold in separate auction rooms. (In New Zealand all lots are displayed on the same floor and sold in the same room). In some instances, woolbuying firms allot the responsibility of valuing star lots to junior buyers and some of the smaller firms do not buy star lots at all.

Whan[32] suggests that this is part of the reason why star lots sell at a discount. Further, he suggests that when the sale offering is larger than usual or when the proportion of star lots is exceptionally high, the tendency is for star lots to be neglected in favour of big lots.

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29. Australian Wool Board; Report and Recommendations on Wool Marketing, III : pp.12, 35-36, 1967.

30. Whan, R.B.; "Factors influencing the Price Discounts on Star Lots of Wool", Quart.Rev.Agric.Econ., 21:3, p.158, 1968

31. Fourlinnie, J.P. and Whan, R.B.; "The Influence of the Size of Sale Lots of Wool on Wool Buyers' Costs", Quart.Rev.Agric.Econ., 20:3, p.154, 1967.

32. Whan, R.B.; Quart.Rev.Agric.Econ., 21:3, p.159, 1968.

Several of Whan's explanations for the effect of lot size on price were later confirmed by a subsequent study.[33] The basic findings of this study were that lot size had a significant influence on price. In general higher prices were paid for big lots than star lots, however, the size of the price differences was relatively small (less than one cent per pound clean in many cases.) The analysis indicated that within any given sale room no further distinction between lot size was made.

This study also revealed a relationship between the size of the price difference and the proportion of star lots in the total offering. A high proportion of star lots offered for sale was related to larger price discounts on star lots of the wool type considered. It was also observed that the price discount on star lots tended to be larger when the number of bales sold was high.

(b) District of Origin

In addition to the traditional standards used to estimate the value of wool, buyers also accumulate circumstantial information which they take into consideration. In particular, many buyers will purchase from only one centre for some of their clients, or in some cases, buyers will only be interested in wool grown in one area. Such relationships, between the origin of wool and its price, would explain the differences between centres in the average price paid for wool of the same type.

An Australian study by Whan[34] analysed the prices paid for a well defined wool type on the basis of the origins of the individual lots, and showed that differences exist in the average price paid for wool grown in different areas.

Whan suggests that a part of the explanation for the observed price differences between districts lies in differences in wool fibre substance, which in turn may be the result of differences in the effects of atmospheric influence on wool. For example, long exposure to sunshine in one area may produce a more resiliant fibre than that grown in another area. The physical differences between similar wools from different areas would not be directly apparent to the buyer and it is at this point that his past experience would have to play a part in his valuation and

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33. Payne, R.A., Rao, V.Y. and Whan, R.B.; A Study of the Effects of Lot Size and Time of Selling on the Price for Type 62A Wool Sold in Sydney Between 1964-65 and 1966-67, Research Bulletin, University of New England, Armidale, N.S.W., February, 1969.

34. Whan, R.B.; "The Effect of the District of Origin on Wool Prices", Aust.J.Agric.Econ., 9:1, p.67, 1965.

subsequent decision to purchase. Thus, Whan concludes, the differences in average prices between centres are due to the different proportions of offerings drawn from different climatic zones.

(c) Time of Selling

Australian work by Payne et al.[35] has revealed that time of selling affects clean prices paid for otherwise equivalent wools. Significant price differences were discovered between sales, and small price differences were observed between the days of a sale week, and even within a sale day.

Payne et al. used analysis of variance to isolate the effect of time of selling on the price of one particular wool type[36] over a three-year period at one selling centre. In an attempt to remove any exogenous influences on the relationship between time of selling and price, the prices used were clean prices for a free Merino type and only growers' brand big lots were considered.

It was demonstrated that a significant source of price variation existed between different sales within seasons. However, no discernable seasonal pattern of prices was observed, suggesting that the between-sale price variations for an individual type are dependent on the general market conditions prevailing at that particular time.

Payne et al. investigated the price variation within the days of a sale[37] to see if there was any difference between the two selling times (in each sale afternoon two brokers operate, each having approximately two hours to sell his wool). They concluded that there was a tendency for higher prices to be associated with the first selling on each sale afternoon, however, the differences in prices between the time periods for each sale were small (less than one cent per pound clean in most cases).

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35. Payne, Rao and Whan; op.cit.

36. Only one wool type was considered in this study; type 62A, an average spinners, best top making Merino wool, free of vegetable fault, with a quality number of 64/60's and a warp and half warp staple length. This is one of the major fleece wools sold in Sydney and the authors considered that there were sufficient bales of this type sold in the seasons included, to assume that their results were representative of the bulk of Merino wools sold in Sydney.

37. In most cases a sale lasts for four days and there are usually 18 sales per season in Sydney.

The authors could only suggest differences in the degree of competition as the cause behind this effect. They argued that buyers particularly interested in a type will have a tendency to buy it as early as possible, or, that buyers take more care or have more time when appraising lots to be sold first and are therefore more confident in their valuations and bid accordingly. These explanations are based on purely subjective reasoning, however.

In the long run (i.e. over a season) each broker is likely to be on a par with other brokers from the point of view of the time of selling since it is the general practice for a broker to sell first on a given day in one sale and second in the following sale, although the day on which he sells at each sale is completely random from one sale to the next. However, since an individual grower sells only once or twice a year, the equity of his returns may be influenced by this time of selling affect. In addition, the difference in price which has been shown to exist between the two time periods within a day, although small, indicates that false price messages are being given to growers.

At New Zealand selling centres, the order in which brokers sell is generally constant but in each sale the order is determined on a rotational basis. Thus if there are six brokers in a particular centre, A,B,C,D,E and F, and if A sells his wool first in the first sale of the season and F sells his last, then in the second sale F will sell first, A second and E last, and so on. In most cases New Zealand sales only last one day so that here there is also justification for assuming that the time of selling effect within sales, if it in fact occurs, will be the same for each broker in the long run. The non-random order in which brokers sell could perhaps give rise to some time of selling effect favouring a particular broker but it is difficult to conceive what this effect might be.

Variations in the price between the four days of each sale were also examined by Payne et al. and found to be significant in only two seasons (at the 5% level). A closer examination of the average prices received each day did not indicate that any particular day consistently yielded a higher price. Thus it would appear that any differences between the average prices between days which may occur are fortuitous and vary from one season to another.

Some evidence of an interaction effect of time of selling and levels of vegetable fault on Australian wool prices has been detected by Webster and Whan.[38] In a comparison of the price differences between equivalent Merino types with different levels of vegetable fault (at one selling centre, over one season), a significant interaction between the affects of time of selling and levels of vegetable fault was found in two of the 19 comparisons. For these two types the price differences changed from one in favour of the type containing vegetable fault in the early part of the season, to a peak discount in October or November, and then reverted to a premium for the faulty type in the latter part of the season.

A possible explanation offered for these price changes is related to a change in the species of vegetable fault contained in wool sold at different times of the year. Some species of burr are considered to be more expensive to remove than others and buyers will discriminate against these. This could account for the interactions detected in this analysis.

(d) Method of Classing

Since woolbuyers' estimates are based on the same properties of wool as those involved in wool-classing it could be expected that the task of the woolbuyer would be simplified by reducing the variability of these properties and thereby increasing the accuracy of estimation.

There is little evidence to test the proposition that mixed lots are more difficult to value than well classed lines.

Whan[39] reports one small experiment involving 11 mixed lots and 22 lots representing the classed components of the mixtures. The consistency of one appraiser's estimates of yield was similar for both mixed and classed lots. In the case of the mixed lots the error of yield estimation for individual lots was $\pm$ 1.0%, and for the classed lines the error was $\pm$1.2%. This small piece of evidence suggests that mixing does not affect the accuracy of buyers' estimates of yield.

When a number of buyers value lots, the buyer with the highest positive error will purchase the lot (assuming identical price limits). Thus, if mixing does increase the error inherent in valuation, the price paid for mixed lots is likely to be higher than the average of its classed components.

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38. Webster and Whan; op.cit.

39. Whan, R.B.; "Is Wool Classing Worthwhile?", Wool Tech. Sheep Breeding, 15:1, p.87, 1968.

There are two factors that would reduce the impact of this effect. The first is the possibility of reduced competition on mixed lots due to a lack of interest from some buyers; the second would be the imposition of a discount for mixing after the normal valuation had been determined. If there are diseconomics during processing as a result of mixing then it would be expected that either of these factors would operate in the market.

As part of their study of the economics of binning[40] (or bulk classing as it is called in Australia) the Australian Bureau of Agricultural Economics (B.A.E.) included a price comparison under different classing methods. Their results for four different types are set out in table 5 below.

TABLE 5

A Comparison of Prices Paid for Different Classing Methods

Types	Price difference between Growers' Brand and Binned Wools	Price difference between Growers' Brand and Inter-lotted Wools	Price difference between Inter-lotted and Binned Wools
62	+1.57N.S.	+1.39*	+0.18N.S.
78B	+3.26*	+2.98*	+0.28N.S.
148C	-	+3.90*	-
423	+2.29	+0.33N.S.	+1.96*

* Significantly different at 5% level. + Indicates that difference is in favour of first mentioned method.

Source: B.A.E.; op.cit.

From these results it was concluded that binned and interlotted wool generally obtain lower prices than growers' brand wool of the same type. There is also some evidence of a significant price difference in favour of interlotted wool as compared to binned wool.

The reasons suggested for this price advantage in favour of growers' brand wool are the difficulty of estimating the yield of lots containing wool from different origins and the effect of moisture on the weight of rehandled wool. Because of the difficulty of assessing the yield of a lot containing wool from mixed sources, the buyer will probably make a conservative estimate of yield. Some buyers also complain of the presence of a number of types of vegetable fault in binned wool. Similarly,

40. B.A.E.; Economics of Bulk Classing of Wool, Wool Economic Research Report No.2, August, 1960.

buyers also appear to make an allowance for extra moisture when assessing the yield of rehandled wool and generally discount their yield estimates by 2%-3% for this reason.

Pierse and Beggs[41] also compared different classing methods as part of their study of the distribution of lot sizes at New Zealand auctions. Lots of five bales and less and 26 bales and over were ignored since a significant lot size-mode of offering interation had already been revealed outside this range. They concluded that, for the 1964/65 season, reclassed, interlotted and growers' brand wool received premiums of 0.14, 0.10 and 0.06 pence per pound clean respectively over binned wool. However, Pierse and Beggs were only concerned with documenting these differences and offered no explanation as to their cause.

2.4.3 Unexplained Price Variation:

Although within-sale fluctuations in wool prices can be largely explained by differences in the physical properties of lots, lot size, method of classing and so on, with wool of the same type, lot size, classing, district of origin and sold virtually at the same time, small price variations still exist. This random variation in the price of identical lots has been estimated to range from 1.2 to 2.2 cents per pound.[42]

These estimates were based on the prices paid for pairs of sale lots, each pair being produced from a single classed line within a clip, displayed side by side in the sale and sold one immediately after the other. In a similar experiment,[43] the price differences between 'identical' lots were as high as 9.25 cents per pound, while the average difference was 1.8 cents per pound.

The level of this unexplained price variation has been studied by Willet and Whan[44] for particular types of wool during one week of Australian auction sales. The total price variation calculated in this study is the residual price variation left after variations due to district of origin and time of selling have been removed.

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41. Pierse and Beggs; op.cit.
42. Whan, R.B.; "Opportunities for a Marketing Authority in the Australian Wool Market", Wool Tech. Sheep Breeding, 15:2, p.65, 1968.
43. Whan; ibid.
44. Willet, Helen E. and Whan, R.B.; "Price Variation Within Wool Auction Sales", Quart.Rev.Agric.Econ., 22:2, p.66, 1969.

Willet and Whan construct the following model for the clean price paid for a particular lot of wool sold at a particular auction sale:

$$P_{ijklmn} = \frac{G_{ijklm}}{Y_n} = \text{a general mean} + T_i + L_j + C_k + D_l + S_m + W_{ijklmn}$$

where: P_{ijklmn} = the calculated clean price paid;

G_{ijklm} = the greasy price paid at auction;

Y_n = the yield estimated for the particular lot by an Australian Wool Board appraiser; n = 1... N lots;

T_i = effect of type of wool, i = 62, 62A, 62AB, 78 ...etc;

L_j = effect of lotsize; j = big or star lots;

C_k = effect of wool preparation or classing, k = grower's brand, bulk classed or interlotted wools;

D_l = effect of district or origin of wool; l = Western District of Victoria, Riverina....etc;

S_m = effect of time of sale for different selling centres; e.g. m = 1 of up to 18 sales in Sydney, where a sale series usually lasts for 3-4 days of one week;

W_{ijklmn} = residual term or error.

This statistical model identifies the factors affecting the price paid for a lot of wool at auction.

The study examines the variation of the residual term, W_{ijklmn}, which Willet and Whan call the 'residual price variation' and which they isolate by analysis of variance. The analysis is conducted separately for each particular type of wool, separately for big and star lots, and separately also for selling centres (three). To avoid differences due to method of classing, only grower-brand wools were included in the study. Hence the analysis permits the study of how the different wool types, lot size and selling seasons (two) affected the size of the residual price variation.

Measured as a coefficient of variation,[45] the residual price variation is generally about $\pm$ 4.0% of the price of wool and ranges from 11.9% to 1.7% for the types selected in the study. The residual price variation is higher for star lots than for big lots; is not generally

45. The coefficient of price variation is the ratio of the standard deviation divided by the mean price for the type and is usually expressed as a percentage.

related to the quality number; is higher for fleece wools of shorter staple length than for longer wools; is higher for lower styled fleece wools than for better styled fleece wools in two of the three selling centres; is higher for wools with a larger proportion of fault than for wools with up to 3% or free of fault; and is higher for skirting types than for fleece types.

It has been suggested that two likely sources of this unexplained price variation are variations in buyers' estimates of value; and variations in demand throughout the sale period.[46]

(a) Variation in buyers' estimates of value.

Potential buyers at a wool auction estimate the value of each sale lot based on the physical properties of the lot and a set of clean price limits specified by their principals. Using estimates of type and yield, these clean price limits are converted into greasy price limits, which represent the maximum price the buyers are prepared to pay for each lot. These greasy price limits then form the basis of the buyers' bidding during the sale.

Variations can and do occur in buyers' estimates of value on the same lots of wool. These variations reflect differences in buyers' estimation skill and in the bias of estimation, and occur because the properties of wool are subjectively appraised. An estimate of the value of the variance of valuations in the Australian wool market is 9.50 cents per pound greasy.[47]

If all the buyers in an auction sale have identical price limits, then the successful bidder will be the one whose estimate of value contains the largest positive error. The difference between the buyers' estimate of value and the price paid will vary according to the number of buyers in the market and the distribution of valuations. For a single lot, the price will be determined by the second highest valuation in the market, with the lot going to the bidder with the highest valuation, either at, or one bid above, the second highest valuation.

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46. Whan and Richardson; op.cit.

47. Whan and Richardson; ibid.

One source of variation in buyers' estimates of value arises from the fact that there is not a strong association between the physical features of the fleece used to determine value and the fibre properties important in processing.[48] This results in variability in the perceived importance of appraised characteristics in terms of their processing performance. Hence, two buyers can make the same appraisal of the physical characteristics of a lot, yet have different valuations because of differences in their assessment of the importance of these characteristics to their principals.

The second source of variation in buyers' estimates of value arises from errors in estimation of the properties of a lot. There is a strong evidence that, on individual lots, buyers' estimates of yield, fineness and length can be seriously in error.[49] What is more, their estimates of these qualities are not random but are often biased by other visual factors, which may penalise a particular grower or area. Buyers' estimates are also affected by physical factors such as fatigue, light conditions and the information contained in the sale catalogue.

This component of the variation in buyers' valuations has two aspects. First, the accuracy or trueness of estimation, that is, the ability of the buyer to make the correct estimates of yield and type. And, second, the consistency of buyers' estimates; that is the buyer's ability to give the same appraisal repeatedly for the same lots.

(i) <u>The accuracy of buyers' estimates</u>:

Considering this first aspect in terms of each of the important fleece characteristics in turn:

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48. The fact that the strength of association between fleece and staple features and the important textile properties of wool is, in most cases, weak has been established by a number of authors: Lang, W.R.; "Fibre Thickness, Crimp Frequency and Quality Number of Australian Wool", <u>Wool Tech. Sheep Breeding</u>, <u>8</u>:2, p.11, 1961; Paynter, J.R. and Whan, R.B.; "The Relationship Between Quality Number in Wool and Fibre Diameter Within Clips", <u>J.Text.Inst.</u> <u>58</u>:7, p.273, 1967; Ross, D.A.; "The Relation of Count to Other Characteristics of New Zealand Wools", <u>N.Z.J. Agric.Res.</u> <u>1</u>: p.666, 1964; Roberts, N.F. and Dunlop, A.A.; "Relations Between Crimp and Fineness in Australian Merinos", <u>Aust.J.Agric.Res.</u>, <u>8</u>:5, p.524, 1957.

49. Charlton, D.; "Purchasing Wool to Meet Micron Specifications", <u>Wool Tech. Sheep Breeding</u>, <u>12</u>:2, p.23, 1965; Whan, R.B. and Moffat, D.H.; "Some Differences Between Estimated and Tested Yields for Greasy Wool Sold in Australia", <u>J. Text.Inst.</u>, <u>59</u>:1, p.39,1968.

(a) The relationship between appraised yield and measured yield.

Along with clean usable fibre, greasy wool contains skin secretions, moisture, dirt and vegetable matter. The characteristics of wool important in processing are those of the clean wool. The clean wool content (i.e. the percentage of clean wool present in a bale or lot) is therefore of fundamental importance to the market value of greasy wool, although yield itself is not a 'characteristic'.

The ability of buyers and brokers to estimate the yield of greasy wool is based on past impressions gained by visual and tactile appraisal of wool. These impressions may be modified by the knowledge of the effect of certain districts of origin or climatic factors on the yield performance of wool.

The difference between estimated and tested yields for Australian greasy wool have been studied by Whan and Moffat.[50] For 122 free grown, fault free, Merino lots, Whan and Moffat compared the tested yields with a buyer's and valuers' estimates of yield.[51]

Comparisons between estimated and tested yields for lots of the same quality number revealed no significant difference between the average of the buyer's estimates and tested yield. This close agreement was confirmed by mill results. On the other hand, the average of valuers' yield estimates was 1.3% higher than the average of tested yields. Both sets of appraisals tended to under-estimate the yield of finer wools and over-estimate the broader types.

The variance of tested yields ($S^2 = 3.80$) was higher than for the buyer's estimates ($S^2 = 1.50$) and similar to that associated with the valuers' estimates of yield ($S^2 = 3.92$). This indicates that the buyer tends to confine his estimates of yield within a narrow range around the average yield for the type.

While the close agreement between the means of buyer's and valuers' estimates and tested yields ensured that mill expectations of yield were fulfilled, the correlation between estimated and tested yields for individual lots revealed a much less satisfactory relationship. These coefficients are a measure of the agreement between tested and estimated yields for individual lots, and in no case did the correlation coefficients differ from zero. This disagreement for individual lots indicates some inefficiency in subjective estimation methods.

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50. Whan and Moffat; op.cit.

51. In the New Zealand context, brokers would be in the same position as the valuers whose estimates are considered here. That is, appraisers who do not have close contact with the ultimate performance of the wool and whose experience ranges over many types of wool.

This lack of agreement for specific lots was examined in greater detail by comparing the distribution of the difference between the estimated and tested yields of individual lots with those obtained by substituting random numbers and random normal numbers for estimated yields.

When these distributions were examined, it was clear that the best-informed specialist estimator (i.e. the purchaser) also gave the best performance (i.e. the largest concentration of observations around zero difference.) The valuers, with a more general experience, were not as accurate, but their distribution of differences was significantly better than the 'no-skill' distributions generated from random normal numbers and random numbers. These observations illustrate that differences between estimates and tested yields are minimised by experience and a knowledge of the mill performance of specific purchases.

An interesting aspect of yield appraisal is reported by Mackay and David,[52] who investigated the distribution of appraised yield from Sydney buyers' figures. On close study, it was found that the frequency of occurrence of a yield denoted by an odd number was nearly always <u>less</u> than the frequency for the yields denoted by the even numbers on either side of it. There was, apparently, a preference by the appraisers for even numbers.

Appraisers can achieve a high level of accuracy when estimating yield averaged over a large number of lots. (If a buyer could not, competitive pressures would probably eliminate him from business). However, the degree of accuracy of subjective yield assessment on individual lots is not high. This is understandable because many relevant factors such as moisture content, types of dirt and dust contamination and vegetable matter contamination are not easily detected and make assessment difficult. There is also a natural tendency to under-estimate the amount by which particular wools differ from the general average and to under-estimate high yielding wools and over-estimate low yielding wools. These genetic and environmental details are largely unknown to buyers or brokers and, in the absence of specific tests, the absolute value for the yield of individual lots will not be known.

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52. Mackay, B.H. and David, H.G.; "Some Problems of Sampling the Australian Wool Clip for Objective Appraisal", <u>Wool Tech. Sheep Breeding</u>, <u>12</u>:1, p.57, 1965.

It is now common for buyers to deliver wool with a guaranteed yield, and any over-estimate on the buyer's part may become the basis of a claim. The risk of over-yielding will be minimised as the consignment becomes larger and includes wool grown under different environmental conditions. Consignments containing one or two sale lots would have a high probability of yield error. Whereas the costs arising from low- and high-yielding wools cancel each other out for the manufacturer, the position for the buyer is such that there is a 'risk' cost associated with over-yielding. This is a marketing cost that may be minimised by yield testing.

From the wool grower's point of view, Whan and Moffat[53] conclude ".... there will be a loss in income when buyers under-estimate yields and an income gain when they over-estimate. Since the environmental and genetic factors influencing yield will affect the whole clip, the entire income of individual growers will be altered according to the direction of the yield bias. Furthermore, it is likely that the bias will be consistent from season to season. The sum of all growers' incomes is probably unaffected by these errors in yield, but it is clear that the equity of income distribution among growers can be disturbed."

(b) The relationship between quality number and fibre diameter.

Quality number[54] is an arbitrarly designated series of numbers, related to the spinning ability of greasy wool and determined principally by fibre fineness. Originally, the numbers were related to the limiting number of hanks of worsted yarn (one hank = 560 yards) which could be spun from one pound of top. Today few, if any, wools are actually spun to their limits so quality number is something of a misnomer. To add a little to the confusion, the term is defined in relation to worsted manufacture but is applied indiscriminantly to both woollen and worsted raw material.

The technical importance of fibre diameter in textile manufacturing is well established.[55] Research has shown diameter to be the most significant factor in determining the physical characteristics of the

53. Whan and Moffat; op.cit.

54. Sometimes referred to as 'count'. However, the term 'count' should, strictly speaking, be confined to a yarn.

55. Bastawisy, A.D., Onions, W.J. and Townend, P.P.; "Some Relationships Between the Properties of Fibres and Their Behaviour in Spinning", J.Text.Inst., 57:7, T1, 1961; Roberts, N.F.; "The Effect of Fibre Thickness, Length and Crimp on Worsted Spinning Limits. Yarn Irregularity and Handle; Wool Tech. Sheep Breeding, 8:2, p.27, 1961.

finished fabric. Spinning limits and yarn regularity are directly and heavily dependent on the mean fibre diameter of wool, as is the handle or softness to touch.

The importance of quality number stems from its traditional use as an indicator of fibre diameter and this is the standard that classers brokers and buyers use to estimate fibre diameter. This estimate of fineness is broadly based on the frequency of crimps in the staple which in turn, is related to fibre diameter.[56]

The assumption, that there is a strong inverse association between quality number (or staple crimp frequency) and fibre diameter, has been examined on a number of occasions.[57] It has been shown that this relationship is poor and variable; some factors which affect it are the environment, the age, the strain or breed of sheep and the general nutritional level of sheep.[58] Crimp, and hence quality number, is not a good estimate of fibre diameter and many wools with a similar number of crimps per inch have widely differing fibre diameters.

Whan and Paynter[59] concluded that 48% of the variation in fibre diameter within flocks is associated with differences in appraised quality number. Further estimates, by the B.A.E.,[60] of the variation in fibre diameter accounted for by differences in quality number were 38% and 64% , and, in this analysis the coefficients of determination[61] for the relationship between quality number and fibre diameter for two sets of appraisals were 0.76 and 0.77.[62]

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56. Lang, W.R.; "The Dependence of Wool Quality Number on Crimp and Fineness in Australian Wool", J.Text.Inst., 38:T257, 1947.

57. Lang, W.R.; "The Crimp-Fineness Relationship in Australian Merino Wool", J.Text.Inst., 38: T241, 1947; ———; J.Text.Inst., 38: T257, 1947; ———; Wool Tech. Sheep Breeding, 8:2, p.11, 1961; Ross; op.cit.; Whan and Paynter; op.cit.

58. Roberts and Dunlop; op.cit.

59. Whan and Paynter; op.cit.

60. B.A.E.; The Economics of Wool Classing, Wool Economic Research Report, No.21, p.17, 1970.

61. The square of the correlation coefficient, the coefficient of determination, is equal to the proportion of the Y variance explained by the linear influence of X.

62. See Chapter Four, Section 4.2.1.

These results conflict with those given by Lang[63] and Skinner;[64] in fact the latter found no association between quality number and fibre diameter in a fine Merino clip. Whan[65] suggests that the reason for this disagreement could be due to the fact that Skinner's results were drawn from a super spinners clip and that quality number may be a poor guide to average fibre diameter in finer wools. However, for New Zealand Merino and Halfbred wools, Ross[66] reports the correlation between count and diameter as -0.919. Similarly, for New Zealand crossbred wools and all wools Ross's correlation coefficients were high (i.e. -0.631 and -0.950 respectively.)

However, Ross's results were based on appraisals of auction lots as opposed to the Australian practice of using individual fleece samples and this could explain some of the difference. Furthermore, comparing Ross's results with similar results for Australian wool, Charlton[67] concludes that, for the same crossbred quality number, New Zealand wools have a broader fibre diameter than Australian wools. This difference is quite marked at the strong end of the crossbred range.

According to Ross,[68] the regression line representing the change of diameter with count is much steeper for fine wools than coarse wools; the difference between successive counts being 3.11 microns for fine wools and only 1.27 microns for coarse wools.

Charlton[69] also reports differences in the diameter-quality number relationship between some Australian selling centres. These differences can be explained by considering the type of wool sold in each centre and the strain of Merino producing the wool. Significant between-centre differences in the diameter-quality number relationship were also observed in this analysis, thus confirming Charlton's Australian observation for the New Zealand situation.[70] This lack of uniformity between centres, not to mention on the international level, emphasises the severe disadvantages of assessing fibre diameter by quality number.

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63. Lang, W.R.; J.Text.Inst., 38: T241, 1947.
64. Skinner, J.N.; "Some Factors Affecting the Clean Price of Greasy Wool", Aust.J.Agric.Econ., 9:2, p.176, 1965.
65. Whan, R.B.; Wool Tech. Sheep Breeding, 11:2, p.29, 1964.
66. Ross; op.cit.
67. Charlton; op.cit.
68. Ross; op.cit.
69. Charlton; op.cit.
70. See Chapter Four, Section 4.2.1.

The observation, that there is a satisfactory relationship between quality number and average fibre diameter in mill blends, is supported by Lang[71] and Roberts and Dunlop.[72] Clearly this situation is satisfactory enough for the users of wool, but the fact that crimp, and hence, quality number is, in individual cases, a poor guide to diameter, means that the equity of income distribution among wool growers can be badly astray.

The grower producing wool finer than its quality number suggests will be penalised, while wool coarser than its quality number indicates will be over priced. Roberts and Dunlop[73] have shown that price differences of 20% or more are common for clips having the same mean diameter but widely differing crimps. In addition, there is divergence in the average-diameter/quality number relationship between selling centres and on an international level due to the particular types of wool sold in each centre or grown in each country.

The use of quality number as a means of classifying wools of different average fibre diameters is clearly subject to some reservations.

(c) The relationship between staple length and fibre length.

Average staple length (together with staple length variation and soundness) is used as a guide to the average fibre length in the top to be produced. Fibre length in tops is of major technical importance in combing and worsted spinning sections of the textile industry. Average fibre length determines strength, fineness and appearance of yarn spun from top, and the dividing line between combing and carding types is determined by length.[74]

The assumption, that staple length is a satisfactory estimator for the average fibre length of the resultant top, is not well justified. This is because:

(a) considerable fibre breakage occurs in the top making process, and

(b) the strength of association between staple length and the length of the constituent fibres is weak.

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71. Lang, W.R.; J.Text.Inst., 38: T241, 1947.

72. Roberts and Dunlop; op.cit.

73. Roberts and Dunlop; ibid.

74. Roberts; op.cit.; Paynter, J.R.; "The Importance of Wool Style and Physical Fleece Characters as Determinants of Greasy Wool Values", Wool Tech. Sheep Breeding, 11:1, p.69, 1964.

Staple length is affected by the degree of fibre crimp and the restraint placed on the longer fibres by the shorter fibres in the staple. The average length of the individual fibres, when straightened, usually exceeds the length of the straightened staple.[75]

Whan[76] reports that the ratio of average fibre length to staple length has been found to range from 0.87 ± 0.08 to 1.46 ± 0.05; the standard deviation of these tests range from ± 0.05 to ± 0.21. Some factors that may influence this ratio are the age, strain or breed of sheep and the number of fibres grown per unit area of skin.

In another small trial carried out to obtain an estimate of the strength of association between staple length and average fibre length it was concluded that staple length accounted for only 46% of the average fibre length variation of staples.[77] The range of correlation coefficients for five lines of 58's to 60's combing wool was from 0.58 to 0.71.

In terms of the wool market, it is clear that the use of staple length as a guide to average fibre length can be quite unreliable. The error can range from -13.0% to 46.0% of the staple length.[78] This type of variation raises the question of the validity of staple length as a classing and valuing standard. Indeed the lack of a strong association between staple length and average fibre length, coupled with the high variability of fibre lengths within staples (i.e. up to 15.5%), suggests that the tolerance of textile machinery for length variation may be higher than is generally acknowledged.

However, even though the association between staple length and fibre length is not strong, staple length is the only practical measure available to the broker and the buyer for estimating fibre length. Thus, it will continue to be used as a value determining parameter.

(ii) The consistency of buyers' estimates

The second aspect of errors in estimation, the consistency of buyers' estimates, has been investigated by a number of authors.

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75. B.A.E.; op.cit., 1970.
76. Whan, R.B.; Wool Tech. Sheep Breeding, 15:1, p.87, 1968.
77. B.A.E.; op.cit., p.21, 1970.
78. Whan, R.B.; Wool Tech. Sheep Breeding, 15:1, p.90, 1968.

Douglas, Whan and Willet[79] determined the consistency and accuracy of yield, type and price estimates for each of six appraisers employed by a large Australian wool-buying firm. Two sets of estimates were obtained from each of the appraisers for each of several sale lots. The wools appraised were both fleece and skirtings of topmaking style and showing varying vegetable fault.

A simple one-way analysis of variance was used to isolate the component of variation due to differences between lots, σ_L^2, and a residual component that reflects the accuracy of the appraiser's estimates, σ_e^2. The consistency of the individual appraiser's estimates is expressed in the form of an intra-class correlation coefficient, R_I, where:

$$R_I = \frac{\sigma_L^2}{\sigma_e^2 + \sigma_L^2}$$

A value of 1.0 for this coefficient indicates that the appraiser's error of estimation is zero, i.e. $\sigma_e^2 \rightarrow 0$ or, in other words, that the appraiser's estimate accounts for all of the variation in that particular characteristic.

The value of the intra-class correlation coefficient as a measure of consistency can be illustrated by assuming that an appraiser has an error of $\pm$ 2.0 cents per pound. Clearly this appraiser will be more consistent in detecting price differences in a population ranging over, say, $\pm$ 25.0 cents than in a population having prices in the range $\pm$ 2.0 cents. Thus, the intra-class correlation coefficient provides a measure of the appraiser's relative performance in relation to the wool he has to value.

The accuracy of estimation is expressed by the standard deviation of the appraiser's repeat estimates on the same lots of wool. However, this is not an absolute measure of accuracy since a consistent bias in an appraiser's estimates could mean that, while the standard deviation of his estimates was low, the difference between appraised characteristics and their measured counterparts was relatively high.

(b) Variations in demand throughout the sale period

The number of bidders does not remain constant throughout a sale period. Order sizes vary and consequently the time required to fill orders will also vary. Buyers will withdraw from bidding as their orders

79. Douglas, S.A.S., Whan, R.B. and Willet, Helen E.; "The Consistency of the Valuations of Greasy Wool by Six Appraisers in a Wool-Buying Firm", J.Text.Inst., 61:3, p.108, 1970.

are filled or simply to balance purchases against orders. In other cases, a buyer may employ a strategy that requires temporary withdrawal from the market or will enter the sale as new orders are received. Such variations in demand produce many inexplicable price movements throughout a sale.

Whan and Richardson[80] have developed a simulation model of an auction market showing the relationship between the variation in valuations, the price variation and the number of independent bidders in the market. The only assumptions in this model are that all the variables incorporated in the model are normally distributed and that lots of the same type are identical. The model is:

$$N_B = 0.53\ [(S_v + \overline{P} - \overline{V})/S_p^2]$$

where N_B = the number of independent buyers in the market;

$\overline{P}$ = the average price paid in cents per pound;

$\overline{V}$ = the average valuation in cents per pound;

S_p = the standard deviation of prices paid for individual lots in cents per pound;

$S_v = (S^2_B + S^2_e + S^2_L)^{\frac{1}{2}}$

S^2_B = the variances of a single bidder's estimates of value on identical sale lots;

S^2_e = the variance of different bidders' estimates on identical sale lots with the same price limits;

S^2_L = the variance of price limits between bidders for the same lots.

From a practical point of view there are problems in estimating $\overline{V}$, S_p and the components of variance of S^2_v. However, Whan and Richardson make approximations of these and their values give an estimate of $N_B = 11$ as the average number of bidders at wool auction sales in Australia.

This model has several important implications for wool marketing. A reduction in the value of S_v (the standard deviation of valuations) has a marked effect on the competition required to produce a predetermined value of S_p (the standard deviation of prices paid) or $\overline{P} - \overline{V}$. The introduction of objective measurement as a basis for selling wool would have the effect of reducing the value of S_v. This in turn would reduce the number of bidders required to maintain a constant variation of prices paid or, alternatively, reduce price variation and/or increase average prices paid with the same number of buyers.

80. Whan and Richardson; op.cit.

In view of the general tendency for woolbuyers to use the average prices paid at a previous sale as a basis for valuation, long term stability of prices will be achieved when $\overline{P} - \overline{V} = \overline{P}n - \overline{P}(n-1) = 0$. This condition occurs when: $\Delta p = 1.88 \log N_B - 1.033 = 0$ (where $\Delta p = (\overline{P} - \overline{V})/S_v$), i.e. $N_B = 3.5$ buyers.

The implication of this in practice is that an auction held with less than four bidders does not provide enough competition to force buyers to pay their predetermined valuation. Under these conditions the average price paid, $\overline{P}n$, will be less than $\overline{P}(n-1)$ and, in the longer term, prices will fall. When there are four or more bidders in the auction $\overline{P}n$ will be greater than $\overline{P}(n-1)$ and prices in the long term will rise.

The refinement of the relationships set out in this paper may provide both buyers and sellers with useful indicators of the strength of competition in the market. A seller could base his decision to sell on both a reserve price and the strength of competition. A bidder may be able to use the shift between average valuations and average prices to estimate optimal price limits (i.e. those price limits that would allow the bidder to fill all orders at the minimum price).

A Wool Marketing Authority, such as the New Zealand Wool Marketing Corporation, could base its buying and selling operations on the level of competition in the market. It may be sufficient for the authority to bid in the market when there are only two or three bidders operating. Any intevention at that point would have the short term effect of stabilising prices and maximising returns to growers by preventing a fall in prices. The short-term price reductions produced by the Authority's selling operations would be minimised if selling was only carried out when a large number of bidders were active in the market (i.e. say 10 or more).

The major criticism of the model presented in this paper is the assumption that individual type classifications are homogenous with respect to their important commercial properties. As Whan and Richardson themselves point out, the classification of sale lots by type will be subject to the same errors as are inherent in the estimation of greasy price limits. Differences in the homogeneity of sale lots classified as 'identical' would increase the size of S_e and S_B and hence S_v.

2.5 PRICE FORMATION AND BINNED WOOL:

In practice the woolclasser has two conflicting objectives; one is to build uniform lines, the other is to produce large lots (i.e. six bales or more) which are of sufficient size to attract full competition. The conflict arises because wool is an extremely variable material. No two fleeces are exactly alike; indeed no two staples are alike. This variation means that the classer has to establish limits of tolerance in his classing standards that are both acceptable to the buyer and in accord with the volume of wool to be classed. The larger the volume of wool to be classed the narrower the practical limits of tolerance (other things being equal).

Within clips the volume of wool available for classing is much smaller than that available within a broker's store for classing into binned lines. It might be expected, therefore, that the limits of classing tolerance for growers' brand lots would generally be wider than for comparable binned lots, and that binned lots would tend to be less variable than growers' lots. However, an individual clip is likely to be more homogeneous to begin with, than the wool from a number of sources which is available for binning.

In fact it has been shown that practices such as binning, blending and mill sorting are more likely to increase rather than decrease variation within lots.[81] For example, wool having the same crimp frequency but grown in different flocks often has large variations in average fibre diameter. Consequently, tops made from unclassed clips from an individual flock are likely to be more uniform for fibre diameter than tops made from wool grown in different flocks matched for crimp frequency.[82]

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81. Whan, R.B.; "Potential Savings from the Sale of Wool by Sample and Measurement", Quart.Rev.Agric.Econ., 24:4, p.208, 1971.

82. Complete homogeneity is not necessarily always desirable and yarn production can in fact suffer when tops are too uniform with respect to length for example. A difficulty also arises in the definition of uniformity in wool as there are no generally recognised limits of tolerance allowable in uniform lots. This inability to define uniformity of wool stems partly from the fact that the standards used to measure the value of wool are only loosely associated with the fibre properties important in manufacture. The result is that individual mills have their own concepts of uniformity, and these may not necessarily agree with those of the classers.

Buyers express a preference for even lines over comparable mixed lines, since it is more difficult to estimate the value of a mixed line. As a result the valuations placed on binned lots are usually more conservative than those placed on other lots.[83]

In practice, therefore, binned lots sell at a discount compared to growers' lots and, in fact, there is a significant price difference in favour of all modes of offering as compared to binned wool.[84] Apparently the between-farm component of variability in binned lots is high enough to out weigh the effect of a greater volume of wool in the broker's store. That is, while the broker has more fleeces to select from, because individual clips vary so widely, his tolerance limits for binned wool have to be wider, not narrower, than for growers' lines. It has also been suggested that buyers discount binned wool because of the effect of moisture on rehandled wool and the difficulty of estimating yields of wool from different origins.

2.6 THE EFFECT OF OBJECTIVE MEASUREMENT ON GREASY WOOL PRICES:

A series of price comparisons have been carried out by the B.A.E.,[85] to estimate the return to the Australian wool industry from a system of marketing based on measured fibre diameter rather than quality number. The average fibre diameter was measured for each of 1,527 sale lots purchased by one buyer. In all cases the appraised quality number of the sale lots was the basis for the price paid at auction.

It was found that the return from tops made from mill batches of uniform fibre diameter was higher than those based on quality number. The difference ranged from 7.4 to 0.9 cents per pound clean. Such price differences will vary according to the distribution of fibre diameters within quality number groups and market price relationships.

Two further Australian studies have examined the effect of pre-sale testing of lots on wool prices. The first, a pilot trial reported by Douglas and Whan,[86] compared the auction prices for tested and untested lots of similar wools from one particular clip, where fibre measurement had indicated that the wool was finer than the visual estimates had suggested and where, as a consequence, tested wool sold for a premium over untested wool.

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83. B.A.E.; op.cit., p.16, 1960.

84. This has been discussed previously in this chapter. See Section 2.4.2, p.29.

85. B.A.E.; op.cit., p.19, 1970.

86. Douglas, S.A.S. and Whan, R.B.; A Pilot Study of Pre-Sale Testing of Greasy Wool, B.A.E. Occasional Paper No.1, 1969.

The second study, conducted by Tier and Shepherd[87] included wool from an additional 13 clips, which were selected to include at least some clips believed to have wool of thicker mean fibre diameter than indicated by visual estimates. Because sample lots were drawn from different strains of sheep and included different wools it was possible to explore the affect of these factors on the incidence of premiums or discounts.

A total of 100 comparisons was made between prices received for tested and untested lots of wool. In aggregate there was a statistically significant premium of 1.32 cents per pound (2.9 cents per kilo) greasy for tested wool over untested.

The size of the premium, however, varied considerably. It had a standard deviation of ± 3.0 cents per pound greasy and extreme values of 12.12 cents in favour of tested wool and 6.50 cents in favour of untested wool were encountered.

The source of this premium was then investigated by Tier and Shepherd. Different premiums were noted for different clips, and all but one clip showed a price premium for testing. Similarly the level of the premium differed significantly between different strains of wool and between wool groups, with the latter appearing to be associated with the major part of the observed premium. In particular hogget wools were shown to exhibit significantly greater premiums than other groups (adult or skirtings).

These premiums were shown to emerge primarily as a result of two factors.[88]

(i) a constant marking up of price for wool which has been tested, and

(ii) a revision of buyers' appraisals of fibre diameter and yield.

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87. Tier, T.J. and Shepherd, M.A.; "An Analysis of the Price Premium Paid for Pre-Sale Tested Greasy Wool", Quart.Rev.Agric.Econ., 15:1, p.50, 1972.

88. From the design of the experiment, the only identifiable reasons which could have given rise to the observed premium were associated with the provision of the test certificate results. To test this proposition, the relationship between the size of the premium and the differences between tested and appraised values of fibre diameter and yield were investigated.

A functional relationship was estimated in which the dependent variable, the price premium, was expressed in terms of its linear relationship with the difference between tested and appraised fibre diameter and the difference between tested and appraised yield. The following result was obtained:

Premium = 1.213 - 2.387 (tested minus appraised fibre diameter) + 0.346 (tested minus appraised yield).

Degrees of freedom corrected $R^2 = 0.47$; $d = 1.35$.

The constant component of the premium is thought to have arisen from the provision of more accurate information to buyers before purchase, with a consequent reduction in buying risk. This could be expected to lower buying costs (for example 'claims' for not matching order specifications) and, consequently, may lead to some increase in the price paid for wool at auction. This factor appears to offer a plausible explanation for the observed constant component of the premium.

Further to this risk reducing element, pre-sale testing may, when it becomes more common, lead to some additional increase in auction prices for wool owing to a transfer of the cost of testing to the grower. At present a large part of the total clip is tested by the buyer before shipment. The cost of this testing is a buyer expense and must therefore be deducted from the price limit used by him in the auction room. Pre-sale testing, when practised on a wider scale, would eliminate the need for much post-sale testing, in which case the cost of buyer testing could logically be expected to be added to the buyer's price limit.

Buyer adjustment of valuation in response to differences between buyers' appraisal and tested values for fibre diameter and yield appears to explain much of the variation in the premium paid. Fibre diameter adjustments were shown to have the greater influence; most wools which had large premiums/discounts also had large appraisal/test fibre diameter differences. The adjustment of buyers' valuations was found to vary significantly between different wool groups. Buyers were apparently more responsive to test/appraisal differences in hogget wools than in either skirtings or adult wools.

As more testing is done prior to sale, the impact of these factors in leading to a premium for tested wool may decline owing to the correction of bias in visual appraisal. Tier and Shepherd in fact found some evidence that this had already occurred for hogget wools where, over the period of the trial, the premium for tested hogget wool tended to fall as buyers adjusted their apparently consistent under-estimates of fibre diameter. However, the constant value associated with the price premium can be expected to increase as more testing is done before sale and buyers are able to amalgamate complete mill consignments on the basis of test certificates.

CHAPTER THREE

SOURCES OF WOOL PRICE VARIATION AND THE RELATIVE ECONOMIC IMPORTANCE OF GREASY WOOL CHARACTERISTICS

3.1 INTRODUCTION:

In this chapter a detailed discussion of the methodology and results of two of the five sections of this analysis is given. The two sections concerned, each dealing with one of the major objectives of this thesis, are:

SECTION 3.2: Partitioning of the sources of binned wool price variation over time and determination of the extent to which these prices are explained by appraised and measured characteristics.

SECTION 3.3: Determination of the relative economic importance of greasy wool characteristics.

At the beginning of each section a brief outline of the section is given. This is followed by a full discussion of the analysis concerned.

Before discussing this analysis in detail it may be helpful to the reader to repeat the nature of the information used. For approximately 8,500 binned lots over three seasons, 1968/69, 1969/70, 1970/71, the following data was obtained: sale price, measured yield, fibre diameter, staple length and staple length standard deviation; brokers' appraisals of yield, quality number and staple length class and a buying firm's appraisals of the same characteristics. In fact, it was not possible to collect a complete set of data for all lots; therefore, in some analyses, the number of lots used was less than 8,500.

For convenience, the buying firm is referred to as 'the buyers' in parts of this and the following chapter. It should, however, be remembered that 'the buyers' or 'the buying firm' refers to a number of appraisers whose estimates may or may not be the same as those of the actual buyers who in fact purchased the lots.

3.2 SOURCES OF BINNED WOOL PRICE VARIATION:

Outline:

(i) The sources of binned wool price variation were isolated by factorial analysis, and then recombined into an hierarchial analysis of variance model expressing the variance of binned wool prices in terms of:

Between types
Within-types between-seasons
Within-seasons between-centres
Within-centres between-sales
Within-sales between-lots

(ii) The within-sale between-lot source of price variation was then explored in terms of the extent to which it was explained by each group of appraisers separately and the measured information. This involved regression of the appraisal and measurement data on the deviation of sale price from the monthly average price.

(iii) By obtaining estimated prices for the two groups of appraisers from regression, it was then possible to add a further source to (i) above. That is, the source of variation within-types between-appraisers.

3.2.1 Hierarchial Analysis of Variance of Binned Wool Prices:

Using five buying-firm wool types, a factorial analysis of the variance of clean, binned wool prices was carried out with seasons, centres, sales and types being treated as different factors. The relevant sums of squares were then recombined to produce three hierarchial analysis of variance (ANOVA) models, expressing clean price variation in terms of different combinations of these factors.

The five wool types used were:

Type	Description
1.	50's, good average topmaking, B/C style, 3½" - 5"
2.	48/50's, " " " , " " , 4" - 6"
3.	48/48's, " " " , " " , 4" - 6"
4.	46/48's, " " " , " " , 4" - 6"
5.	44/46's " " " , " " , 4" - 6"

These types were selected because they covered a fairly wide quality number range (and there is ample evidence that quality number is the most important determinant of wool prices) yet were identical (virtually) in all other characteristics. Since quality number is so important in price determination, it seems likely that the greatest variation between types would occur when quality number is allowed to vary while all other characteristics remain constant. We could complete the analysis with each type characteristic varying in turn while the others are held constant. Comparison of the proportion of variance between types would then provide a measure of the relative importance of the different type characteristics. However, this problem is approached using regression analysis in Section 3.3 of this chapter.

Each sale price was corrected for yield (clean price = greasy price x 100/yield) using the buying firm's estimate of yield so that, if the market was efficient, the clean price variation between lots of the same type should have been very small, at least within sales.

The lots were selected so that each type was represented twice, in three sales, in each centre, in each season (one sale at the beginning, in the middle and at the end of each season).

Before discussing and interpreting these results it should be pointed out that we are dealing here with a totally fixed effects model. Neither the types, seasons nor the sales involved represent a random sample of their respective populations. A mixed model, in which some of the components were random, would have been preferable since in this case inferences about the population could have been made. Unfortunately random samples of types or sales could not be taken because of incomplete data, hence observations from those sales, types and seasons actually selected cannot be generalised.

Different proportions of the total variance would be expected with a different selection of types, seasons or sales. In particular, the selection of types has a major influence on the relative size of the various sources of variance. For example, less of the total variance would be explained by type if the range of quality numbers selected was narrower.

The types used in this section are considered to be a fair representation of New Zealand fleece wool types over a period of relatively stable prices (see table 6) so there is some justification for this investigation even though the results obtained cannot strictly be generalised. However, this section is, at best, an incomplete description of the nature of wool price variation.

The model of wool price formation proposed in this section is of the form:

$$P_{ijklm} = u + Y_i + C_j + S_k + T_l + YC_{ij} + YS_{ik} + YT_{il} + CS_{jk} + CT_{jl} + ST_{kl} + YCS_{ijk} + YCT_{ijl} + YST_{ikl} + CST_{jkl} + YCST_{ijkl} + E_{ijklm}$$

where:

$i = 1 \ldots y$ years;

$j = 1 \ldots c$ centres;

$k = 1 \ldots s$ sales;

$l = 1 \ldots t$ types;

$m = 1 \ldots r$ replicates;

P_{ijklm} is the clean price of the ijklm th lot.

TABLE 6

New Zealand Average Greasy Wool Prices

	Average Prices (cents per kilo)	Differences Between Seasons	Fluctuations (Percent)
1955-56	84.86	- 6.39	- 7.0
1956-57	100.60	+ 15.74	+ 18.6
1957-58	75.62	- 24.98	- 24.8
1958-59	66.27	- 9.35	- 12.4
1959-60	82.03	+ 15.76	+ 23.8
1960-61	74.12	- 7.91	- 9.6
1961-62	71.98	- 2.14	- 2.9
1962-63	78.70	+ 6.72	+ 9.3
1963-64	101.17	+ 22.47	+ 28.5
1964-65	77.40	- 23.77	- 23.5
1965-66	76.46	- 0.94	- 1.3
1966-67	64.77	- 11.69	- 15.3
1967-68	50.42	- 14.35	- 22.2
1968-69	61.86	+ 11.44	+ 22.7
1969-70	56.48	- 5.38	- 8.7
1970-71	53.42	- 3.06	- 5.4
1971-72	66.46	+ 13.04	+ 24.4
Average	73.09	11.48	15.3

Source: New Zealand Wool Commission; Statistical Analysis of New Zealand Wool Production and Disposal.

The factorial analysis of variance of clean, binned wool prices for five wool types, and the first of three hierarchial analysis of variance models constructed from this factorial analysis, are given in tables 7, 8 and 9.

TABLE 7

Factorial ANOVA of Clean, Binned Wool Prices (Five wool types).

Source	Degrees of freedom	Sums of Squares	Mean Squares
Mean	1	1,028,013.965	
Types (T)	4	13,543.594	3,385.898
Seasons (Y)	2	3,994.461	1,997.230
Centres (C)	7	306.917	43.845
Sales (S)	2	223.280	111.640
T x Y	8	668.751	83.594
T x C	28	328.391	11.728
T x S	8	219.951	27.494
Y x C	14	144.618	10.330
Y x S	4	100.195	25.049
C x S	14	108.500	7.750
T x Y x C	56	472.741	8.442
T x Y x S	16	270.749	16.922
Y x C x S	28	332.801	11.886
T x C x S	56	495.749	8.853
T x Y x C x S	112	1,282.200	11.448
Error	360	1,211.823	3.366
Total	720	1,051,718.684	

TABLE 8

Hierarchial ANOVA of Clean, Binned Wool Prices

Model 1.

Source	Sums of Squares	d.f.	Mean Squares	F
Mean	1,028,013.965	1		
Between types	13,543.594	4	3,385.898	1,005.85
Within-types between-seasons	4,663.212	10	466.321	138.53
Within-seasons between-centres	1,252.667	105	11.930	3.54
Within-centres between-sales	3,033.425	240	12.639	3.75
Error	1,211.823	360	3.366	
Total	1,051,718.686	720		

All F values significant at 0.1% level.

TABLE 9

Sources of Clean Price Variation

Model 1.

Source of Variation	Sums of Squares	Variance	% of Total Variation
Between types	13,543.594	18.837	57.14
Within-types between-seasons	4,663.212	6.486	19.67
Within-seasons between-centres	1,252.667	1.742	5.28
Within centres between-sales	3,033.425	4.219	12.80
Within-sales between-lots	1,211.823	1.685	5.11
Total	23,704.721	32.969	100.00

Bearing in mind the limitations of this analysis, we observe in Model 1 that the variance between types is very high, which is to be expected considering the range of types concerned. The variance within-types between-seasons is also relatively high, accounting for nearly 20% of the total price variation. Provided this between-season variation represents an easily identifiable trend, then the efficiency of the marketing system will not necessarily be impaired.[1]

However, the Wool Marketing Study Group showed clearly that seasonal wool prices have fluctuated randomly over a wide range in the past.[2] Prices in recent seasons have shown little more stability, as table 6 shows, although over the period 1968-69 to 1970-71 prices in general were relatively more stable than for any similar period over the past eleven years.

The average greasy price for the last five years (1967-68 to 1971-72) was 57.73 cents per kilo; the average between-year change (either up or down) was 9.45 cents per kilo; and the average percentage change 16.7%. This is not a measurement of fluctuations according to recognised statistical methods, but it does give a simple measurement which indicates the range of price movements and also the wide variation in these price movements.

The individual grower is more concerned, however, with prices at a particular centre rather than the general pattern of prices.

Logically, the variation within-seasons between-centres should be very small or non-existent. One would hope that identical wool sold in Auckland or Invercargill, for example, would fetch the same price. For the lots considered here, the variation within-seasons between-centres is highly significant, however, this accounts for only 5% of the total price variation.

A more important source of price variation is the variation within-centres between-sales, which is also highly significant and contributes nearly 13% of the total price variation. This variation, like that within-types between-seasons, is acceptable in terms of an efficient market provided it is due to real, identifiable changes in the general price level. If, however, the variation is largely due to random fluctuations, as has been suggested by the Wool Marketing Study Group and others,[3] then there will be no trend for growers (or anyone else) to identify.

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1. The concept of market efficiency is defined and discussed in Chapter 1, Section 1.4.
2. W.M.S.G.; Wool Price Fluctuations, Report No.1, August, 1965.
3. W.M.S.G.; ibid.

The Wool Marketing Study Group also concluded that there were considerable disparities in the average price received within each centre for similar periods (say first to third main sales). This conclusion is subject to the limitation that the nature of the wool offered varies throughout the season and this can substantially affect the average price received. However, even when the centre offerings were substantially similar, average price fluctuations between centres were still quite marked.

It is possible that the results of the analysis of variance, summarised by Model 1, and the findings of the Study Group are partly due to the accident of a particular centre happening to have its sales when the general price level was at its higher or lower points within a season. The other confounding factor is the assumption that lots of the same type do in fact appear the same to buyers.

The error term in Model 1, representing the within-sales between-lots (of the same type) source, contributes 5% to the total price variation. This source reflects the variation in buyers' valuations of 'identical' lots as well as the other factors responsible for within-sale fluctuations between 'identical' lots.[4] This source of variation could be substantially reduced if valuations were based on objective measurement of important processing properties rather than on subjective appraisal. (Results of tests for yield and fibre diameter on a series of sale lots indicate that fibre measurement is more consistent than traditional subjective estimates).[5]

One of the problems with Model 1 (and also with the Study Group's price analyses) is that with centres, years and sales all combined results are confounded by a time/geographical interaction. In an effort to overcome this problem, two further hierarchial models were constructed in which centre and time effects are separated. These models are summarised in tables 10 to 13.

With the centre effect removed, we see that the within-seasons between-sales component is significant but relatively small, accounting for only 3% of the total price variation over time. Again, provided it is non-random, this variation will not affect the efficiency of the market. However, The Wool Marketing Study Group concluded that this is probably not the case.[6]

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4. Within-sale price fluctuations for 'identical' lots are discussed in detail in Chapter Two, Section 2.4.
5. Whan, R.B.; "The Role of Objective Measurement in Australian Wool Marketing," <u>Text.Inst. and Industry</u>, <u>1</u>:6, p.154, 1969.
6. W.M.S.G.; <u>Final Report of the Wool Marketing Study Group</u>, Wellington, November, 1967.

TABLE 10

Hierarchial ANOVA of Clean, Binned Wool Prices

Model 2.

Source	Sums of Squares	d.f.	Mean Squares	F
Mean	1,028,013.965	1		
Between types	13,543.594	4	3,385.898	487.96
Within-types between-seasons	4,663.212	10	466.321	67.20
Within-seasons between-sales	814.174	30	27.139	3.91
Error	4,683.740	675	6.939	
Total	1,051,718.684	720		

All F values significant at 0.1% level.

TABLE 11

Sources of Clean Price Variation

Model 2.

Source	Sums of Squares	Variance	% of Total Variation
Between types	13,543.594	18.837	57.14
Within-types between-seasons	4,663.212	6.486	19.67
Within-seasons between-sales	814.174	1.132	3.43
Within-sales between-lots	4,683.740	6.514	19.76
Total	23,704.721	32.969	100.00

The Group investigated the extent to which underlying trends in differentials between different types of wool were distorted by random fluctuations over the course of a single season

Using prices for a sample of 21 full length, fleece wool types offered in 27 sales over the 1964-65 season, the Group found the variations in average differentials to be significant. If these differences represented a trend over the course of the season then this information would be important to growers. However, it was found that, in only 20 cases out of the 84 pairs of prices tested, was a statistically significant trend sustained. Furthermore, only a small proportion of the variance in type differences was explained by the trend. Thus, in almost all cases, sophisticated analysis was necessary to identify a trend.

Assuming a similar situation to the one identified by the Study Group, the within-seasons between-sales variation identified here, although representing only a small percentage of the total price variation, would serve to obscure trends in the differentials between types over the course of a season. (The within-seasons between-sales price variation could, of course, be high and yet completely explained by an easily identifiable trend).

Over all centres, the within-sales between-lots source of variation is high, representing nearly 20% of the total price variation.

TABLE 12

Hierarchial ANOVA of Clean, Binned Wool Prices

Model 3.

Source	Sums of Squares	d.f.	Mean Squares	F
Mean	1,028,013.965	1		
Between centres	306.917	7	43.845	13.03
Within-centres between-seasons	4,139.078	16	258.692	76.85
Within-seasons between-sales	764.776	48	15.933	4.73
Within-sales between-types	17,282.126	288	60.007	17.83
Error	1,211.823	360	3.366	
Total	1,051,718.684	720		

All F values significant at 0.1% level.

TABLE 13

Sources of Clean Price Variation

Model 3.

Source of Variation	Sums of Squares	Variance	% of Total Variation
Between centres	306.917	0.427	1.30
Within-centres between-seasons	4,139.078	5.757	17.46
Within-seasons between-sales	764.776	1.064	3.23
Within-sales between-types	17,282.126	24.036	72.91
Within-sales between-lots	1,211.823	1.685	5.11
Total	23,704.721	32.969	100.00

From Model 3 we see that the between centres variance accounts for less than 2% of the total price variation. Thus, although the within-seasons between-centres variation accounted for 5% of the total variation, over the three year period price variation between centres was very small, (although highly significant). This is encouraging from the growers' point of view since it implies that within-season between-centre price differences tend to cancel out over several seasons.

In a similar manner, the between-types variance within sales accounts for 72.9% of the total variance but, over all centres sales and years, the proportion due to this source is reduced to 57.2%.

3.2.2 Investigation of the Within-Sale Between-Lot Source of Price Variation:

The error term in Model 1 represents the within-sales between-lots source of binned wool price variation for five selected types. The extent to which this source of wool price variation is explained by appraisal and measurement was investigated by multiple regression of the appraised and measured data on the difference between sale price and monthly average price.

In this section, all the data available was used, not only that for the sample of lots analysed in Section 3.2.1. Thus, the within-sales between-lots source of price variation discussed here is not identical with that source of variation in Section 3.2.1. Clearly for the latter there will be little variation within appraised types that can be explained by appraisal variables.

The model implied in this analysis is:

Sale price - Monthly average price = $\alpha + \beta_1$ Yield + β_2 Average quality number or fibre diameter + β_3 Quality number range + β_4 Average Length + β_5 Length range or standard deviation + Error.

Deviation from monthly average price (DMAP) is used as the dependent variable in order to adjust for general price trends, which would otherwise confuse the relationship between sale prices.

To appreciate the reason for this transformation more clearly, consider the following changes that may take place over time:

(i) The general level of wool prices may change. This will tend to obscure the relationships between appraisals and measured data.

(ii) The composition of the <u>total</u> offering for any particular sale may change.

(iii) The composition of the <u>sample</u> for which we have information may change. By inspection of brokers' bin numbers it would appear that the composition of the sample is relatively constant within a season but not constant over the three-year period. That is, the same bins tend to occur in successive sales at each centre within a season but not over the three seasons.

(iv) Standards of broker classing may change so that, although we have the same wool in terms of measured characteristics, the composition of the sample <u>appears</u> to change.

If the composition of the total clip or of the sample changes (the change may be real or only imagined by appraisers) then correcting for trend by the use of deviation from sale average price or the average price of the sampled bins is inappropriate. One solution, however, is to use the deviation from monthly average price. In this way the price of each lot is adjusted for the general price level at the time and differences in the relative explanatory powers of appraisals and measurement over time are not confounded by a time (or composition) effect.

The results of multiple regressions of DMAP on the two sets of appraisals and the measurement information over the period 1968-69 to 1970-71 are given below. In these tables, 14 to 16, the following terms and abbreviations are used:

DMAP = Deviation from monthly average price (cents per pound)
B = Buying firm BR = Brokers M = Measured
YIE = Yield (%) AQN = Average quality number
RQN = Quality number range AVL = Average staple length (inches)
RAL = Staple length range (inches) FID = Fibre diameter (microns)
LSD = Staple length standard deviation
100P = The significance of the 't' test, where * denotes $p < .1\%$; ** denotes $p < .05\%$; *** denotes $p < .01\%$; **** denotes $p < .001\%$
Corrected R^2 = Degrees of freedom corrected R^2.

TABLE 14

Regression of One Buying Firm's Appraisals on DMAP

Y	X	Regression Coefficient	Standard Error	Student's T	100P
DMAP	CONS	- 93.3069	2.1432	- 43.53	****
DMAP	BYIE	0.4033	0.0178	22.60	****
DMAP	BAQN	1.3123	0.0213	61.66	****
DMAP	BRQN	- 0.4330	0.0560	- 7.72	****
DMAP	BAVL	0.8871	0.0782	11.34	****
DMAP	BRAL	- 0.7483	0.1398	- 5.37	****

$R^2 = 0.7526$. Corrected $R^2 = 0.7250$.
Number of observations = 8,448.

In view of their relative positions in the wool marketing system, it would be expected that the buyers would explain more of the variation in DMAP than the brokers. Brokers' appraisals, in turn, would be expected to explain more of the variation in DMAP than would the measured data, since, under the present system, measurement information plays little or no part in price fixing. Comparison of the respective multiple correlation coefficients (R^2) confirms this hypothesis.

TABLE 15

Regression of Brokers' Appraisals on DMAP.

Y	X	Regression Coefficient	Standard Error	Student's T	100P
DMAP	CONS	- 97.0359	2.1448	- 45.24	****
DMAP	BRYIE	0.4128	0.0183	22.51	****
DMAP	BRAQN	1.3535	0.0219	64.84	****
DMAP	BRRQN	- 0.2055	0.0566	- 3.63	***
DMAP	BRAVL	0.7035	0.0788	8.92	****
DMAP	BRRAL	- 0.1135	0.0704	- 1.61	

$R^2 = 0.7185$. Corrected $R^2 = 0.7178$.

Number of observations = 5,956.

TABLE 16

Regression of Measured Data on DMAP

Y	X	Regression Coefficient	Standard Error	Student's T	100P
DMAP	CONS	34.8059	1.4839	23.46	****
DMAP	MYIE	0.0903	0.0244	3.71	***
DMAP	MFID	- 1.2446	0.0314	- 39.61	****
DMAP	MAVL	2.0232	0.1290	15.68	****
DMAP	MLSD	- 7.2361	0.4782	- 15.13	****

$R^2 = 0.5662$. Corrected $R^2 = 0.5654$.

Number of observations = 8,444.

For the lots used in this analysis the buyers' appraisals explained 72.50% of the variation in DMAP over the three years; brokers' appraisals explained 71.78% of the variation; and measured data 56.54%. Furthermore, the standard errors of the significant regression coefficients are smallest for buyers' appraisals and largest for the measured data.

The size of the R^2 values for these regressions may appear rather low considering the fact that the sale prices had already been corrected for trend. However, it must be remembered that the use of monthly average price as a trend correction for sale prices is a fairly coarse compromise, since up to eight or nine sales may be held in any one month. Over a period as long as three years, external factors, such as changes in demand and supply, would have a strong influence on wool prices which would not be adequately described by the deviation from monthly average price. Furthermore, it is readily conceded that the model used omits several important explanatory variables. Estimates of binned wool value are based on a whole range of subjective characteristics, which include colour, character, handle, density and degree of weathering as well as yield, length and count. Part of the unexplained price variation is due to these excluded variables.

Now to consider the regression coefficients for each of the independent variables in turn, remembering that the dependent variable, DMAP, is the difference between sale price and monthly average price. In the discussion that follows an increase in DMAP refers to a positive increment if sale price exceeds monthly average price and to a negative increment if sale price is less than monthly average price.

It is important to note that there is an interaction between the partial regression coefficients discussed here, the general price level and the nature of the independent variable concerned. It can be assumed that the coefficient for yield will be directly related to the average price level over this (or any other) period. A higher general price level, for example, would mean an increase in the value of an additional percent of yield and, hence, a larger regression coefficient. A similar situation can probably be assumed for staple length, within certain processing constraints.

On the other hand, a change in the general price level may have little or no effect on the margin between adjacent quality numbers. Thus, a higher general price level may leave the value of an additional unit of quality number, and hence the value of the regression coefficient, unchanged.

Therefore, in the discussion that follows, the regression coefficients refer only to the period 1968-69 to 1970-71 and cannot correctly be applied to other time periods.

(a) Yield:

In this analysis, the appraised yields are estimates of the percentage of clean wool present in each binned lot, while the measured yield is a washing yield at 16% regain.[7]

A one percent increase in the buyers' yield appraisal would have resulted in an increase of 0.40 cents per pound in DMAP, if all other variables remained constant. The same increase in brokers' yield appraisal and measured yield would have increased DMAP by 0.41 cents per pound and 0.09 cents per pound respectively. The low value of the coefficient for measured yield simply reflects the fact that measurement played little or no part in price fixing during this period.[8] The sign of the coefficients is positive as expected. That is, the higher the yield, the higher the sale price.

(b) Average quality number or fibre diameter:

In view of the importance of fibre diameter and the relationship between quality number and fibre diameter,[9] it would be expected that the regression coefficients for average quality number be positive and highly significant, and that for fibre diameter negative and also highly significant. This is confirmed by the results of regression analysis.

A one unit increase in appraised average quality number (other variables constant) was worth 1.31 cents per pound on the basis of the buyers' appraisals; 1.35 cents per pound on the basis of the brokers' appraisals. A one micron increase in fibre diameter would have decreased DMAP by 1.25 cents per pound. (From: "Proposed National Wool Standards for Fineness and Description", one micron is approximately equal to 1¼ quality number units).

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7. Each test specimen is scoured in a series of hot detergent solutions to produce a scoured product similar in all respects to that obtained by commercial scouring. The dry weight (at 16% regain) is determined after oven drying and corrected for the amount of vegetable matter present.

8. See Chapter Two, Section 2.4.3.

9. See Chapter Two, Section 2.4.3.

(c) Quality number range:

Too great a spread of fibre diameters can introduce spinning difficulties when yarn is being spun to near the limit permitted by the average diameter of fibres in tops.[10] This circumstance is rare, however. The influence of diameter spread on handle of fabrics is currently under examination.

Although the effect of fibre diameter spread on processing performance is negligible, except in extreme cases, the assumption that the larger the quality number range the lower the DMAP (all other things being equal) is confirmed by regression coefficients for appraised quality number range. These show that a one unit increase in the buyers' and brokers' quality number ranges would have decreased DMAP by 0.43 cents per pound and 0.21 cents per pound respectively.

(d) Average staple length:

The importance of staple length in textile processing is related to its average value and its variation.[11] Increasing length is desirable, provided it does not mean a change in the system of processing, or that, at its upper limits, it does not interfere with the performance of textile machinery.

For the lots analysed in this section, the mean appraised staple lengths and standard deviations, and the mean measured length and its standard deviation are given in table 17.

TABLE 17

Mean Staple Length and Staple Length Standard Deviation

	Mean (")	Standard Deviation
Buying firm	4.046	1.061
Brokers	4.443	1.086
Measured	4.392	0.923

10. Australian Wool Board; Objective Measurement of Wool in Australia. A summary of the Principal Findings of the Australian Wool Board's Objective Measurement Policy Committee, p.12, 1972.

11. See Chapter Two, Section 2.4.3.

On the basis of these values and the previous discussion it can be assumed that an increase in average staple length would be desirable to the processor. Thus, it could be expected that the partial regression coefficients for average length be positive, as they in fact are. An increase of one inch in average buyer-appraised staple length (all other variables constant) would have increased DMAP by 0.89 cents per pound. The same increase in average broker-appraised length and measured length would have increased DMAP by 0.70 cents per pound and 2.02 cents per pound respectively.

In view of previous investigations into the affect of length on clean price, the size and level of significance of these coefficients is probably due mainly to the association between length and yield[12] rather than any direct affect of length on sale price.

The difference between coefficients for appraised and measured staple length are due to differences in the nature of appraisal and measurement of this characteristic. Measured average staple length is a continuous parameter, representing the average distribution of staple lengths in each lot. Appraised average staple length, on the other hand, is derived from a staple length class and hence its distribution is discrete. Thus, two lots may differ by up to two inches in appraised staple length but still fit into the same staple length class (and, hence, for the purposes of this analysis, have the same average staple length).

The effect of staple length appraisal into length classes is to underestimate the value of an additonal inch of staple length. The result of this situation is that, although on average over a large number of lots, there are no significant differencesbetween appraised and measured staple length, the regression coefficient for measured length is significantly larger than those for its appraised counterparts.

(e) Staple length range:

Traditionally the importance of uniformity in fibre length in wool tops has been emphasised because of the necessity of fibre control and adjustment of ratch in the Bradford open drawing process. Only comparatively recently has it been found that uniformity in fibre length is so undesirable that tops which are too 'square' (i.e. too uniform in fibre length) do not spin satisfactorily. In fact, uniform length

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12. In Chapter Four, Section 4.2.1, the correlations between length and yield are calculated as 0.325 for the buying firm, 0.310 for the brokers, and 0.286 for the measured data.

synthetic fibre tops require treatment by a random breaking process to enable them to be dealt with by worsted spinning machinery.[13]

Research has shown that the normal form of fibre distribution, which is produced by the vigorous fibre breakage that occurs during carding, combing and spinning, is in fact an ideal basis for efficient yarn production. In other words, there is an optimum fibre length distribution for best spinning performance and yarn properties.

The values of mean staple length range and its standard deviation for both groups of appraisers, and average measured length standard deviation and its standard deviation for the binned lots analysed are given in table 18.

TABLE 18

Staple Length Range / Standard Deviation and its Standard Deviation

	Staple Length Range / Standard Deviation	
	Mean (")	Standard Deviation
Buying firm	1.485	0.540
Brokers	1.827	1.066
Measured	0.869	0.235

The brokers' length range is twice as variable as that of the buying firm, although the difference between the average range of the two appraisals is only 0.34 inches (this difference is significant at the 5% level). However, the regression coefficient for brokers' length range, - 0.11, is non-significant while the same coefficient for the buying firm, - 0.75, is highly significant. This is an interesting result since it implies that the brokers were unable to effectively appraise a parameter of economic importance to this particular buying firm. The poor relationship between buyer and broker length range is confirmed in Chapter Four[14] by a low, non-significant correlation coefficient (i.e. r = - 0.017).

13. McMahon, P.R.; "A New Look at Woolclassing", Wool Tech. Sheep Breeding, 16:2, p.105, 1969. Bratt, R.L.; "The Effect of Staple Strength on Worsted Processing. Part III: Fibre Length Distribution and Spinning", J.Text.Inst., 56: T62, 1965.

14. See Chapter Four, Section 4.2.1.

The partial regression coefficient for measured length standard deviation is also negative and highly significant (-7.24), confirming that length variation does have an important influence on price.

The implication of these regression coefficients is that less length variation would be desirable. However, this situation may be due to the long held belief in the desirability of length uniformity, resulting in increasing price discounts for increasing length variability, rather than to a reflection of the processing importance of length variation.

It should also be pointed out that appraised staple length range is not a true range in the sense that it does not express the difference between the longest and shortest staples. The length class from which mean staple length and staple length range are calculated, is a trade description of the staple lengths in the lot. This distribution indicates the range in which the majority of staples can be expected to fall, so the distribution is truncated and it may even be skewed. Thus appraised staple length range underestimates the true physical range of staple lengths in a lot.

3.2.3 Variation Between Appraisers' Estimates of Value:

In Section 3.2.1 price variations for particular buying firm wool types were investigated. A similar approach was also used by the Wool Marketing Study Group. The problem with this approach is that the demand effect may be confounded by the appraisal effect. That is, the assumption, that all the lots of the same type appear identical to the buyer who purchases the wool, is only true to the extent that his appraisals agree with those of the appraisers who initially assessed the lots. Since the lots are subjectively appraised into types originally, the prices paid for them must include an appraisal component which inevitably confounds attempts to isolate demand effects.

If we had each appraisers valuation for every lot we could add an additional source to Model 1, that is, the variance within-types between-appraisers. Thus we could estimate the size of the appraisal source in the variance of prices for lots of the same type. Unfortunately these valuations are not available. However, by obtaining estimated 'prices' or valuations for the two appraisers we can calculate this additional source of variance.

For 450 lots of the same types as in Section 2.3.1, estimated valuations were calculated for each appraiser by multiple regression analysis of greasy price on appraised yield, average quality number, quality number range, average staple length and staple length range. These estimated valuations were then corrected for yield and used to calculate the following analysis of variance and sources of price variation tables (tables 19 and 20).

TABLE 19

ANOVA of Estimated Appraiser Valuations

Source	Sums of Squares	d.f.	Mean Squares	F
Mean	1,172,103,696.000	1		
Between-types	16,355.967	4	4,088.992	47.79 ****
Within-types between-appraisers	538.060	5	107.612	1.26
Error	76,135.468	890	85.545	
Total	1,172,196,725.495	900		

**** denotes significant at $p < .001\%$

TABLE 20

Sources of Price Variation

Source of Variation	Sums of Squares	Variance	% of Total Variation
Between types	16,355.967	18.194	17.58
Within-types between-appraisers	538.060	0.599	0.58
Error	76,135.468	84.689	81.84
Total	93,029.495	103.481	100.00

The estimate of the within-types between-appraisers variance for these lots is 0.599 (thus the standard deviation of valuations is 0.775 cents per pound). This value is non significant and contributes less than one percent to the total price variation. However, this result undoubtedly underestimates the size of this source of price variation.

By its very nature, the technique of using regression to estimate the appraisers' valuations from their appraisals and actual prices reduces the variation in these valuations to a minimum. In view of this it is, perhaps, not surprising that the variation between appraisers' valuations is so small and non significant.

A solution to this problem would be to add a random error term to each estimated valuation to account for deviations from regression. If this was done and the analysis of variance repeated, then the within-types between-appraiser variance would be larger and possibly significant.

For their model of an auction market, Whan and Richardson[15] estimate the value of the variance of buyers' valuations on 'identical' lots as 9.50 cents per pound greasy. This value would be less, however, for clean prices.

3.3 THE RELATIVE ECONOMIC IMPORTANCE OF GREASY WOOL CHARACTERISTICS: Outline:

In this section, regressions of appraisals on sale prices indicate the relative economic importance of various binned wool characteristics and how this varies over time

From a grower's point of view, the relative economic value of wool characteristics is related to his broker's appraisal, but, at auction, it is related to the buyers' appraisals. Consequently both of these aspects are considered.

3.3.1 Relative Economic Importance:

For each lot, the appraisers' estimates of quality number and staple length class were converted into average quality number and quality number range, and average staple length and staple length range. Simple and multiple regression analysis of appraised yield, average quality number, quality number range, average staple length and staple length range on greasy prices over the three year period were used to give the relative economic importance of these characteristics.

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15. Whan, R.B. and Richardson, R.A.; "A Simulated Study of an Auction Market," Aust.J.Agric.Econ., 13:2, p.91, 1969.

For a model of the form used here: i.e.

$$\hat{P}_j = \hat{\beta}_1 + \hat{\beta}_2 X_{2j} + \ldots + \hat{\beta}_n X_{nj}$$

where: P_j is the sale price of lot j in cents per pound;

X_{ij} is the value of characteristic i for lot j.

The partial regression coefficient, $\hat{\beta}_i$, can be interpreted as the average or expected change in greasy price, P_j, when characteristic X_{ij} increases by one unit: $X_{2j} \ldots X_{i-1j}, X_{i+1j} \ldots X_n$ remaining constant. That is, the partial regression coefficient of a wool characteristic is a measure of the economic importance of that characteristic. The standard form[16] of these partial regression coefficients gives the relative economic importance of the variable (or in this case, the wool attribute) involved.

The results of simple and multiple regression analysis of brokers' appraisals on greasy wool prices are summarised in table 21.

Using brokers' appraisals, all the simple regression coefficients are statistically significant. The negative sign of yield, indicating that an increase in yield causes a decrease in greasy price, is explained by the high negative correlation between yield and average quality number.[17] Similarly, the negative sign for average staple length is explained by the high, negative correlation between staple length and crimps per inch[18] and, hence, average staple length and average quality number. As expected, the coefficients for quality number range and staple length range are negative.

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16. The standardised form of the partial regression coefficient $\hat{\beta}_i$ in the relationship:

$$\hat{Y}_i = \hat{\alpha} + \Sigma_i \hat{\beta}_i X_i$$

is given by:

$$\beta_i^* = \hat{\beta}_i \sqrt{\frac{G_{ii}}{G_{yy}}}$$

where: β_i^* = standardised partial regression coefficient ;

$G_{ii} = n\Sigma X_i^2 - (\Sigma X_i)^2$;

$G_{yy} = n\Sigma Y^2 - (\Sigma Y)^2$.

17. In Chapter Four Section 4.2.1 the correlation between the brokers' estimates of yield and average quality number is calculated as, r = -0.509.

18. Ross, D.A.; "The Relation of Count to other Characteristics of New Zealand Wools", N.Z.J. Agr.Res., 7: p.660, 1964, gives the correlation between crimp and length for all wools as, r = -0.870.

TABLE 21

Regressions of Broker-Appraised Wool Attributes on Greasy Wool Prices

Characteristic	Simple Regression Coefficients	Regression Coefficients 5 Variables		Regression Coefficients 3 Variables	
		Partial	Standard Partial	Partial	Standard Partial
Yield	- 0.19 ****	0.41 ****	0.29	0.41 ****	0.30
Average Quality Number	1.05 ****	1.33 ****	0.90	1.37 ****	0.93
Quality Number Range	- 1.55 ****	- 0.27 ***	- 0.06		
Average Staple Length	- 0.72 ****	0.83 ****	0.13	0.90 ****	0.14
Staple Length Range	- 0.35 *	- 0.10	- 0.02		
% Variation in Prices Explained (5956 observations)		60.67		60.39	

* denotes $p < .1\%$; ** denotes $p < .5\%$; *** denotes $p < .01\%$; **** denotes $p < .001\%$.

All of the partial regression coefficients are significant, except that for staple length range. The coefficient for average quality number is more than three times larger than that for yield, 1.5 times as great as that for average staple length and nearly five times greater than that for quality number range. However, in standard partial form, the coefficient for average quality number is three times greater than that for yield which, in turn, is more than twice as large as that for average staple length. The coefficient for quality number range indicates that this characteristic is relatively unimportant.

Of the total variation in greasy prices over this period, 60.67% is explained by the five variables yield, average quality number, average staple length, quality number range and staple length range.

When staple length range and quality number range were omitted the relative importance of yield, average quality number and average staple length remained the same. The control of price variation was 60.39%, not significantly different from control with five variables.

Further estimates of relative economic value were obtained by comparing the reduction in control of price variation which occured when each of the three important variables was deleted in turn in the presence of the other two. Deletion of average quality number caused a reduction in control of 58.12%; yield 6.02% and average staple length 1.61%. Once again the overwhelming importance of average quality number is demonstrated.

From a grower's point of view, the relative economic importance of yield, quality number, length etc. is based on his broker's appraisal of these characteristics. However, it is not the broker who buys the grower's wool and what the grower is really interested in is the relative economic value of wool characteristics to the buyer.

Using the buying firm's estimates, the regression analyses were repeated and the results compared with those obtained using brokers' appraisals. These results are summarised below in table 22.

TABLE 22

Regressions of Buyer-Appraised Wool Attributes on Greasy Wool Prices

Characteristic	Simple Regression Coefficients	Regression Coefficients 5 Variables		Regression Coefficients 3 Variables	
		Partial	Standard Partial	Partial	Standard Partial
Yield	- 0.10 **	0.43 ****	0.30	0.46 ****	0.32
Average Quality Number	1.10 ****	1.33 ****	0.87	1.42 ****	0.93
Quality Number Range	- 2.08 ****	- 0.31 ****	- 0.07		
Average Staple Length	- 0.26	1.05 ****	0.16	1.08 ****	0.17
Staple Length Range	- 3.07 ****	- 0.80	- 0.06		
% Variation in prices explained (8448 observations)		64.29		63.58	

** denotes $p < .5\%$; **** denotes $p < .001\%$.

The reduction in control of price variation which occurred when each of the three important characteristics was deleted in the presence of the other two was: 63.21% for average quality number; 7.18% for yield and 2.30% for average staple length.

The partial regression coefficient for average quality number is a little over three times as large as that for yield, nearly 1.3 times larger than that for average staple length and more than four times larger than the coefficient for quality number range. In standard partial form, the coefficient for average quality number is less than three times that for yield, which is less than twice that for average staple length. The coefficient for quality number range is relatively unimportant.

It is apparent that the relative economic importance of the five fleece characteristics concerned is similar for both buyers and brokers; except that the buying firm attached relatively more importance to features other than average quality number, particularly yield and staple length. Compared to average quality number, yield and average staple length have been shown to be of minor importance in greasy price formation. However, they should obviously not be neglected. On the basis of their broker's appraisal, growers could well be encouraged to underestimate the importance of yield and staple length. In this case the uncertainty arising from subjective appraisal and lack of effective communication would have diminished the efficiency of the market.

Two similar investigations of the influence of fleece and fibre properties on price, one by Dunlop and Young, the other by Skinner, are summarised in Chapter Two.[19] Since these studies are concerned with clean prices it is impossible to compare directly their results with those obtained in this analysis. Furthermore, these studies included only certain, selected Merino types. However, the overwhelming importance of quality number, or count, in influencing wool prices is apparent, and the three sets of results confirm the conclusion that characteristics such as yield, length, colour and handle affect the assessment of value, but only within a limited price range set by the buyer's estimate of the fineness of the lot.

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19. See Chapter Two, Section 2.4.1.

The approach used in this, and other similar analyses, of relating the market price of wool to the degree of development of greasy wool characteristics, cannot show whether the wool trade is placing the correct emphasis on these features. On the other hand, information on the relative economic value of alternative characteristics enables growers and breeders to concentrate on those characteristics held to be important.

Logically, the wool trade should pay for wool features in correct proportion to their importance in terms of processing performance. The relative economic value of alternative wool characteristics should be clearly apparent to growers so that they can concentrate on those features sought by the trade.

However, until such time as the wool trade accepts objective measurement of important processing properties as the basis for valuing wool, the attention given by wool producers to various fleece characteristics may well be disproportionate to their manufacturing potential.

3.3.2 Changes in Economic Importance Over Time:

For each sale over the period 1968-69 to 1970-71, partial regression coefficients were calculated by multiple regression of the five appraised fleece characteristics detailed in the previous section on sale price. The coefficients for each sale are tabulated in tables 23 and 24; with the sales in chronological order.[20]

The fact which is immediately obvious from these tables is that, over a period covering the first half of the 1969-70 season (from the second to sixth sales at all centres) the regression coefficients for appraised yield are smaller and less significant than the same coefficients before or after this period.

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20. In these tables each sale is identified by a number a : b, where a represents the centre and b the sale number. The eight selling centres are coded from one to eight in the following manner:

1. Auckland	5. Christchurch
2. Napier	6. Timaru
3. Wanganui	7. Dunedin
4. Wellington	8. Invercargill

The level of significance of the regression coefficients is indicated as follows: * denotes $p < .1\%$; ** denotes $p < .05\%$; *** denotes $p < .01\%$; **** denotes $p < .001\%$.

TABLE 23

Buying Firm's Regression Coefficients : 1968/69 Season

Centre / Sale	7:2	5:2	1:2	2:2	6:2	8:2	4:2	3:2	5:3	1:3	7:3	2:3	8:3	4:3	3:3	5:4	6:3	7:4	2:4	8:4	1:4	4:4	7:5	3:4	5:5	1:5	2:5	8:5	4:5
R^2	.88	.81	.92	.73	.85	.69	.67	.73	.79	.81	.88	.69	.72	.76	.73	.83	.84	.87	.74	.72	.90	.85	.89	.64	.84	.87	.61	.73	.76
Yield	.55 ****	.54 ****	.65 ****	.59 ****	.64 ****	.68 ****	.82 ****	.46 *	.49 ****	.48 ****	.59 ****	.50 ****	.78 ****	.59 ****	.53 ****	.45 ****	.14	.51 ****	.61 ****	.65 ****	.63 ****	.52 ****	.52 ****	.49 ****	.38 ****	.52 ****	.15	.73 ****	.52 ****
Average Quality Number	1.80 ****	1.58 ****	1.38 ****	1.44 ****	1.63 ****	.48 ****	.86 ****	.71 ****	1.44 ****	1.58 ****	1.54 ****	1.02 ****	1.00 ****	1.22 ****	.72 ****	1.51 ****	1.24 ****	1.54 ****	1.01 ****	.87 ****	1.57 ****	1.09 ****	1.51 ****	1.12 ****	1.28 ****	1.51 ****	1.57 ****	.90 ****	1.15 ****
Quality Number Range			-1.11 **									-.64 **					-1.16 ****		-.40 *			-.73 ***	-.72 ***		-.74 ***	-.46 *	-.90 ***		
Average Staple Length						.59 *		1.66 *		.96 **																.40 *		.36 *	
Staple Length Range						-3.21 **												-2.28 *	-3.48 ****										-1.90 *
Degrees of Freedom	78	68	26	62	78	65	49	37	71	49	88	77	70	54	54	65	80	88	97	80	66	53	84	58	71	58	94	81	56

Centre / Sale	6:4	3:5	5:6	1:6	2:6	7:6	4:6	8:6	1:7	5:7	2:7	3:6	7:7	4:7	6:5	1:8	5:8	8:7	2:8	5:9	1:9	7:8	3:7	4:8	8:8	2:9	1:10
R^2	.86	.67	.89	.82	.66	.90	.76	.73	.81	.82	.73	.66	.81	.77	.80	.85	.83	.53	.80	.82	.87	.72	.70	.81	.35	.90	.76
Yield	.49 ****	.49 ****	.34 ****	.56 ****	.60 ****	.61 ****	.43 ****	.40 ****	.65 ****	.36 ***	.54 ****	.56 ****	.62 ****	.42 ****	.36 ****	.60 ****	.37 ****	.31 ****	.60 ****	.41 ****	.62 ****	.45 ****	.66 ****	.58 ****	.57 **	.61 ****	.61 ****
Average Quality Number	1.63 ****	.70 ****	1.65 ****	1.41 ****	1.25 ****	1.85 ****	1.20 ****	1.07 ****	1.03 ****	1.61 ****	1.02 ****	.48 ****	1.70 ****	.98 ****	1.34 ****	1.35 ****	1.58 ****	.62 ****	.83 ****	1.45 ****	1.17 ****	1.29 ****	.58 ****	.85 ****	.53 *		.86 ****
Quality Number Range		-.37 *	-.42 *											-.62 **	-.73 **	-.39 *								.50 *			
Average Staple Length							.70 *						.88 *	.56 *			1.72 ***										.91 **
Staple Length Range				-.85 *	-1.98 *	-2.98 *					-1.71 *						-1.00 **	.62 *		-.67 *					1.16 *		
Degrees of Freedom	62	55	68	62	81	82	49	79	62	68	81	63	69	43	69	50	61	67	59	63	49	72	40	28	44	20	36

TABLE 23 (cont.)

Buying Firm's Regression Coefficients : 1969/70 Season

Centre / Sale	6:1	8:1	7:1	5:1	7:2	5:2	1:2	2:2	6:2	8:2	4:2	3:2	5:3	1:3	7:3	2:3	8:3	4:3	3:3	5:4	6:3	7:4	2:4	8:4	1:4	4:4	3:4	5:5	1:5	7:5
R^2	.84	.65	.84	.83	.84	.86	.81	.59	.75	.67	.46	.29	.89	.80	.88	.56	.32	.57	.53	.86	.83	.82	.69	.60	.78	.68	.62	.90	.84	.88
Yield	.52 ****	1.14 **	.43 ***	.02	.02	-.06	-.09	.28	-.15	.46 ***	.45	.19	.28 *	-.28	-.30 *	.21	.50 *	.27	.35	-.07	.02	-.17	.15	.61 ***	.64 *	.45 **	.28	.04	.30	-.11
Average Quality Number	1.00 ****	.34	1.09 ****	1.00 ****	1.17 ****	.91 ****	1.24 ****	.65 ****	.86 ****	.32 ***	1.03 ****	.39 **	1.08 ****	1.19 ****	.99 ****	.64 ****	.32 **	.87 ****	1.06 ****	1.05 ****	.78 ****	.92 ****	.92 ****	.65 ****	1.33 ****	.76 ****	1.09 ****	1.27 ****	1.23 ****	1.30 ****
Quality Number Range			-2.15 **			-.78 *							-1.19 ****					-.62 *			-.76 **				-.80 *	-.98 ***			-.81 *	
Average Staple Length																											1.98 **			2.19 **
Staple Length Range			-5.43 ***	-3.32 **	-4.66 *				-3.78 **	-2.22 **			3.34 **		-3.31 ***	-2.72 **							-2.84 **			-2.86 *				-4.27 ****
Degrees of Freedom	46	11	43	41	65	33	23	45	52	27	29	50	37	33	62	68	45	40	53	42	50	44	70	50	41	42	52	40	34	61

Centre / Sale	2:5	8:5	4:5	6:4	3:5	1:6	5:6	2:6	7:6	4:6	8:6	1:7	5:7	3:6	7:7	2:7	6:5	1:8	4:7	8:7	2:8	5:8	1:9	7:8	3:7	4:8	8:8	2:9	1:10
R^2	.53	:44	.50	.80	.37	.54	.76	.45	.83	.55	.40	.50	.79	.62	.78	.52	.61	.39	.71	.87	.30	.79	.86	.86	.64			.93	.88
Yield	.15	.47 *	.26 *	.12	.54 **	.58 **	.01	.16	-.20	.63 ****	.50 ***	.73 ****	.05	.54 ****	-.05	.40 ***	.14	.63 **	.29 *	.45 ****	.37	.11	.65 ****	-.65 **	.41 ****			.44 **	.76 ****
Average Quality Number	.76 ****	.69 ****	.51 ****	1.05 ****	.33 *	.79 ****	1.11 ****	.50 ****	1.07 ****	.96 ****	.39 ***	.48 ***	1.04 ****	.50 ****	.75 ****	.43 ***	.74 ****	.65 ***	.12	.63 ****	.23	.84 ****	.38 **	.39 *	-.07				
Quality Number Range	-.54 *	-.54 *						-.59 **																-1.17 **					.31 **
Average Staple Length							2.19 *		1.57 *	.74 *			1.27 **			.96 **	1.01 **		-1.84 *	.91 *									
Staple Length Range	-2.19 *		-1.72						-2.83 *	-.77 *					-2.74 **	-1.58 *													
Degrees of Freedom	68	50	36	57	52	42	42	55	56	44	47	34	42	36	38	41	47	27	11	31	16	38	26	18	20				23

TABLE 23 (cont.)

Buying Firm's Regression Coefficients : 1970/71 Season

Centre / Sale	6:1	8:1	7:1	5:1	7:2	5:2	1:2	6:2	2:2	8:2	4:2	3:2	5:3	1:3	7:3	2:3	8:3	4:3	3:3	5:4	6:3	7:4	2:4	8:4	1:4	4:4	3:4	5:5	1:5
R^2	.62		.86	.93	.82	.73	.87	.72	.80	.91	.88	.78	.84	.91	.89	.77	.89	.91	.81	.82	.76	.76	.80	.89	.85	.89	.85	.84	.67
Yield	.25		.49 ****	-.32	.29 *	.23	.55 ***	.07	.50 ****	.55 ****	.43 ****	.55 ****	.49 ****	.61 ****	.49 ****	.52 ****	.60 ****	.61 ****	.52 ****	.16	.35 ***	.38 ****	.49 ****	.57 ****	.77 ****	.65 ****	.70 ****	.51 ****	.47 ****
Average Quality Number	.96 ****		1.18 ****	.98 **	.95 ****	1.03 ****	1.25 ****	.71 ****	.54 ***	.30 **	.96 ****	.85 ****	.99 ****	1.13 ****	1.20 ****	.75 ****	.64 ****	1.39 ****	1.11 ****	.98 ****	1.03 ****	1.03 ****	.82 ****	.34 ***	1.16 ****	.68 ****	.76 ****	.93 ****	.62 ****
Quality Number Range									-.77 **				-.59 *			-.62 **													
Average Staple Length										.54 *		3.83 ****			.81 *						1.28 **	.97 *							
Staple Length Range			-3.34 *		-3.82 **				-3.20 *			-5.21 **			-1.87 *	-2.27 **													
Degrees of Freedom	50		42	6	61	44	18	61	42	19	31	35	39	28	48	66	22	35	40	42	57	50	61	20	34	36	34	50	29

Centre / Sale	7:5	2:5	8:5	6:4	4:5	3:5	1:6	5:6	2:6	4:6	7:6	8:6	1:7	5:7	3:6	7:7	2:7	6:5	1:8	4:7	8:7	2:8	5:8	1:9	7:8	3:7	4:8	8:8	2:9
R^2	.49	.79		.86	.79	.67	.87	.61	.79	.52	.77		.76	.52			.89	.77	.77					.77		.91			
Yield	.09	.41 ****		.47 ****	.47 ****	.27 **	.50 ****	.33 ***	.48 ****	.52 **	.28 ****		.34 ***	.25 **			.33 *	.40 ****	.44 ****					.54 ****		.59 ****			
Average Quality Number	.74 ****	.69 ****		1.06 ****	.36 *	.29 **	.44 ****	.68 ***	.47 **	.57	.91 ****		.23	.63 ****			1.21	.73 ****	.55					-.03		-.51 **			
Quality Number Range		-.42 *					-.45 *																						
Average Staple Length	1.04 *				-.21 *	.67 *	.96 *		.90 **		1.40 **		.88 *											.61 *		.82 **			
Staple Length Range																													
Degrees of Freedom	46	55		53	25	30	29	35	35	7	35		19	30			3	30	18					20		8			

TABLE 24

Brokers' Regression Coefficients : 1968/69 Season

Centre / Sale	7:2	5:2	1:2	2:2	6:2	8:2	4:2	3:2	5:3	1:3	7:3	2:3	8:3	4:3	3:3	5:4	6:3	7:4	2:4	8:4	1:4	4:4	7:5	3:4	5:5	1:5	2:5	8:5	4:5
R^2	.89	.86	.87	.67	.85	.60	.59	.93	.85	.88	.91	.68	.72	.78	.85	.86	.85	.88	.78	.74	.86	.78	.87	.73	.93	.82	.85	.66	.78
Yield	.53 ****	.52 ****	.61 ****	.59 ****	.29	.32 **	.84 ****	.46 ****	.65 ****	.72 ****	.87 ****	.50 ***	.46 ****	.63 ****	.60 ****	.59 ****	.21	.38 ****	.29 **	.56 ****	.61 ****	.56 ****	.67 ****	.37 ****	.80 ****	.56 ****	.46 ***	.53 *	.51 ****
Average Quality Number	1.86 ****	1.70 ****	1.65 ****	.92 **	1.55 ****	.82 ****	1.11 ****	1.58 ****	1.40 ****	1.30 ****	1.81 ****	1.45 ****	1.04 ****	1.17 ****	1.10 ****	1.83 ****	1.36 ****	1.59 ****	1.42 ****	1.10 ****	1.29 ****	1.01 ****	1.76 ****	1.37 ****	2.13 ****	1.42 ****	2.09 ****	.92 *	1.07 ****
Quality Number Range			-.92 **	-1.70 **		-1.45 ***		-.99 ***		-.48 *			-1.22 ***		-.55 *	-1.25 *	-1.25 *		-.96 **		-.62 ***	-.62 *		-1.34 ****			-1.41 **		-.72 *
Average Staple Length								.45 *																					
Staple Length Range				.95 *				-1.69 *			-.33 **																		
Degrees of Freedom	52	46	26	36	22	50	38	26	31	46	62	35	52	42	43	45	25	48	30	59	70	42	60	58	21	54	29	10	43

Centre / Sale	6:4	3:5	5:6	1:6	2:6	7:6	4:6	8:6	1:7	5:7	2:7	3:6	7:7	4:7	6:5	1:8	5:8	8:7	2:8	5:9	1:9	7:8	3:7	4:8	8:8	2:9	1:10
R^2	.89	.49	.92	.78	.72	.89	.77	.69	.86	.88	.67	.51	.85	.79	.83	.71	.85	.43	.71	.74	.83	.72	.71	.74	.20	.89	.71
Yield	-.12	.34 ****	.45 **	.56 ****	.30	.90 ****	.40 ****	.53 ****	.62 ****	.51 ****	.37 ****	.37 ****	.42 ***	.36 ****	.39 *	.51 ****	.44 *	.29 *	.43 ****	.39	.63 ****	.44 ***	.52 ****	.59 ****	.66 **	.71 ****	.58 ****
Average Quality Number	1.38 ****	.60 ****	1.96 ****	1.01 ****	1.78 ****	2.24 ****	1.02 ****	1.14 ****	1.18 ****	1.99 ****	1.10 ****	.57 ****	1.53 ****	.76 ****	1.83 ****	.90 ****	1.90 ****	.54 **	.72 ****	1.54 **	.71 ****	1.14 ****	.90 ****	.60 ***	.73 *		.43 **
Quality Number Range		-.67 **		-.47 **	-1.85 *		-.64 *				-.64 *			-1.06 ****		-.80 **			-.62 **		-.74 *		-.89 **			-.75 *	-.74 *
Average Staple Length							.72 *			1.62 *											.64 *						
Staple Length Range									1.06 *													-2.09 *	.60 *				
Degrees of Freedom	14	55	28	55	25	63	39	59	53	26	57	61	35	40	21	49	18	38	47	8	40	51	30	27	36	20	35

TABLE 24 (cont.)

Brokers' Regression Coefficients : 1969/70 Season

Centre / Sale	6:1	8:1	7:1	5:1	7:2	5:2	1:2	2:2	6:2	8:2	4:2	3:2	5:3	1:3	7:3	2:3	8:3	4:3	3:3	5:4	6:3	7:4	2:4	8:4	1:4	4:4	3:4	5:5	1:5	7:5
R^2	.74	.75	.72	.86	.87		.65	.59	.71	.40	.54	.56	.88	.62	.88	.55	.31	.58	.44	.93	.81	.83	.67	.49	.60	.56	.60	.87	.53	.87
Yield	.43 *	.72 **	.67 **	.29 *	-.12		.48 **	.15	-.07	.22	.21	.32 *	.22	-.09	-.30 *	.08	-.01	.17	.20	.07	.10	-.30	.06	.44 *	.35	.11	.17	.01	.28	.02
Average Quality Number	1.13 ****	.64 *	1.32 ****	1.61 ****	1.26 ****		1.02 ****	.95 ****	.91 ****	.43 ****	.89 ****	.68 ****	1.71 ****	.96 ****	1.30 ****	.96 ****	.44 ***	.96 ****	.94 ****	1.34 ****	1.13 ****	1.56 ****	1.06 ****	.85 ****	1.11 ****	.79 ****	.96 ****	1.24 ****	.94 ****	1.49 ****
Quality Number Range												.32 *																		
Average Staple Length				2.89 **								.70 **	2.12 **		1.79 **					1.36 **		1.36 **								1.79 **
Staple Length Range				-2.33 *						1.27 *										-1.39 *		2.78 *								
Degrees of Freedom	20	11	27	20	64		22	25	41	27	28	48	25	33	50	33	35	28	50	28	28	35	38	34	39	30	43	12	33	37

Centre / Sale	2:5	8:5	4:5	6:4	3:5	1:6	5:6	2:6	7:6	4:6	8:6	1:7	5:7	3:6	7:7	2:7	6:5	1:8	4:7	8:7	2:8	5:8	1:9	7:8	3:7	4:8	8:8	2:9	1:10
R^2	.43	.42	.46	.83	.31	.51	.82	.33	.80	.48	.11	.30	.77	.22	.86	.39	.52	.32	.50	.72	.12	.76	.80	.82	.83			.98	.87
Yield	.30	.90	.34	-.02	.23	.50 **	.05	.17	-.14	.69 **	.19	.43 **	-.10	.36 **	-.40 *	.36 *	-.05	.53 **	.47 *	.54 ****	.17	-.03	.52 ****	-.74 *	.53 ****			.60 **	.63 ****
Average Quality Number	.78 ****	.84 ***	.53 ***	.87 ****	.50 ***	.62 ****	1.04 ****	.53 **	1.14 ****	.78 ****	.33	.22	1.05 ****	.40 **	.88 ****	.31 *	.41 *	.41 **	.61 **	.61 ***	.28	1.00 **	.36 ***	.69 '**	.28 **				.19 *
Quality Number Range		-1.28 *		-.70 *																								-.31 *	
Average Staple Length													2.36 **		1.85 **	.98 *									.56 *				
Staple Length Range																													
Degrees of Freedom	47	35	35	34	40	36	28	40	18	33	28	30	30	30	22	35	24	27	11	27	11	16	24	18	11				17

TABLE 24 (cont.)

Brokers' Regression Coefficients : 1970/71 Season

Centre / Sale	6:1	7:1	5:1	7:2	5:2	1:2	6:2	2:2	8:2	4:2	3:2	5:3	1:3	7:3	2:3	8:3	4:3	3:3	5:4	6:3	7:4	2:4	8:4	1:4	4:4	3:4	5:5	1:5
R^2	.69	.79		.81	.88	.83	.71	.73	.95	.81	.56	.66	.72	.82	.65	.88	.65	.74	.85	.75	.71	.70	.88	.94	.77	.91	.89	.66
Yield	.51 **	.48 **		.11	-.58	.44 **	.22	.62 ****	.65 ****	.71 ****	.42 ***	.31	.42 **	.51 ****	.54 ****	.62 ****	.48 **	.48 ****	.05	.44 ****	.78 ****	.66 ****	.56 ****	.53 ****	.55 ****	.58 ****	.08	.59 **
Average Quality Number	1.43 **	1.49 ***		1.01 ****	.71	1.13 ****	.93 ****	1.09 ****	.36 *	1.17 ****	1.06 ****	1.16 ****	1.08 ****	1.13 ****	1.18 ****	.67 ****	1.28 ****	1.07 ****	.95 ****	1.16 ****	1.17 ****	.66 **	.39 **	1.39 ****	.60 ****	.98 ****	1.06 ****	.62 **
Quality Number Range													-.75 *											-.32 *				
Average Staple Length				1.11 *																								
Staple Length Range									-3.08 *																			
Degrees of Freedom	35	41		49	6	15	47	33	11	23	34	24	27	47	34	13	26	38	24	54	49	32	18	23	14	26	25	18

Centre / Sale	7:5	2:5	8:5	6:4	4:5	3:5	1:6	5:6	2:6	7:6	4:6	8:6	1:7	5:7	3:6	7:7	2:7	6:5	1:8	4:7	8:7	2:8	5:8	1:9	7:8	3:7	4:8	8:8	2:9
R^2	.78	.72		.90	.43	.35	.72	.74	.79		.68			.63	.47			.77					.64	.80		.85			
Yield		.51 ****		.50 ****	.63 **	.43 **	.62 **	.21 **	.63 ****		.55 **			.22	.49 **			.40 ****					.15	.60 ***		.77 ****			
Average Quality Number	.89 ***	.66 ****		1.03 ****	.40 *	.33 *		.86 ****	.71 ***		.22			.88 ****	.61 *			.76 ***					.88 **	-.76		.41 *			
Quality Number Range																													
Average Staple Length	1.79 **								1.33 **																	1.25 *			
Staple Length Range																													
Degrees of Freedom	32	45		37	17	24	9	38	17		7			27	10			24					12	10		8			

In general, the regression coefficient, $\hat{\beta}_i$, is a function of the correlation between X_i and Y_i and the variances of X_i and Y_i. Thus, a decrease in $\hat{\beta}_i$ may be caused by one of three occurrences:

(i) An increase in the variance of X_i;

(ii) A decrease in the variance of Y_i;

(iii) A decrease in the correlation between X_i and Y_i.

The mean standard deviations of sale price and appraised yield over the first half of the 1969-70 season compared with their respective mean values over all three seasons are given in table 25.[21]

TABLE 25

Mean Standard Deviations of Sale Price and Appraised Yield

	Average Standard Deviation	
	Period 1968/69-1970/71	Period 1/10/69-30/4/70
Buyer Yield	3.60	2.26
Broker Yield	3.64	2.53
Sale Price	4.05	3.86

From table 25, on average during the period of 1969-70 concerned, the standard deviations of appraised yield were less than those over the three seasons as a whole; the standard deviation of sale prices was also less than the three-year average, but only marginally so. The net affect of these changes, other things being equal, would be to increase the regression coefficient for yield rather than to reduce it.

On this basis we cannot, therefore, discount the hypothesis that there was a substantial decrease in the power of yield as an explanatory variable of sale price. The implication of this is that, for a considerable period of the 1969-70 season, the economic importance of yield to brokers and at least one buying firm sharply declined.

21. The standard deviations of buyer yield, broker yield and sale price for each sale are given in Appendix A.

If this is the case, then it represents an anomalous situation since yield is a fundamental wool property, second in economic importance only to fibre diameter. The price margins for yield over this period would have been much less than indicated by the economic importance of yield before (or after). If yield is important at one point in time then relatively unimportant six months later, clearly the grower cannot confidently estimate the value of his clip nor anticipate the requirements of the market.

It is difficult to suggest a plausible reason for this phenomenon, possibly the demand situation over this period encouraged appraisers to place more emphasis on other wool features regardless of yield.

It must be remembered that basically this analysis has only revealed an interesting observation and it is possible that the apparent decline in the economic importance of yield during 1969-70 is in fact due to changes in the relationships between yield and other wool characteristics. However, obviously here is a situation that warrants further investigation and, whatever the reason for it, one which illustrates the sort of inefficiencies that occur in the wool auction system; both in rewarding growers for features desired by the trade and allowing them to accurately interpret these requirements.

It is also apparent from tables 23 and 24 that significant differences exist between coefficients for the same characteristic at consecutive sales in the same centre and at the same sale over the three seasons. Thus, a grower who sold his wool at the second Auckland sale in each season would have found an additional percent of yield, for example, worth 0.65 cents per pound, -0.09 cents per pound and 0.55 cents per pound in consecutive seasons. Similarly, in 1968-69 the difference between second and third Auckland sales in the value of an additional percent of yield was 0.17 cents per pound.

Such differences may be explained by differences in the composition of sale offerings or in the samples for which data was available. However, it is also possible that these results are further evidence of the confusing messages that the wool auction system gives to growers.

CHAPTER FOUR

RELATIONSHIPS BETWEEN APPRAISALS, BETWEEN APPRAISALS AND WOOL PRICES AND BETWEEN APPRAISED AND MEASURED GREASY WOOL CHARACTERISTICS

4.1 INTRODUCTION:

This chapter deals with the remaining three sections of this analysis, namely:

SECTION 4.2: The investigation of relationships between appraisals and between appraised and measured greasy wool characteristics.

SECTION 4.3: The investigation of the impact of economic circumstances on appraisal.

SECTION 4.4: The investigation of the effect of objective measurement on the equity of income distribution among growers.

As for the previous chapter, each section is preceded by a brief outline of the section and this is followed by a full discussion of the analysis concerned.

4.2 RELATIONSHIPS BETWEEN APPRAISALS AND BETWEEN APPRAISED AND MEASURED GREASY WOOL CHARACTERISTICS:

Outline:

(i) The linear relationships between appraisals and between appraised and measured characteristics were investigated by simple correlation. Tests between individual means were also carried out.

(ii) For the two most important fleece characteristics, yield and fibre diameter, the distributions of appraisals about measurement were determined and studied.

(iii) The results of (i) and (ii) above suggested that, for yield, appraisers tend to appraise towards the mean. That is, appraisers tend to under-yield high yielding wools and over-yield low yielding wools. Accordingly this hypothesis was tested.

4.2.1 Correlation Coefficients and Tests Between Individual Means:

To establish the relationships between appraisals and between appraised and measured characteristics, a correlation matrix of appraised and measured parameters was calculated in which r, the correlation coefficient, is defined as:

$$r = \frac{n\sum XY - (\sum X).(\sum Y)}{((n\sum X^2 - (\sum X)^2).\ (n\sum Y^2 - (\sum Y)^2))^{\frac{1}{2}}};$$ where X and Y are two variables

The correlation matrix, calculated for 5757 binned lots over three seasons, is given in table 26. The means and standard deviations of the fourteen variables involved are given in table 28.

Because of the large number of observations used, most of the correlation coefficients are significant at the 0.1% level.[1] All of the coefficients for the correlations between appraisals and between appraisals and measurement for the same characteristic are high (i.e. r = 0.76 or greater), except for the associations between appraised quality number ranges and length ranges. The correlation between buyer quality number range and broker quality number range is only 0.317, although this value is significant, while the correlation between broker and buyer length ranges is -0.017 and is non-significant.

Apart from the expected high correlations between appraisals and between appraisals and measurement on the same characteristic, the correlation coefficients also reveal several other significant relationships which would not otherwise be immediately obvious. These are:

(i) A positive association between appraised fineness and appraised yield (i.e. for the buying firm, r = 0.441; for the brokers, r = 0.509). Whan and Moffatt[2] suggest that appraisers tend to confine their estimates of yield within a narrow range around the average yield for the type, which they assess first. This would result in a functional relationship between quality number, the prime determinant of style, and yield.

---

1. The significance of a sample correlation coefficient is tested by computing:

$$t = \frac{r\sqrt{n-2}}{1-r^2}$$

and inferring a significant correlation between X and Y if $|t|>t_e$; where t_e is an appropriate value from the 't' distribution with n - 2 degrees of freedom.

2. Whan, R.B. and Moffatt, D.H.; "Some Differences between Estimated and Tested Yields for Greasy Wool Sold in Australia", J.Text.Inst., 59:1, p.39, 1968.

TABLE 26

Correlation Coefficients - 5757 binned lots

	Buyer Yield	Buyer Avg. Q. No.	Buyer Q. No. Range	Buyer Avg. Length	Buyer Length Range	Broker Yield	Broker Avg. Q. No.	Broker Q. No. Range	Broker Avg. Length	Broker Length Range	Meas. Yield	Meas. Fibre Dia.	Meas. Length
Buyer Avg. Q. No.	-.441												
Buyer Q. No. Range	-.099	-.311											
Buyer Avg. Length	.325	-.327	-.202										
Buyer Length Range	.161	-.237	.049	.346									
Broker Yield	.881	-.518	-.028	.308	.167								
Broker Avg. Q. No.	-.427	.959	-.331	-.291	-.223	-.509							
Broker Q. No. Range	-.044	-.271	.317	-.183	-.034	-.001*	-.291						
Broker Avg. Length	.302	-.386	-.143	.771	.147	.309	-.363	-.160					
Broker Length Range	.013*	-.052	.017*	.064	-.017*	-.005*	-.044	.089	.093				
Measured Yield	.785	.572	.077	.240	.187	.782	.563	.080	.248	.020*			
Measured Fibre Dia.	.415	-.865	.263	.280	.154	.493	-.877	.261	.397	.041*	.538		
Measured Length	.330	-.462	-.111	.763	.130	.344	-.435	-.117	.850	.100	.286	.465	
Measured Length S.D.	.050	-.388	.136	.368	.098	.070	-.374	.098	.440	.104	.118	.335	.514

* denotes <u>non</u>-significant at 5% level.

However, the existence of a true physical relationship between yield and fibre diameter is confirmed by the coefficient for measured fibre diameter and measured yield (i.e. r = 0.538). This coefficient is larger than both of the coefficients for appraised quality number implying that the appraisers underestimate the strength of the relationship between yield and fibre diameter. This could be related to the tendency for appraisers to over- or under-estimate extreme yields (this hypothesis is discussed later in Section 4.2.3).

(ii) A positive relationship between length and fibre diameter (i.e. r = 0.465). While it is not apparent why measured length and fibre diameter should be related,[3] the equivalent relationships for appraised length and quality number can be explained by the relationship between quality number, crimp frequency and length.[4]

(iii) A positive relationship between length and yield. Intuitively, anyway, it could be expected that longer wools would trap more dirt and vegetable matter than shorter wools. In this case the association between length and yield would be negative. However, it could also be expected that shorter wools would be less weathered and thus contain relatively more grease and suint than longer wools. If this were the case the association between length and yield would be positive. The relationship between length and yield probably involves both of these factors.

Although the correlation between measured length and measured yield is only 0.286, the equivalent appraised relationships are higher (i.e. for the buying firm, r = 0.325; for the brokers, r = 0.309).

(iv) A positive relationship between measured length and measured length standard deviation (i.e. r = 0.514). This indicates that, as average staple length increases, so its variation increases. Similar relationships exist between buyer- and broker-appraised staple length and staple length range, but the association is much weaker; in fact for the brokers the coefficient is almost non-significant. (The definition of appraised staple length range has been discussed previously. See Chapter Three, Section 3.2.2). It is is interesting to note that the associations between appraised average staple length and measured length standard deviation are quite strong, however.

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3. A positive association between length and fibre diameter would tend to occur if finer wooled sheep were shorn more frequently.
4. See Chapter Two, Section 2.4.3.

(v) A positive relationship between measured staple length standard deviation and fibre diameter (i.e. r = 0.335). This relationship is difficult to explain but is probably due to the relatively strong relationships between staple length standard deviation and staple length, and staple length and fibre diameter. Similar weak, negative associations exist between appraised quality number and appraised staple length range.

(vi) A negative association between quality number and quality number range (i.e. For the buying firm, r = -0.311; for the brokers, r = -0.291). This implies that coarser wools are more variable with respect to their fibre diameter and, biologically, this is in fact the case. In addition, classers sort finer wools more precisely on the basis of quality number than they do coarse wools. This is related to the range of end uses for fine and coarse wools and results in coarse bins generally having a wider quality number range than fine bins. The relationship between quality number and its range is investigated later in Section 4.2.2.

At this point it is interesting to compare the results of this study with those of Ross[5] who investigated the interelations of count, fibre diameter, staple crimp, staple length and yield in data on 76 fine (i.e. Merino and Halfbred) wool sale lots and 168 crossbred sale lots. The lots in Ross's analysis varied in appraised count from 40/44's to 64's.

There is relatively poor agreement between the correlation coefficients calculated by Ross and those calculated from data on 5757 lots used in this analysis. However, Ross's coefficients were based on data from lots sold in only two centres, Dunedin and Christchurch. Of the 244 lots measured by Ross, 180, or 74%, were from Dunedin and, when his results are compared with coefficients calculated on data from 977 lots sold only in Dunedin, the agreement is much better. This is shown in table 27.

There are no significant differences between the coefficients calculated by Ross for his fine wool lots and those calculated for the Dunedin lots included in this analysis. In general the latter tend to be smaller than the total correlation coefficients calculated by Ross, but larger than his coefficients for crossbred lots.

5. Ross D.A.; "The Relation of Count to other characteristics of New Zealand Wools", N.Z.J. Agric.Res., 7: p.666, 1964.

TABLE 27

Comparison of Correlation Coefficients

	This Study			Ross (1964)		
	Buyers	Brokers	Measured	Crossbred	Fine	Total
Length vs. Count						
All Data	-.327	-.363		-.686**	-.756**	-.943**
Dunedin	-.653	-.640				**
Length vs. Diameter						
All Data			.465	.409	.676**	.897**
Dunedin			.768	**		**
Yield vs. Count						
All Data	-.441	-.509		-.204**	-.720**	-.793**
Dunedin	-.667	-.736		**		**
Yield vs. Diameter						
All Data			.538	.623	.793**	.881**
Dunedin			.742	**		**
Yield vs. Length						
All Data	.302	.309	.286	.171	.615**	.766**
Dunedin	.617	.559	.709	**		

** denotes that the difference between Buyers' and Brokers' coefficients and Ross's coefficients is significant at 1% level. For Yield vs. Diameter, Dunedin lots, Ross's total wool coefficient is significantly larger than that for the Buyers but not for the Brokers. All other differences are non-significant.

To test the significance of the difference between two independent estimates of a correlation coefficient it is incorrect, particularly in the case of small samples, to rely on using the standard error of the correlation coefficient itself. The distribution of r is very far from the Normal distribution, which is tacitly assumed as a good approximation when the standard error approach is used. It is, however, correct in most cases to transform the estimates by Fisher's Z transformation and to refer the difference of these Z values to the standard error of their difference.[6]

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6. Moroney, M.J.; Facts from figures, Penguin Books, London, p.314, 1954.

Fisher's Z transformation is of the form:

$$Z = 1.15 \log_{10} \left(\frac{1 + r}{1 - r} \right)$$

where N_1 and N_2 are the sizes of the samples from which the correlation coefficients were calculated, and the standard error of the difference between two Z values is given by:

$$\sqrt{\frac{1}{N_1 - 3} + \frac{1}{N_2 - 3}}$$

The significance of the t value given by:

$$t = \frac{Z_1 - Z_2}{\sqrt{\frac{1}{N_1 - 3} + \frac{1}{N_2 - 3}}}$$

is tested against an appropriate value, t_e , from the t distribution and a significant difference inferred if $|t| > t_e$.

Tests of significance on the differences between correlations of appraisals and of appraised and measured characteristics in this analysis revealed the following:

(i) The correlations between appraisals on the same parameters are significantly higher than those between appraisals and equivalent measured characteristics (except for the association between broker-appraised average length and measured length).

(ii) The correlations between broker-appraised average quality number and average staple length and their measured equivalents are significantly higher (at the 1% level) than those for the same buyer-appraised characteristics and their measured equivalents.

(iii) In three South Island centres, Christchurch, Timaru and Dunedin, the positive associations between yield and fibre diameter, length and fibre diameter and length and yield are very strong. In fact, in these centres these coefficients are approximately 20% higher than the same coefficients in other centres or for all lots together.[7]

In addition, correlations between appraisals on the same parameters are significantly lower in these centres (the coefficients for staple length range were non-significant), while the correlations between appraised characteristics and their measured counterparts are significantly higher, except for the association between appraised and measured length for which the reverse is the case.

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7. Tables of correlation coefficients, parameter means and standard deviations, calculated for each of the three seasons 1968-69, 1969-70 and 1970-71, and for each selling centre are given in Appendices B and C.

A possible explanation for these results is the suggestion that the samples from these three centres are finer than samples from other centres or the total sample, and that the relationships between fleece characters are therefore stronger. However, while measured fibre diameter is lower and quality number higher for these centres, the differences are not significant.

(iv) Coefficients for the 1970-71 season are, in general, significantly higher than those in 1969-70 which, in turn, are generally larger than those in 1968-69. One could hypothesise that, as the W.R.O.'s measurement programme progressed, brokers' appraisals would become more accurate and hence the correlations between broker appraisals and measured characteristics would increase over time. This may be true, and, though it could also be hypothesised that improved broker performance would influence buyers and thus increase the accuracy of their estimates, it does not explain the increase in correlations between measured characters.

Despite these significant differences observed between correlation coefficients over time, between centres and within centres, there are no significant differences between the mean values of any parameter[8] (see table 28). This applies not only to all the lots analysed as a whole but also within and between seasons and within centres.

The lack of significant differences between means indicates that, on average, over a large number of lots, there is close agreement between the buying firm's and brokers' appraisals and between appraisals and measurements. However, correlation coefficients show that, for individual lots, the agreement between appraisers is less satisfactory and individually their estimates may be in error.

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8. The significance of the difference between two sample means is tested by computing:

$$t = \frac{\text{difference between means}}{\text{standard error of the difference between means}}$$

and inferring a significant difference if $|t| > t_e$; where t_e is an appropriate value from the t distribution with n-2 degrees of freedom.

TABLE 28

Means and Standard Deviations

(5757 Binned lots)

Characteristic	Mean	Standard Deviation
Buyer Yield (%)	75.53	4.21
Buyer Average Quality Number	48.80	3.85
Buyer Quality Number Range	1.64	1.45
Buyer Average Length (in)	4.21	1.06
Buyer Length Range (in)	1.57	0.59
Broker Yield (%)	74.92	4.25
Broker Average Quality Number	49.23	4.00
Broker Quality Number Range	2.53	1.35
Broker Average Length (in)	4.66	1.12
Broker Length Range (in)	1.86	1.13
Measured Yield (%)	76.58	4.73
Measured Fibre Diameter (Microns)	33.27	3.50
Measured Length (in)	4.59	0.94
Measured Length Standard Deviation	0.90	0.22

This situation is illustrated by the appraisers' estimates of quality number range and staple length class. While the differences between mean buyer and broker quality number range and staple length range are non-significant, the correlation coefficients for the relationships between appraisals of these parameters are extremely low. In fact, for staple length range, there was no significant linear association between the two appraisals.

Thus although total revenue to growers is probably unaffected by appraisal errors, the equity of income distribution among growers is not.[9] Furthermore, the possibility of variation in brokers' and buyers' appraisals means that the grower may be forced to make ill informed judgements about the textile industry's quality requirements.

9. This is investigated in Section 4.4.

4.2.2 The Relationship Between Appraised Yield and Measured Yield and Quality Number and Fibre Diameter:

In this particular section only yield and quality number were considered for two reasons:

(i) The importance of yield and fibre diameter. These are by far the most important determinants of wool prices.

(ii) As far as length is concerned, exhaustive studies of the relationship between appraised and measured length have already been carried out on these lots by W.R.O.[10]

For the buyers and the brokers, six different quality numbers were selected on the basis of appraised quality number.[11] The appraised yield for each lot was subtracted from the measured yield to produce a yield difference. Then a table of quality numbers and their respective fibre diameter ranges was set up.[12]

For each quality number (two fine, two medium, two coarse) the measured fibre diameter of each lot and its yield differences were converted into frequency distributions and the following percentages calculated.

(i) % yield estimates lower than measured yield.
(ii) % " " equal to " " ($\pm$ 0.5%).
(iii) % " " greater than " "
(iv) % fibre diameters coarser than the expected fibre diameter.
(v) % " " equal to " " " "
(vi) % " " finer than " " " "

In addition, means and variances of estimated and tested fibre diameter and yield and correlations between appraisals and measurements on these parameters were calculated.

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10. Fraser, I.E.B.; "Improvements in Wool Handling for Market", Wool Tech. Sheep Breeding, 16:1, p.19, 1969.

11. The same six quality numbers were selected for both the buyers and brokers but, because in some cases the broker quality numbers contained only a small number of observations, adjacent quality numbers were also investigated. Thus, results are given for six buyer-appraised and nine broker-appraised quality numbers.

12. The quality number/fibre diameter table used was "Proposed National Wool Standards for Fineness and Description", found in: Agar, M.M.; "Objective Measurement and Sale by Sample in New Zealand and Australia", Wool, 5:4, p.22, 1972/73.

These results are given in tables 29, 31 to 33 and 36 to 39. In these tables and the discussion which follows, a 'correct' appraisal refers to a yield estimate which equals its measured equivalent plus or minus 0.5%, or to a fibre diameter which falls in the range expected for a lot of its appraised quality number.

Thus, the concept of a 'correct' or 'incorrect' appraisal is related to the accuracy of the measured data; the assumption being that measured yield and fibre diameter are correct.

(a) The relationship between appraised yield and measured yield.

From table 29 it is apparent that, in general, as quality number increases the percentage of lots over-yielded increases and the percentage of lots under-yielded decreases, and vice versa as quality number increases. This observation, which is illustrated in Fig.1, is true for both the buying firm and the brokers and is confirmed by the results of a further analysis in which the lots concerned were categorised on the basis of measured fibre diameter. These categories were:

1. fine : 27.9 microns and finer
2. medium : 28.0 microns - 33.5 microns
3. coarse : 33.6 microns and coarser.

The results of this analysis are summarised in table 30.

Table 30 shows that, as fibre diameter increases, the percentage of lots under-yielded increases and the percentage of lots over-yielded decreases. It is also interesting to note that, as fibre diameter increases, the percentage of lots correctly appraised also increases. This latter observation conflicts with the situation revealed by the distributions of appraised yield about measured yield for different quality numbers (see table 29). For these distributions the percentage of lots correctly estimated by the buyers remains relatively constant as quality number decreases (i.e. as fibre diameter increases) while the percentage correctly estimated by the brokers tends to decrease as quality number decreases. This analysis does not, however, suggest reasons for these differences.

On nearly 6,000 lots the buying firm and the brokers correctly yielded approximately the same number of lots (about 15%), and, as previously discussed, there are no significant differences between appraised means or between appraised and measured means. However, on these lots the buying firm over-yielded more and under-yielded less than the brokers; the difference being approximately 11%.

TABLE 29

The Distribution of Appraised Yields about Measured Yield

Quality Number	Buyer - Estimated Yield				Broker - Estimated Yield			
	Number of lots	% Over-Estimated	% Correctly Estimated	% Under-Estimated	Number of lots	% Over-Estimated	% Correctly Estimated	% Under-Estimated
58/60					112	45.53	16.96	37.47
58/58	125	75.20	11.20	13.60	27	55.55	25.92	18.51
56/58					254	37.40	14.17	48.38
56/56	187	62.54	13.90	23.51	36	27.77	25.00	47.22
52/54					286	26.22	12.58	61.13
52/52	462	44.70	15.58	37.61	100	31.00	18.00	51.00
50/50	536	45.46	15.29	39.13	147	23.80	11.56	64.60
46/48	966	20.76	12.31	66.73	475	24.42	13.47	62.07
44/46	464	14.62	10.34	74.95	282	12.41	10.28	77.26
Total	2740	34.35	13.21	52.42	1719	26.97	13.69	59.34

TABLE 30

The Distribution of Appraised Yields about Measured Yield

Fibre Diameter	Buyer - Estimated Yield				Broker - Estimated Yield			
	Number of Lots	% Over-Estimated	% Correctly Estimated	% Under-Estimated	Number of Lots	% Over-Estimated	% Correctly Estimated	% Under-Estimated
Fine	417	45.86	11.04	43.10	417	31.42	11.67	56.90
Medium	2305	47.25	13.02	39.74	2305	33.36	14.36	52.28
Coarse	2976	25.54	21.64	52.82	2976	19.66	19.05	61.29
Total	5698	38.23	14.58	47.18	5698	27.84	15.55	56.60

TABLE 31

The Distribution of Buyer-Appraised Yield about Measured Yield

Measured Yield minus Appraised Yield (a)		Buyer Yield Greater than Measured Yield										Buyer Yield Less than Measured Yield								
Quality Number	Number of Lots	-9%	-8%	-7%	-6%	-5%	-4%	-3%	-2%	-1%	0	1%	2%	3%	4%	5%	6%	7%	8%	9%
58/58	125	0.80	0.80	1.60	6.40	4.80	15.20	13.60	18.40	13.60	11.20	6.40	3.20	1.60	0.80	0.80		0.80		
56/56	187		0.53	1.06	2.67	5.88	9.09	9.09	16.04	18.18	13.90	10.16	6.41	4.27	2.67					
52/52	462	2.81	0.21	0.43	0.64	2.59	4.54	8.87	11.25	15.36	15.58	15.58	10.17	4.54	3.24	1.94	1.29	0.43	0.21	0.21
50/50	536	0.18	0.18	1.30	1.11	1.86	3.91	8.39	11.00	17.53	15.29	15.29	8.58	6.52	6.34	1.30	0.55	0.55		
46/48	966	0.10		0.10	0.20	0.51	1.75	3.20	5.90	9.10	12.31	16.97	16.56	13.97	9.00	6.21	2.48	0.72	0.51	0.31
44/46	464			0.21		0.21	0.21	1.50	3.44	9.05	10.34	18.96	16.37	16.59	10.56	6.89	3.44	1.50	0.43	0.21
Total	2740	0.58	0.15	0.55	0.88	1.64	3.50	5.77	8.65	12.63	13.21	15.66	12.63	10.15	7.01	3.98	1.79	0.73	0.29	0.18

a. Corrected to the nearest whole percent.

TABLE 32

The Distribution of Broker-Appraised Yield about Measured Yield

Measured Yield minus Appraised Yield (a)		Broker Yield Greater than Measured Yield										Broker Yield Less than Measured Yield								
Quality Number	Number of Lots	-9%	-8%	-7%	-6%	-5%	-4%	-3%	-2%	-1%	0	1%	2%	3%	4%	5%	6%	7%	8%	9%
58/60	112	1.78		0.89	0.89	1.78	4.46	7.14	9.82	18.75	16.96	10.71	8.92	7.14	3.57	4.46		2.67		
58/58	27						14.81	3.70	18.51	18.51	25.92	11.11	7.40							
56/58	254				1.18	2.75	2.36	7.08	10.23	13.77	14.17	14.56	7.48	9.44	5.51	3.93	3.54	0.78	0.78	2.36
56/56	36						8.33	2.77	5.55	11.11	25.00	22.22	11.11	8.33			2.77	2.77		
52/54	286	0.34				0.34	2.79	2.79	6.29	13.63	12.58	18.88	15.38	10.83	4.54	5.24	2.44	2.09	0.69	1.04
52/52	100					1.00	2.00	4.00	11.00	13.00	18.00	14.00	18.00	13.00	2.00		2.00	2.00		
50/50	147			0.68		0.68	0.68	5.44	5.44	10.88	11.56	11.56	19.72	12.24	9.52	6.12	3.40	0.68	0.68	0.68
46/48	475	0.21		0.21	0.21	0.42	1.89	3.15	5.68	12.63	13.47	16.42	15.15	13.47	6.31	5.68	3.36	1.05	0.21	0.42
44/46	282						0.35	1.41	4.25	6.38	10.28	13.12	19.14	14.89	12.41	7.44	5.31	1.77	1.77	1.41
Total	1719	0.23		0.18	0.29	0.82	2.27	3.90	6.99	12.29	13.69	15.14	14.56	11.82	6.52	5.07	3.20	1.46	0.64	0.93

a. Corrected to the nearest whole percent.

Correlation coefficients calculated in the previous section show that there is a significant relationship between fibre diameter and yield (i.e. r = 0.538; as fibre diameter increases, so yield increases). It can be postulated that appraisers have more difficulty assessing extreme yields and for this reason produce larger than usual estimation errors for the lots associated with either end of the yield scale. This would explain why the yield of coarse and fine wools tends to be under- and over-estimated but not why the error should be in the direction that it is. To explain the latter it could be hypothesised that there is a tendency in subjective appraisal to narrow the range of appraisals towards their mean. Since fine wools are generally lower yielding than coarse wools, this would explain why the former tend to be over-yielded and the latter under-yielded.

In fact, it has been shown in a number of experiments[13] that appraisers are non-linear in estimating the yield of wool; very high yielding wools are usually under-estimated and very low yielding wools over-estimated. This phenomenon is investigated in Section 4.2.3.

An examination of tables 33 and 34 reveals that, for all cases except one (buyer-appraised 56's), the variances for tested yields are higher than those for both the buying firm's and brokers' estimates. These differences are highly significant in total and for each quality number except broker-appraised 58's.

The yield variances calculated in this analysis are, in general, significantly greater than those reported by Whan and Moffat.[14] This difference is explained by the fact that Whan and Moffat used data on growers' lots rather than on binned lots as in this analysis. The variance of wool characteristics in binned lots, containing wool from a number of different clips, is greater than the variance of characteristics in growers lots, containing wool from only one clip.[15]

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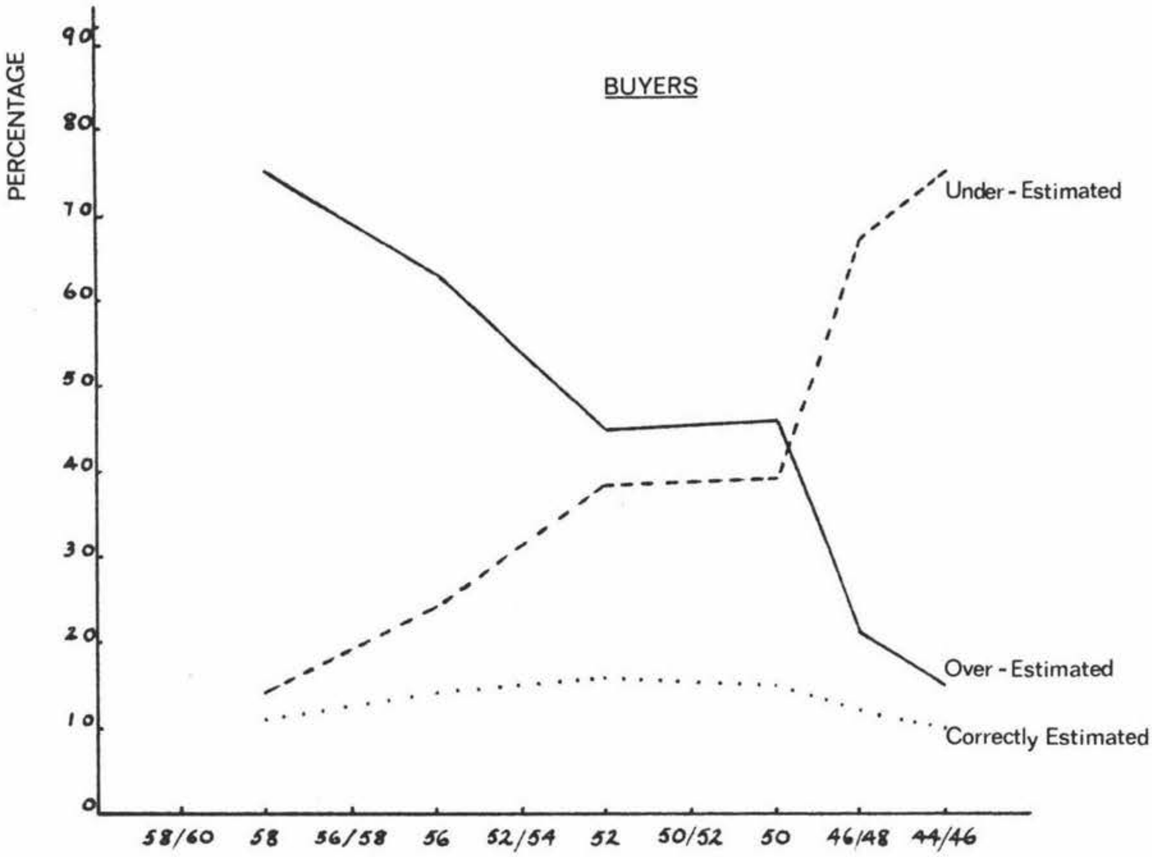
13. Roberts, N.F.; "The Relation Between the Softness of Handle of Wool in the Greasy and Scoured States and its Physical Characteristics", Text.Res.J., 26:8, p.687, 1956.

14. Whan, R.B. and Moffat, D.H.; "Some Differences Between Estimated and Tested Yields for Greasy Wool Sold in Australia", J.Text.Inst., 59:1, p.39, 1968.

15. Whan, R.B.; "Potential Savings from the Sale of Wool by Sample and Measurement", Quart.Rev.Agric.Econ., 14:4, p.208, 1971.

FIG. 1. The relationship between appraised yield and quality number.



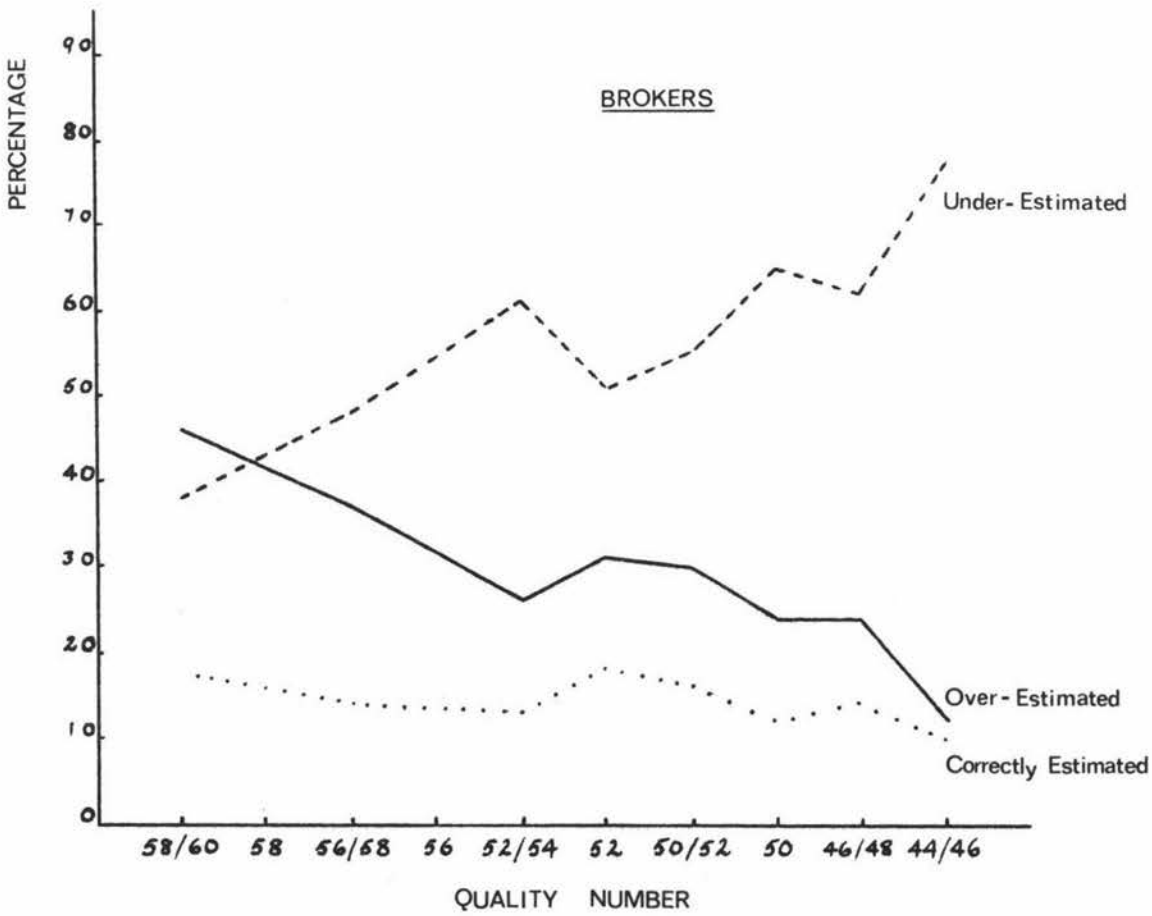


TABLE 33

Means and Variances of Appraised and Measured Yields

		Buyer-estimated Yield		Measured Yield			Broker-estimated Yield		Measured Yield	
Quality Number	Number of Lots	Mean (%)	Variance (s^2)	Mean (%)	Variance (s^2)	Number of Lots	Mean (%)	Variance (s^2)	Mean (%)	Variance (s^2)
58/60						112	68.51	7.01	68.36	12.12
58/58	125	70.21	7.17	68.27	11.49	27	66.70	5.22	65.89	7.50
56/58						254	68.91	13.88	69.55	14.32
56/56	187	70.02	19.63	69.11	15.87	36	69.33	6.17	69.75	13.42
52/54						286	73.56	11.87	74.65	17.24
52/52	462	75.13	13.14	74.87	13.53	100	75.00	8.08	75.62	11.53
50/50	536	76.83	9.69	76.57	33.40	147	76.95	3.18	78.32	8.78
46/48	966	77.36	5.21	78.77	9.42	475	77.19	3.75	78.60	7.52
44/46	464	77.32	4.35	79.21	9.16	282	77.32	7.25	79.68	9.19
Total	2740	77.02	13.25	77.54	20.96	1719	74.34	20.04	75.53	28.23

TABLE 34

Differences and Correlations between Appraised and Measured Yields

Quality Number	Buyers vs. Measured				Brokers vs. Measured			
	Number of Lots	Average Yield Difference (%) (a)	Variance Ratio (b)	Correlation Coefficients (c)	Number of Lots	Average Yield Difference (%)	Variance Ratio	Correlation Coefficients
58/60					112	0.15	1.73	.577
58/58	125	-1.94	1.60	.671	27	0.82	1.44N.S.	.785
56/58					254	0.64	1.03	.665
56/56	187	-0.86	1.24	.737	36	0.42	2.17	.550
52/54					286	1.09	1.45	.737
52/52	462	-0.26	1.03	.725	100	0.62	1.43	.735
50/50	536	-0.27	3.45	.669	147	1.37	2.77	.487
46/48	966	1.40	1.81	.600	475	1.41	2.00	.490
44/46	464	1.89	2.11	.646	282	2.36	1.27	.504
Total	2740	0.52	1.58	.794	1719	1.19	1.41	.848

a. Measured yield - appraised yield.

b. Variance measured yield / variance appraised yield.

c. Correlation between appraised and measured yield.
All yield differences non-significant.
All variance ratios significant at 0.1% level, unless denoted N.S.

There are no significant differences between the averages of the buyers' estimates and measured yields or of the brokers' estimates and measured yields (see table 34). However, both appraisers tend to over-estimate the yield of the finer wools and under-estimate the coarser types, with the result that there is a trend from the 58's, where the buyer- and broker-appraised yields are 1.94% and 0.82% greater than the measured yields, to the 44/46's, where the estimated yields are 1.89% and 2.36% lower.

The correlations of appraised and measured yield are all significant; a much more satisfactory situation than the one reported in Whan and Moffat's[16] analysis, where in no case did the coefficients differ significantly from zero. Correlation coefficients are a measure of the agreement between estimated and tested yields for individual lots and in this analysis they range from 0.49 to 0.78 for individual quality numbers and, in total, are 0.79 for the buying firm and 0.85 for the brokers. Thus, in general for individual binned lots, there is fairly good agreement between appraised and measured yield.

TABLE 35

Differences between Buyer- and Broker-Appraised Yield.

Quality Number	Average Yield Difference (%) (a)	Variance Ratio	Correlation Coefficient Difference
58/58	3.50	1.37N.S.	-.114
56/56	0.69	3.18	.198
52/52	0.13	1.63	-.010
50/50	-0.11	3.05	.182
46/48	0.17	1.39	.110
44/46	-0.01	1.67	.142
Total	2.67	1.51	-.056*

a. Average buyer yield - average broker yield.

All yield differences non - significant.

All variance ratios significant at 0.1% level, unless denoted N.S.

* denotes significant difference at 5% level.

16. Whan and Moffat; op.cit.

There are no significant differences between the averages of the buyers' and brokers' estimates of yield, however, there is a trend from the 58's, where the average buyer yield is 3.5% greater than the average broker yield, to the 44/46's, where the brokers' average yield is 0.01% higher (see table 35). For the quality numbers 58's to 46/48's the variances of the buyers' yield estimates are greater than those of the brokers' estimates. In total, and for the 44/46's, the relative size of the variances is reversed, but the total variances are not strictly comparable since the brokers' estimates of yield correspond to a wider range of appraised quality numbers.

Comparison of correlation coefficients shows that, in total, there is a significantly higher agreement on individual lots between the brokers' appraisals and measured yields than for the buying firm's appraisals and measured yields. However, within quality numbers there are no such significant differences.

(b) The relationship between quality number and fibre diameter.

This analysis reveals no discernable pattern of fineness estimation in the percentage of lots coarser or finer than expected, such as it did for yield estimation. However, three important results emerge from investigation of the relationship between quality number and fibre diameter which is summarised in tables 36, 37 and 38.

1. There is a spread of between 4.4 and 8.9 microns in diameter within each quality number. That is, two lots which have been typed with the same quality number may differ by as much as nearly nine microns in their diameter. The average diameter spread within a quality number is 6.7 microns for the buyers and 7.3 microns for the brokers.

The spread of diameter within a quality number is generally greater for lots in the crossbred range (average spread 8.05 microns) than those in the medium range (average spread 7.1 microns) which, in turn, is generally greater than for fine wools (average spread 6.0 microns).

2. There is considerable overlap in diameter between appraised quality numbers. For example, of the lots typed 46/48's by the buyers, 13.6% lie in the 44/46's diameter range, while 11% of the lots typed 44/46's by the buyers in fact lie in the 46/48's range. Similarly, for lots typed 46/48's by the brokers, 11.6% have diameters which lie in the 44/46's diameter range, while 10.6% of those typed 44/46's should be 46/48's on the basis of their measured diameter.

For Australian wools Charlton[17] reports that, within each quality number in the Merino range, there is an almost constant spread of five microns in diameter. He also notes that, in general, the finer quality numbers tend to contain a smaller range of fibre diameters than the broader quality ranges and that there is a considerable overlap in diameter between 'straight' quality numbers.

Despite these observations, it is clear from table 39 that, over a large number of lots containing wool from different sources, there are no significant differences either between the median micron value of appraised quality numbers and the average measured fibre diameter of lots in each category, or between the average measured diameter of lots appraised to have the same quality number by the buyers and the brokers.

The variance of measured fibre diameter generally increases as quality number decreases, supporting the observation that the finer quality numbers tend to contain a smaller range of fibre diameters than the broader types (see table 39). In total, the variance of measured fibre diameter for broker-appraised lots is significantly higher than the variance for buyer-appraised lots but, as was the case for yield, these two variances are not strictly comparable because of the wider range of broker-appraised quality numbers. Within quality numbers, the variance of measured diameter is significantly greater for buyer-appraised lots than broker-appraised lots for 58's, 46/48's and 44/46's, and vice versa for 56's, 52's and 50's.

3. On individual lots appraised fineness is often a poor estimator of fibre diameter. (The accuracy of appraisal in estimating average fibre fineness is not high because the diameter of individual wool fibres, each about one-thousandth of an inch, is below the limit of perception of the human eye).

It is apparent from table 38 that, on average, a broker is likely to over- or under-estimate between 65% and 80% of the lots he appraises on the basis of their fibre diameter (or quality number as he would use). Thus, for lots typed as 46/48's quality by the brokers, for example, about 44% are likely to actually be coarser than 46/48's, and 37% likely to actually be finer.

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17. Charlton, D.; "Purchasing Wool to Meet Micron Specifications", <u>Wool Tech. Sheep Breeding</u>, <u>12</u>:2, p.23, 1965.

TABLE 36

The Distribution of Measured Fibre Diameter Within Appraised Quality Number

Quality Number	Buyer-Appraised Quality Number				Broker-Appraised Quality Number			
	Number of Lots	% Over-Appraised	% Correctly Appraised	% Under-Appraised	Number of Lots	% Over-Appraised	% Correctly Appraised	% Under-Appraised
58/60					112	31.25	40.17	28.57
58/58	125	22.70	24.00	52.80	27	11.11	29.62	59.25
56/58					254	39.37	25.19	35.43
56/56	187	34.20	33.15	32.61	36	44.44	22.22	33.33
52/54					286	47.55	25.17	27.27
52/52	462	35.47	20.99	43.49	100	43.00	22.00	35.00
50/50	536	26.66	22.38	50.91	147	30.61	15.64	53.74
46/48	966	43.67	19.46	36.82	475	44.21	21.26	34.52
44/46	464	25.63	34.05	40.28	282	21.98	37.23	40.78
Total	2740	34.38	23.91	41.72	1719	37.76	26.06	36.23

TABLE 37

The Distribution of Measured Fibre Diameter Within Buyer-Appraised Quality Number

Appraised Quality Number	Measured Fibre Diameter : Micron Standard Quality Number (Percentages)																				Number of Lots
	60/64	60	58/60	58	56/58	55	54/56	54	52/54	52	50/52	50	48/50	48	46/48	46	44/46	44	40/44	36/40	
58/58	1.60	14.40	36.80	24.00	15.20	6.40	0.80			0.80											125
56/56	0.53		4.81	8.02	19.25	33.15	19.78	10.16	2.13	2.13											187
52/52					0.43	3.03	5.84	13.85	20.34	20.99	17.09	11.25	4.76	1.94	0.43						462
50/50						0.37	0.93	2.98	6.90	15.11	24.62	22.38	16.60	7.46	2.23	0.37					536
46/48						0.10			0.31	0.51	1.86	4.65	10.86	18.53	19.46	22.77	13.56	5.90	1.24	0.20	966
44/46											0.43	1.50	2.37	4.09	10.99	20.90	34.05	19.39	4.52	1.72	464
Total	0.11	0.66	2.00	1.64	2.08	3.18	2.56	3.61	5.04	6.86	8.43	8.18	8.29	8.98	9.23	11.68	10.55	5.37	1.20	0.37	2740

TABLE 38

The Distribution of Measured Fibre Diameter Within Broker-Appraised Quality Number

Appraised Quality Number	Measured Fibre Diameter : Micron Standard Quality Number (Percentages)																					Number of Lots
	64	60/64	60	58/60	58	56/58	56	54/56	54	52/54	52	50/52	50	48/50	48	46/48	46	44/46	44	40/44	36/40	
58/60	3.57	5.35	19.64	40.17	19.64	8.03	2.67	0.89														112
58/58		3.70	3.70	51.85	29.62	7.40	3.70															27
56/58		1.18	3.93	13.77	16.53	25.19	22.83	11.02	1.18	1.57	1.57	0.78					0.39					254
56/56			2.77	2.77	8.33	19.44	22.22	16.66	16.66	8.33	2.77											36
52/54						0.69	3.49	5.94	17.13	25.17	20.97	13.63	8.74	3.49	0.34	0.34						286
52/52						1.00	3.00	7.00	11.00	13.00	22.00	18.00	20.00	2.00	2.00	1.00						100
50/50						1.36	6.12	3.40	4.76	8.16	10.20	19.72	15.64	17.00	6.80	6.12	0.68					147
46/48											0.63	1.26	5.68	7.15	19.78	21.26	27.78	11.57	4.21	0.63		475
44/46												0.70	0.70	3.90	4.25	10.63	20.56	37.23	18.79	2.83	0.35	282
Total	0.23	0.58	1.98	5.53	4.36	5.06	5.35	3.72	4.42	6.05	6.12	5.59	5.64	4.77	6.92	8.26	11.17	9.31	4.25	0.64	0.06	1719

TABLE 39

Means, Variances and Differences of Measured Fibre Diameter Within Appraised Quality Numbers.

Quality Number	Median Micron	Buyer-Appraised Quality Number			Broker-Appraised Quality Number			Median Micron minus Average Fibre Diameter		Mean Fibre Diameter Difference (a)	Variance Ratio
		Number of Lots	Mean Measured Fibre Diameter (microns)	Variance (S^2)	Number of Lots	Mean Measured Fibre Diameter (microns)	Variance (S^2)	Buyer (microns)	Broker (microns)		
58/60	25.7				112	25.68	1.46		-.02		
58/58	26.6	125	26.26	1.26	27	26.14	0.71	-.34	-.46	.12	1.68
56/58	27.3				254	27.34	1.96		-.04		
56/56	28.0	187	27.81	1.36	36	28.31	1.77	-.19	.35	-.50	1.30
52/54	30.1				286	30.51	1.77		.41		
52/52	30.8	462	30.80	2.19	100	31.01	2.28	.00	.21	-.21	1.04
50/50	32.6	536	31.72	2.95	147	31.83	3.98	-.88	-.77	-.11	1.35
46/48	35.3	966	35.27	3.14	475	35.53	2.24	-.03	.23	-.25	1.41
44/46	37.2	464	36.78	2.44	282	37.12	1.99	-.42	-.08	-.34	1.23
Total		2740	33.06	12.49	1719	32.23	16.82			.83	1.35

a. Mean buyer fibre diameter - mean broker fibre diameter.
All mean differences non-significant.
All variance ratios significant at 0.1% level.

For an individual grower, this estimation error is likely to be biased in one direction or the other and, as well as the financial implications of having his wool binned incorrectly, the grower will tend to make wrong inferences about price and quality number from the information his broker gives him. In addition, an Australian study by Whan[18] revealed that the range of fibre diameters within any quality number group is higher than the range of fibre diameters within individual clips. Thus, the work of a classer or broker is swamped out in a buyer's consignment or mill lot made up of wools of the same quality number but different fibre diameters. On these grounds alone it would be difficult to justify classing for uniformity of quality number.

Even if the grower knows the correct fineness of his clip and its price he would still not be sure of the 'true' value of his wool because the sale price itself is a function of a buyer's subjective appraisal of his lots (and a number of other factors such as the degree of competition in the market).

This analysis shows that, for one buying firm, the percentage of binned lots correctly[19] appraised on the basis of fibre diameter is only between 20% and 30%. As is the case for brokers, the buyers' estimation errors are likely to be biased in one direction for individual clips, depending on whether or not the clip looks finer or coarser than its actual fibre diameter. If the former is the case then the grower benefits financially, but, if his clip is finer than it looks, he is penalised. For binned lots, containing wool from a number of different clips, the fate of any one grower is the result of a complex interaction between his broker's appraisal, the buyer's appraisal and the actual fibre diameter.

Thus, not only is the grower left in the position of making important production and marketing decisions from information which is likely to be highly inaccurate, but, because of inaccuracies associated with appraisal, the equity of income disposal among growers is also disturbed. The use of quality number as a means of classifying wools of different average fibre diameter is clearly subject to some reservations.

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18. Whan, R.B.; "Is Woolclassing Worthwhile?" Wool Tech. Sheep Breeding, 15:1, p.87, 1968.

19. A 'correct' appraisal is defined at the start of this section.

The absence of a close association between average fibre diameter and quality number has implications for classing, buying and processing wool as well as for the grower. In those flocks where there is no relationship between quality number and fibre diameter, a wool classer could disregard quality number as a classing standard and concentrate on building up larger sale lots that were more uniform in some other characteristic such as staple length.

The use of quality number by the buyer as a guide for average fibre diameter can result in claims for supplying wool having incorrect specifications. Where a consignment to a client consists of wool from one flock, there is a relatively high risk that the actual fibre diameter will differ from the predicted diameter to an extent that could result in a claim for misdescription. The chance of such an error is reduced in binned lots and buyers' consignments as the number of different flocks represented in them is increased. However, while blending wools from different flocks increases the possibility of predicting the average fibre diameter, it also increases the variability of fibre diameter in the bin or consignment by mixing the 'fine' and 'broad' sale types. If the basis of appraisal were changed from visual estimates of quality number to the measurement of fibre diameter, the risk of misdescription would be reduced, regardless of the size of the bin or consignment.

The identification of the average fibre diameter of individual classing lines within a clip would allow wool to be processed more efficiently. Where quality number forms the basis for sorting wool for processing, wool having the same quality number but different fibre diameters will be blended. This will result in a monetary loss which will vary according to the difference in price premiums between fine and coarse fibred wool.

Subjective estimates on Australian wool have been checked through objective measurement and it has been found that different appraisers may vary from the average by 1.4 microns or more once in 20 times.[20] A difference of 1.4 microns has real processing significance. It is of the order of the difference between two quality numbers; for example, between 64's and 70's.

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20. Australian Wool Board; Objective Measurement of Wool in Australia, A Summary of the Principal Findings of the Australian Wool Board's Objective Measurement Policy Committee, p.14, October, 1972.

4.2.3 The Distribution of Yield Appraisals for Different Average Measured Yields:

In the previous sections, 4.2.1 and 4.2.2, two observations about the relationship between fibre diameter and yield were made:

1. That there is a significant linear relationship between fibre diameter and yield. That is, as fibre diameter increases so yield increases. Thus, coarse wools are higher yielding, in general, than fine wools.

2. That appraisers tend to over-estimate the yield of fine wools and under-estimate that of coarse wools.

It was suggested that the latter observation could be explained by the hypothesis that appraisers have difficulty in assessing extreme yields and tend to narrow the range of their appraisals towards their mean. In other words, that appraisers tend to under-estimate the yield of high yielding wools and over-estimate that of low yielding wools.

This section of the analysis tests this hypothesis.

The analysis involved over 5,000 lots, which were divided into six categories on the basis of measured yield. For each category the mean measured yield was calculated. Then the percentage of buyer- and broker-appraised yields greater than, equal to, or less than the mean measured yield was determined and the means and variances of appraised and measured yields calculated. These results are given in tables 40 and 41.

From table 40, in general, as mean measured yield increases the percentage of lots under-yielded by the buyers and brokers increases and the percentage over-yielded decreases. The percentage of lots correctly appraised appears to rise to a peak between 75.0% and 79.9%, then decline as measured yield increases. This is illustrated in Fig.2.

Although the only significant differences between mean appraised and measured yield occur when measured yields exceed 85.0%, there is a clear trend from the 60.0 - 64.9% category, where the average appraised yields are greater than average measured yields, to the > 85.0% category, where they are significantly lower (see table 41).

While measured yield variances are small and relatively constant, as would be expected, appraised yield variances, in general, decrease as yield increases. Consequently the ratios of measured and appraised variances are highly significant and show this same trend. (In total, however, measured-yield variance exceeds appraised-yield variances).

FIG. 2. The relationship between appraised and measured yield.

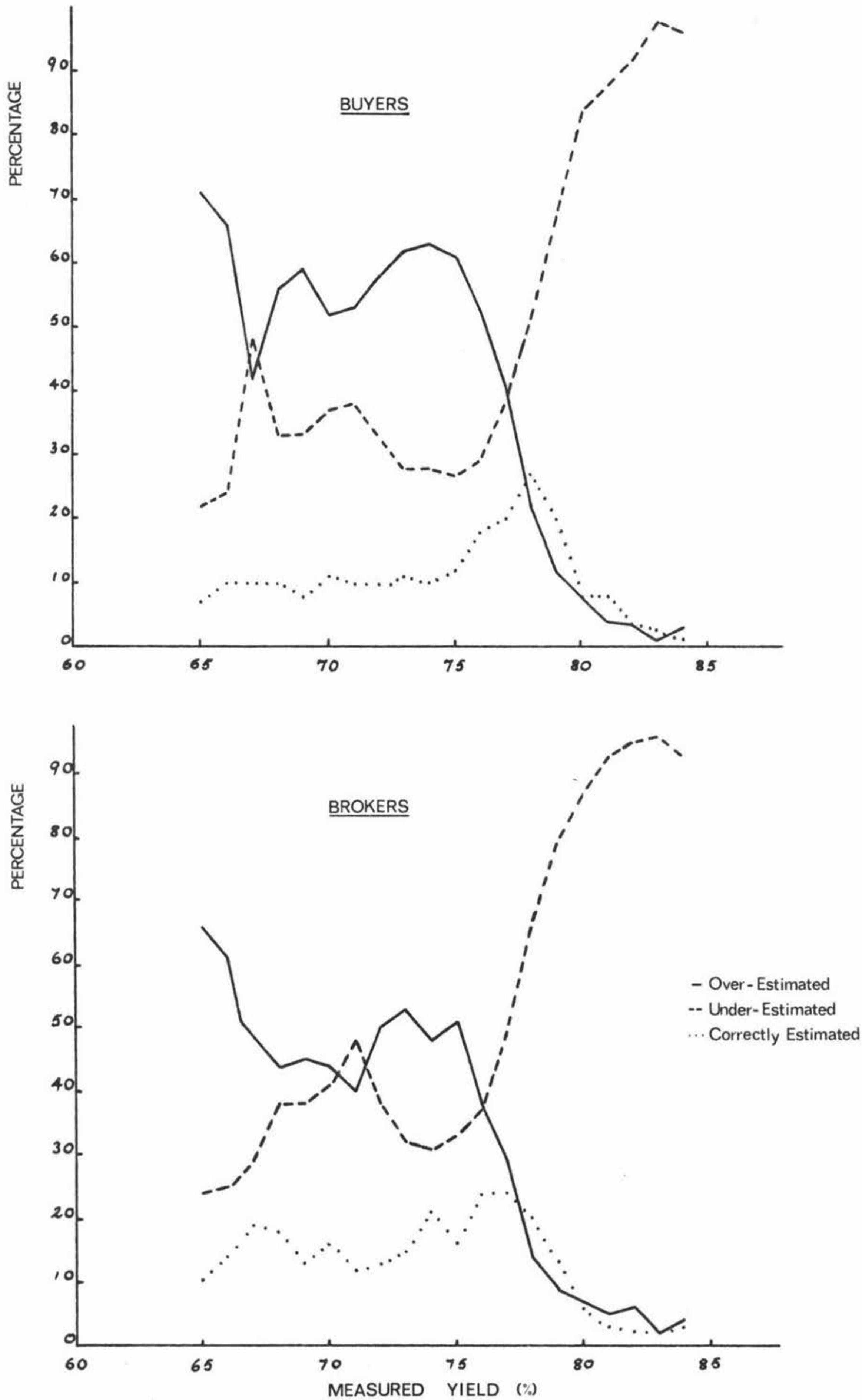

TABLE 40

The Distribution of Appraised Yields about Mean Measured Yield

Measured Yield (%)	Buyer-Estimated Yield			Broker-Estimated Yield			Number of Lots
	% Over-Estimated	% Correctly Estimated	% Under-Estimated	% Over-Estimated	% Correctly Estimated	% Under-Estimated	
60.0 - 64.9	70.09	6.84	23.08	65.81	5.13	29.06	117
65.0 - 69.9	50.51	12.02	37.48	38.90	16.90	44.20	491
70.0 - 74.9	50.65	9.63	39.72	43.18	10.94	45.89	1070
75.0 - 79.9	19.80	22.99	57.22	11.85	17.59	70.57	2667
80.0 - 84.9	1.47	3.08	95.45	2.72	2.86	94.42	1362
>85.0	0.00	0.00	100.00	2.44	0.00	97.56	41
Total	38.23	14.58	47.18	27.84	15.55	56.60	5748

TABLE 41

Means and Variances of Appraised and Measured Yields

Measured Yield (%)	Measured Yield Mean (%)	Measured Yield Variance (S^2)	Buyer-Estimated Yield Mean (%)	Buyer-Estimated Yield Variance (S^2)	Broker-Estimated Yield Mean (%)	Broker-Estimated Yield Variance (S^2)	Difference Between Average Yields (a) Buyer(%)	Difference Between Average Yields (a) Broker(%)	Ratio of Appraised and Measured Variances Buyer	Ratio of Appraised and Measured Variances Broker	Number of Lots
60.0 - 64.9	63.29	1.43	64.81	15.32	64.25	11.30	-1.52	- .96	10.68	7.88	117
65.0 - 69.9	67.88	1.88	68.35	11.40	67.72	10.43	- .47	.16	6.08	5.56	491
70.0 - 74.9	72.79	1.97	72.93	13.17	72.24	12.34	- .14	.55	6.70	6.28	1070
75.0 - 79.9	77.67	1.81	76.88	5.06	76.30	5.40	.79	1.37	2.79	2.98	2667
80.0 - 84.9	81.54	1.41	78.33	3.46	77.76	4.83	3.21	3.78	2.46	3.43	1362
>85.0	86.18	1.61	80.71	4.01	79.12	6.50	5.47**	7.45**	2.39	4.04	41
Total	76.59	21.69	75.53	17.92	74.92	18.21	1.06	1.67	1.21	1.19	5748

a. Measured yield - appraised yield.

** denotes significant at 5% level.

All variance ratios significant at 0.1% level, Thus, the hypothesis that appraisers tend to under-estimate the yield of high yielding wools and over-estimate that of low yielding wools is supported by the results of this analysis.

Two further points which are illustrated by tables 40 and 41 are:

1. Brokers tend to over-estimate low to medium yielding wools less than the buyers and under-estimate such wools more. For high yielding wools both groups of appraisers tend to under- or over-estimate similar percentages of lots. This explains why, in total, the buyers and the brokers correctly appraise approximately the same number of lots but the brokers over-yield less and under-yield more.

Investigation of the differences between average buyer- and brokers-estimated yield (summarised in table 42) reveals that, although the buyers' estimates are consistently higher than the brokers' these differences are not significant. The buyers' yield variances are significantly larger than those of the brokers' for measured yield categories up to 74.9%; above this, and in total, the situation is reversed.

TABLE 42

Mean Differences and Variance Ratios of Appraised Yields

Measured Yield (%)	Number of Lots	Average Yield Difference (%) (a)	Variance Ratio
60.0 - 64.9	117	0.56	1.36
65.0 - 69.9	491	0.63	1.09
70.0 - 74.9	1070	0.55	1.07
75.0 - 79.9	2667	0.58	1.07
80.0 - 84.9	1362	0.57	1.40
>85.0	41	1.59	1.62
Total	5748	0.61	1.02

a. Average buyer yield - average broker yield.
All average yield differences non-significant.
All variance ratios significant at 0.1% level.

2. There is an aberration in the trends mentioned above for the percentages over-estimated and correctly estimated between 70.0% and 74.9%. In both cases the values are smaller than expected.

This latter observation was further investigated by reducing the measured yield categories to individual percentages between 65.0% and 84.0% and repeating the analysis. The results are given in tables 43 and 44.

These tables show clearly the trends observed previously, namely:

(i) Appraisers tend to under-estimate the yield of high yielding wools and over-estimate that of low yielding wools. On average the differences between appraised and measured yields are only significant, however, for very high yielding wools.

(ii) The buyers' average yield estimates are consistently higher than those of the brokers but not significantly so.

(iii) For low yielding wools, the variances of the buyers' estimates generally exceed that of the brokers and vice versa for high yielding wools.

Unfortunately, these results do not help to interpret the anomalous results observed between 68.0% and 73.0%. In this range the trends listed above are confused and often reversed, but for what reason is not readily apparent.

The implications of incorrect yield appraisal have been discussed previously and need no further elaboration. To summarise briefly: The nature of binned lots, containing as they do, wool from a number of different sources, means that there is a good chance that both the buyers' and the brokers' yield estimates will be close to the actual average yield of these lots. However, growers whose wool is low yielding will tend to benefit financially at the expense of growers whose wool is high yielding since appraisers tend to over-estimate low yields and under-estimate high yields.

4.3 THE IMPACT OF ECONOMIC CIRCUMSTANCES ON APPRAISAL:

Outline:

It was suspected that a relationship existed between price changes and appraisers' estimates of yield and fineness over time. Specifically, it was suspected that appraisers' estimates may be biased by economic circumstances, so that appraisers would downgrade wools in times of declining demand and upgrade them when prices were rising.

TABLE 43

The Distribution of Appraised Yields about Mean Measured Yield

Measured Yield (%)	Buyer-Estimated Yield			Broker-Estimated Yield			No. of Lots
	% Over-Estimated	% Correctly Estimated	% Under-Estimated	% Over-Estimated	% Correctly Estimated	% Under-Estimated	
65.0-65.9	71.19	6.78	22.03	66.10	10.17	23.73	59
66.0-66.9	66.25	10.00	23.75	61.25	13.75	25.00	80
67.0-67.9	41.94	9.68	48.39	29.03	19.36	51.61	93
68.0-68.9	56.41	10.26	33.33	44.44	17.95	37.61	117
69.0-69.9	59.44	7.69	32.87	45.46	13.29	41.26	143
70.0-70.9	51.95	11.04	37.01	44.16	16.23	39.61	154
71.0-71.9	52.87	9.55	37.58	40.13	12.10	47.77	157
72.0-72.9	57.69	9.62	32.69	49.52	12.50	37.98	208
73.0-73.9	61.59	10.87	27.54	53.26	14.49	32.25	276
74.0-74.9	62.55	9.46	28.00	48.00	21.09	30.91	275
75.0-75.9	61.39	11.75	26.86	51.32	15.83	32.85	417
76.0-76.9	53.03	17.98	28.99	38.65	24.05	37.30	445
77.0-77.9	41.40	20.35	38.25	26.84	23.86	49.30	570
78.0-78.9	22.30	27.05	50.66	13.93	19.67	66.39	610
79.0-79.9	11.84	20.00	68.16	8.64	12.48	78.88	625
80.0-80.9	7.93	8.30	83.77	6.98	5.66	87.36	530
81.0-81.9	4.22	7.65	88.13	4.75	2.64	92.61	379
82.0-82.9	3.54	3.54	92.91	5.51	2.36	95.13	254
83.0-83.9	0.78	0.78	98.44	1.56	2.34	96.09	128
84.0-84.9	2.82	1.41	95.78	4.23	2.82	92.96	71
Total	38.67	14.97	46.36	28.06	15.94	56.00	5591

TABLE 44

Means and Variances of Appraised and Measured Yields

Measured Yield (%)	Measured Yield: Mean (%)	Measured Yield: Variance (s^2)	Buyer-Estimated Yield: Mean (%)	Buyer-Estimated Yield: Variance (s^2)	Broker-Estimated Yield: Mean (%)	Broker-Estimated Yield: Variance (s^2)	Difference Between Average Yields (a): Buyer %	Difference Between Average Yields (a): Broker %	Ratio of Measured and Appraised Variances: Buyer	Ratio of Measured and Appraised Variances: Broker	Number of Lots
65.0 - 65.9	65.49	.0786	66.76	10.08	66.07	7.15	-0.58	-0.58	128.24	90.94	59
66.0 - 66.9	66.49	.0890	67.43	11.07	66.84	8.51	-0.94	-0.35	124.38	95.63	80
67.0 - 67.9	67.50	.0807	67.42	9.28	66.93	8.63	0.08	0.58	114.94	106.93	93
68.0 - 68.9	68.40	.2353	68.58	8.98	68.05	8.46	-0.18	0.35	38.16	35.95	117
69.0 - 69.9	69.44	.0923	69.95	10.73	69.13	11.53	-0.51	0.31	116.27	124.90	143
70.0 - 70.9	70.45	.0820	70.49	11.80	69.89	9.90	-0.05	0.56	143.85	120.77	154
71.0 - 71.9	71.45	.0706	70.98	12.54	70.20	11.54	0.48	1.25	177.54	163.43	157
72.0 - 72.9	72.40	.0880	72.65	11.74	71.93	11.31	-0.25	0.46	133.38	128.56	208
73.0 - 73.9	73.48	.0663	73.86	9.46	73.24	8.91	-0.38	0.24	142.61	134.37	276
74.0 - 74.9	74.46	.0633	74.68	9.61	73.92	9.02	-0.23	0.53	151.75	142.55	275
75.0 - 75.9	75.47	.0535	75.50	7.64	75.03	7.43	-0.03	0.43	142.74	138.89	417
76.0 - 76.9	76.45	.0557	76.39	5.21	75.74	5.51	0.06	0.70	93.58	98.96	445
77.0 - 77.9	77.47	.0433	76.88	4.31	76.29	4.47	0.59	1.18	99.56	103.17	570
78.0 - 78.9	78.47	.0502	77.32	3.16	76.62	4.21	1.14	1.85	63.01	83.80	610
79.0 - 79.9	79.43	.0486	77.73	3.42	77.23	3.73	1.70	2.20	70.33	76.82	625
80.0 - 80.9	80.41	.0557	77.96	2.97	77.50	3.80	2.45	2.91	53.33	44.06	530
81.0 - 81.9	81.41	.0512	78.22	3.44	77.40	4.77	3.19*	4.02*	67.14	93.21	379
82.0 - 82.9	82.38	.0606	78.74	3.55	78.27	5.08	3.65*	4.56*	58.56	83.80	254
83.0 - 83.9	83.37	.0902	78.67	3.17	78.20	4.92	4.70**	5.18**	35.18	54.58	128
84.0 - 84.9	84.37	.0666	79.62	3.93	79.13	7.41	4.75**	5.25**	58.95	111.21	71
Total	76.82	17.4994	75.73	15.35	75.12	15.82	1.09	1.00	1.1401	1.1065	5591

a. Mean measured yield - mean appraised yield.

* denotes significant at 10% level; ** denotes significant at 5% level.

All variance ratios significant at 0.1% level.

The rationale behind this hypothesis, from a buyer's point of view, is that when demand is declining, for example, and prices are falling, he can become more critical in his appraisal and so downgrade wool without fear of being caught with forward orders, which he is unable to fill. When demand is increasing and prices are rising, increased competition does not allow the buyer to be so critical if he is to fill his orders, hence there is an incentive to upgrade wool.

Brokers are strongly influenced by buyers in their classing practices since buyers are their customers. Thus, it is reasonable to expect brokers to respond directly and quickly, in a similar manner as suggested for buyers, to changes in prices and become more or less critical in their classing as prices fall or rise.

The hypothesis, that appraisers' estimates of yield and fineness are influenced by economic circumstances, implies that the criteria of up or down grading (i.e. the differences between measured and appraised yield and fineness) are serially related. Unless this is so there is little point in testing the hypothesis itself.

The first part of this section outlines the test used to establish whether or not the time series of deviations of appraised yield and fineness from their measured equivalents were non-random. The second part investigates the effect of price changes on appraisals.

4.3.1 Tests of Serial Correlation:

For each sale, the differences between the average of measured and appraised yields and fibre diameters for the buyers and the brokers were calculated (average quality numbers were converted to average fibre diameter measurements using: "Proposed National Wool Standards for Fineness and Description"[21]). These differences were then tested for non-randomness using the serial correlation coefficient.[22]

The serial correlation coefficient:

Given a time series $X_1, X_2, \ldots, X_n$, the correlation between successive terms is defined as:

$$r_1 = \frac{\text{Cov }(X_i, X_{i+1})}{(\text{Var }(X_i).\ \text{Var }(X_{i+1}))^{\frac{1}{2}}}$$

and is called the serial correlation coefficient of order one (since there is one time interval between X_i and X_{i+1}).

21. From: Agar; op.cit.

22. This test for serial correlation is described by: Yamane, T.; Statistics - An Introductory Analysis, Harper and Rowe, New York, p.866, 1964.

We also set $x_{n+1} = x_1$ (where $x_i = X_i - \bar{X}$ and n is the sample size). Hence, this definition is referred to as the circular definition of the serial correlation coefficient. This definition assumes that the time series is long and detrended since otherwise the assumption $x_{n+1} = x_1$ may affect the values of r.

The time series involved in this analysis are relatively long, i.e. over 50 observations, and graphical examination of them revealed no obvious trends, so it seems justifiable to use this circular definition.

To test whether serial correlation exists in a time series, or, in other words, if the series is non-random, the distribution of the serial correlation developed by R.L. Anderson may be used.[23] Anderson's table gives the critical values of r for the 5% and 1% levels of significance. If the value of r, exceeds the corresponding value in the table (which depends on n) then we conclude that there is serial correlation in the population.

The results of tests for non-randomness within medium and coarse wools[24] (based on the buyers' estimates of quality number and the New Zealand Wool Commission's defintion of these categories),[25] within seasons and over three seasons using the serial correlation coefficient, are given in table 45.

The results summarised in table 45 indicate that, in general, yield and fibre diameter differences were positively correlated over the three-year period for medium and coarse wools and for both appraisers. Within seasons there is less evidence of serial correlation but it did exist and was both positive and negative.

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23. This table is reproduced and discussed in: Yamane; op.cit.

24. There were insufficient observations for fine wools to test a fine wool series for serial correlation.

25. The lots in this analysis were classified on the basis of the buying firm's appraisals of quality number using a classification found in: New Zealand Wool Commission; Statistical Analysis of New Zealand Wool Production and Disposal.

    i.e. fine = 56's and finer
    medium = 48/50's to 50/56's
    coarse = 46/50's and coarser

    In section 4.2.1 the correlation between the buyers' and the brokers' estimates of quality number on 5757 lots was 0.959. Therefore, it is not unreasonable to assume that the classification of lots into fine, medium and coarse in this section, although based on buyers' appraisals, applies satisfactorily to the brokers as well.

TABLE 45

Circular Serial Correlation Coefficients

Wool Type/Season	Buyers		Brokers		No. of Lots
	Yield Difference	Fibre Diameter Difference	Yield Difference	Fibre Diameter Difference	
Medium: 1968/69	-.2633**	.0199	-.1950	.0258	56
1969/70	.2166**	.0133	.0109	.0702	57
1970/71	.0245	.0670	-.1863	.3143**	40
1968/69-1970/71	.1922***	.2092***	.1119**	.2677***	152
Coarse: 1968/69	-.1806	.1320	-.1700	.1538	56
1969/70	-.0236	.0129	-.2877***	-.2541*	60
1970/71	.0803	.2406**	-.0527	.0932	39
1968/69-1970/71	.1954***	.2629***	.0914	.2043***	154

** denotes $p < .05\%$; *** denotes $p < .01\%$.

4.3.2 The Impact of Price Changes on Appraisals:

Once it had been established that serial correlation existed among the time series of yield and fibre diameter differences, the impact of economic circumstances on appraisal could then be investigated. The approach used was as follows:

The deviations of appraised yield and fineness from their respective measured characteristics give a measure of up or down grading. This can be regressed on a measure of price trend, which indicates rising and falling demand, to give a model of the form:

$$\text{Measured - Appraised Parameter} = \alpha + \beta.\text{Price Trend} + \text{Error}$$

$$\text{i.e. } \Delta\text{Yield or } \Delta\text{Fibre Diameter} = \alpha + \beta.\Delta\text{Price} + \text{Error}$$

In this model, $\hat{\beta}$ estimates the change in ΔYield or ΔFibre diameter when Δ Price increases by one unit. If $\hat{\beta}$ is negative, then a fall in Δ Price increases Δ Yield or Δ Fibre Diameter. Conversely, if Δ Price rises, then Δ Yield or Δ Fibre Diameter, the difference between measured and appraised characteristics, decreases.

In other words, if the coefficients for $\hat{\beta}$ in the regressions of ΔPrice on Δ Yield and Δ Fibre Diameter are negative and significant, then we cannot reject the hypothesis that the buying firm and the brokers downgraded wool in times of declining demand and upgraded in times of increasing demand.

To calculate the independent variable, Δ Price, sale average prices were used in the following formula:

$$\Delta \text{Price}_{(k)} = 0.4\ (P_k - P_{k-1}) + 0.3\ (P_{k-1} - P_{k-2}) + 0.2\ (P_{k-2} - P_{k-3}) + 0.1\ (P_{k-3} - P_{k-4})$$

where P_k = average sale price[26] for sale k (the sales for the three-year period being numbered chronologically from 1 to 183).

The weights used in the formula for Δ Price, and in fact the formula itself, are purely arbitrary. What was required was an indicator of demand trends measured by changes in sale prices. This formula, which takes into account the difference between sale average prices for four time periods, weighted so as to give more importance to the more recent price changes, was considered suitable for this purpose.

The use of price trend in this analysis as a measure of the demand situation implies a particular sort of expectation model for buyers (and brokers). That is, the expectation that an upward or downward price trend will continue. In view of the general tendency of woolbuyers to use the average prices paid at the previous sale as a basis for valuation,[27] price trend is regarded as an adequate proxy measure for wool buyers expectations about the future.

For each lot involved in the analysis, Δ Price and Δ Yield and Δ Fibre Diameter for both appraisers were calculated. The lots were divided into fine, medium and coarse groups on the basis of the buyers' estimates of quality number and the regressions of Δ Price on the four parameter differences calculated for all wool, for each fineness group and for each group by year. These results are summarised in tables 46 and 47.

For all wool, the regression coefficients for buyers' and brokers' yield differences are negative and highly significant. Thus, the null hypothesis can be rejected for yield appraisal at least. The regression coefficient for the buyers' yield differences is larger than that for the brokers' yield differences, however, not significantly so (see table 46).

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26. Extracted from: New Zealand Wool Commission; Statistical Analysis of New Zealand Wool Production and Disposal, 1968/69, 1969/70, 1970/71 Seasons.

27. Whan, R.B. and Richardson, R.A.; "A Simulated Study of an Auction Market", Aust.J.Agric.Econ., 13:2, p.91, 1969.

TABLE 46

Regression Coefficients and their Standard Errors

Wool Type	Buyers			Brokers		
	No. of Lots	Yield Difference	Fibre Diameter Difference	No. of Lots	Yield Difference	Fibre Diameter Difference
All Wool:	2246	-.0812****	-.0046	1946	-.0664****	-.0046
s.e.		.0084	.0062		.0093	.0042
Fine Wool:	723	-.0048	-.0124	489	-.0143**	-.0129
s.e.		.0119	.0091		.0144	.0068
Medium Wool:	766	-.0531***	-.0555*	712	-.0742****	-.0153
s.e.		.0143	.0254		.0149	.0264
Coarse Wool:	758	-.0731****	-.0058	744	-.0763****	-.0002
s.e.		.0145	.0067		.0138	.0043

* denotes $p < .1\%$; ** denotes $p < .05\%$; *** denotes $p < .01\%$; **** denotes $p < .001\%$

Over the same period there is no evidence to suggest that the appraisers' estimates of fineness were significantly affected by changing prices.

In other words, these results suggest that both the buyers and the brokers significantly upgraded and/or downgraded their estimates of yield over this three-year period in response to changing economic circumstances (measured by a weighted average price difference). This is illustrated in Figs 3 and 3A.

Within fine, medium and coarse types, there is also evidence that both appraisers did in fact alter their yield appraisals in response to changing prices over this period. The regression coefficients for the brokers' yield differences are consistently more significant and larger than those for the buyers' yield differences; the differences in the sizes of these coefficients are not significant, however.

For medium wool, a negative, significant regression coefficient implies that a similar upgrading and/or downgrading occurred in the buyers' estimates of fineness.

FIG. 3. Buyers' yield difference and weighted average price difference by sale.

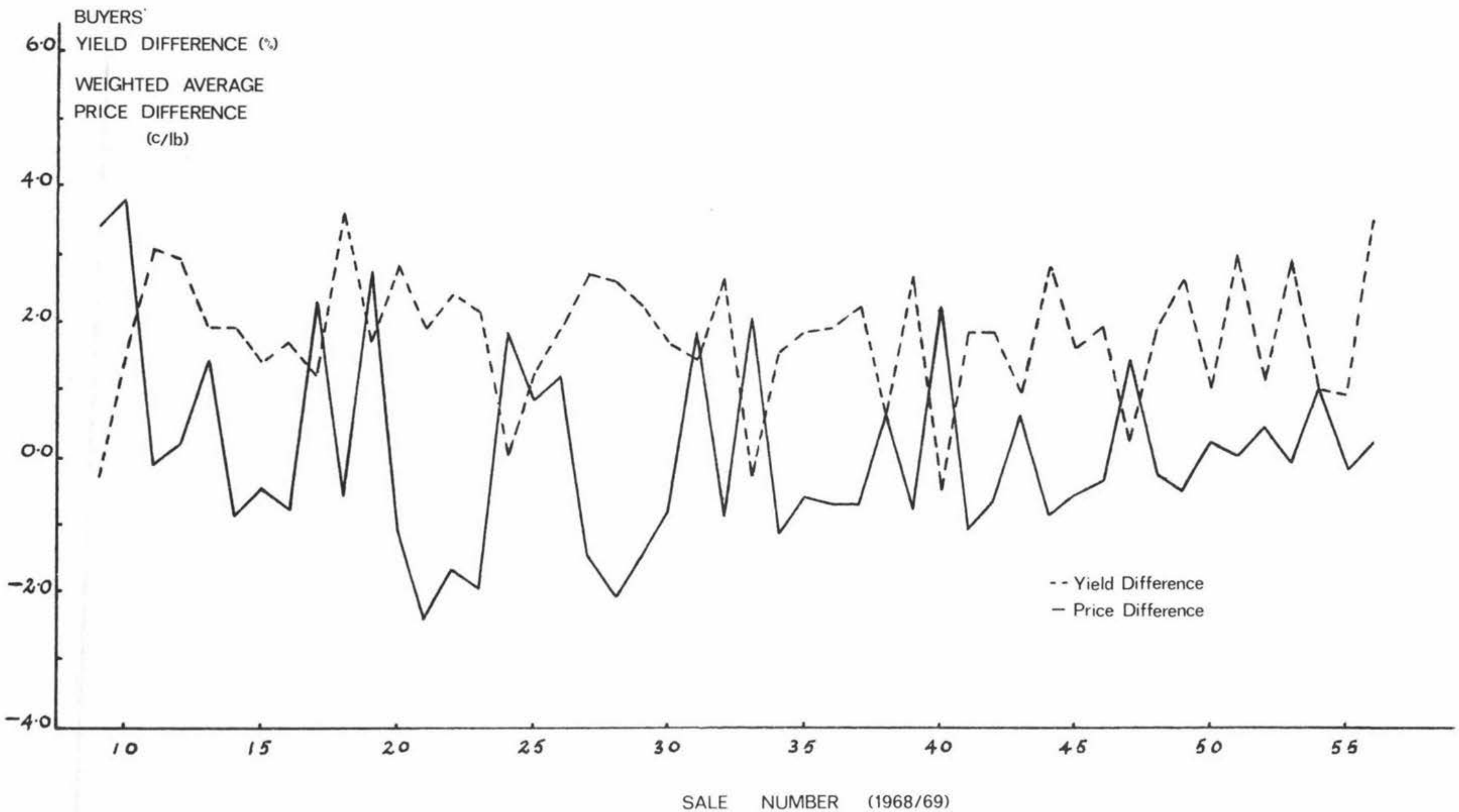
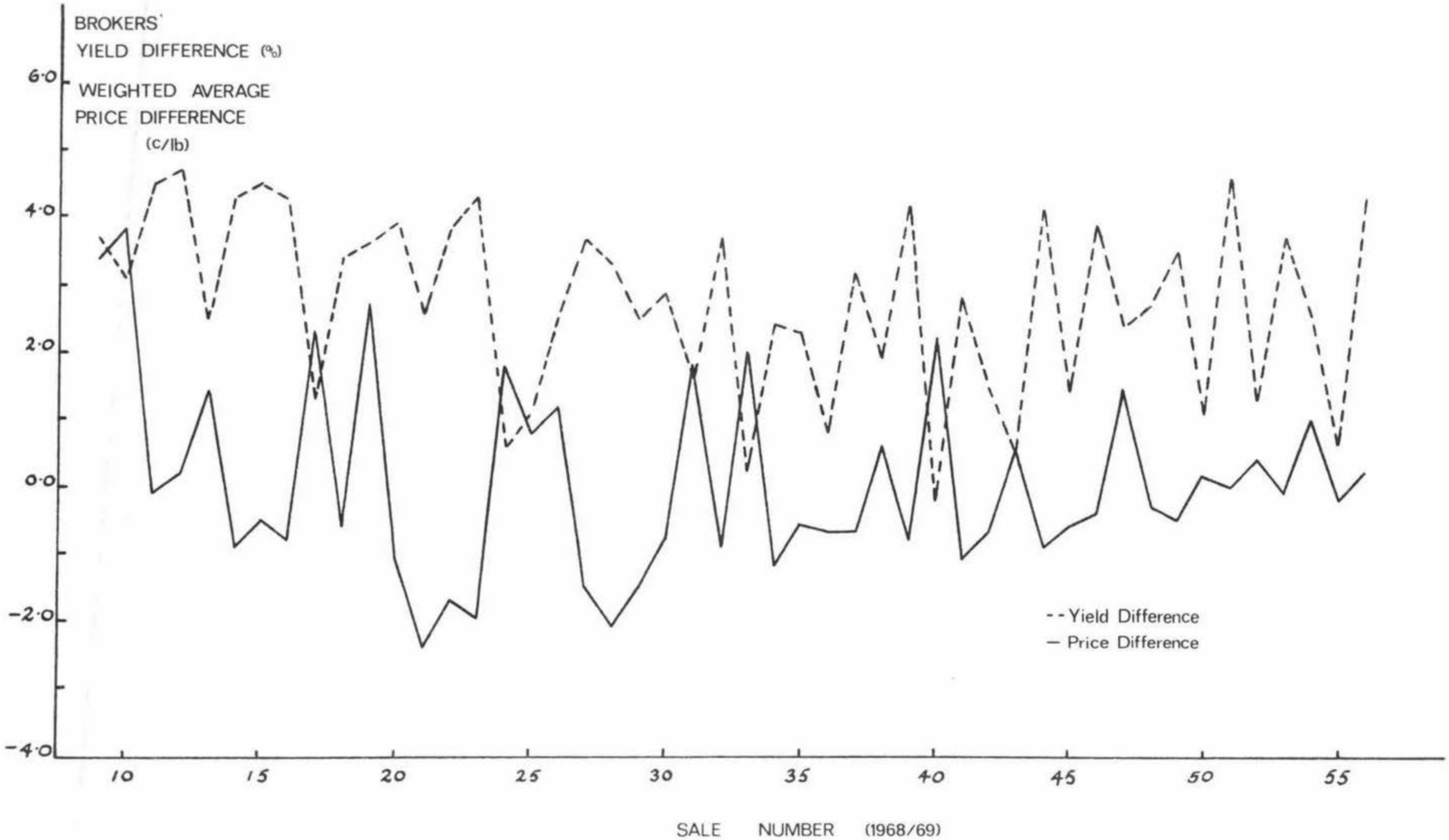


FIG. 3A. Brokers' yield difference and weighted average price difference by sale.



As appraised quality number decreases so the size of the yield-difference regression coefficients increases (negatively) and they become more significant. This implies that this up and/or down grading effect becomes more pronounced as wool becomes coarser. It has previously been shown in Section 4.3.2 that appraisers tend to under-estimate the yield of coarse wools. These two results suggest that this under-yielding affect will be even more pronounced when prices are falling.

Within seasons and types, previous observations are, in general, supported, except for the trend in the size and significance of regression coefficients for the brokers' yield differences. These get smaller rather than larger and less rather than more significant as coarseness increases but, again, the trend is not significant (see table 47).

TABLE 47

Regression Coefficients and their Standard Errors

Season/Wool Type	Buyers			Brokers		
	No. of Lots	Yield Difference	Fibre Diameter Difference	No. of Lots	Yield Difference	Fibre Diameter Difference
1968/69: Fine	294	-.0585**	-.0065	176	.0454	.0001
s.e.		.0222	.0221		.0295	.0223
Medium	254	-.0641*	-.0747	236	-.0997**	-.0548
s.e.		.0315	.0561		.0331	.0583
Coarse	264	-.0660*	.0054	262	-.0785**	.0272
s.e.		.0311	.0097		.0269	.0226
1969/70: Fine	176	.0153	.0058	115	.0023	.0249
s.e.		.0213	.0434		.0311	.0455
Medium	257	-.0337	-.0230	246	-.0490*	.0256
s.e.		.0228	.0403		.0235	.0149
Coarse	265	-.0632*	-.0166	261	-.0490	-.0075
s.e.		.0252	.0114		.0261	.0054
1970/71: Fine	253	.0087	-.0092	198	.0116	-.0042
s.e.		.0127	.0067		.0142	.0048
Medium	253	-.0504**	-.0451	230	-.0674**	.0039
s.e.		.0189	.0365		.0209	.0374
Coarse	229	-.0538**	.0432	219	-.0496*	.0086
s.e.		.0192	.0293		.0196	.0071

* denotes $p < .1\%$; ** denotes $p < .05\%$; *** denotes $p < .01\%$
**** denotes $p < .001\%$

Within seasons, there is some evidence to suggest that the regression coefficients for the buyers' yield differences decreased over the three-year period. This would imply, as far as the buying firm was concerned, that the up grading and/or down grading effect became less pronounced over time. Similarly, a trend in the brokers' yield difference regression coefficients can also be identified (although this trend, like that observed for the buyers, is not statistically significant). These coefficients imply that, as far as the brokers were concerned, the up and/or down grading effect was strong in 1968/69, much weaker in 1969/70 and stronger again in 1970/71 (but not as strong as it had been in the first season). In general, then, it can be concluded that the up grading and/or down grading effect identified in this section decreased over the three-year period considered.

It is interesting to now relate these results to the wool prices actually experienced over this period. These prices are illustrated graphically in Figs 4 and 5.

In general, wool prices fell continuously over the period 1968/69 to 1970/71, but at a decreasing rate. However, at the end of the 1970/71 season prices began to rise again.

In terms of the hypothesis put forward in this section it would be expected that, in general, over this period both appraisers would have tended to down-grade their estimates of yield. From Fig. 6 it can be observed that the curve of the buyers' yield differences lies almost entirely above zero. That is, the difference between measured and appraised yield is almost always positive, indicating that the buyer has under-estimated the true yield value. It is also apparent from Fig 6. that the area between the zero line and the buyers' yield difference curve decreases over time. In other words, the buyers down graded their estimates of yield over the period but at a decreasing rate. A similar situation is revealed in Fig. 6A for the brokers.

From Fig. 5, which shows the patterns of prices for fine, medium and coarse wool, it is apparent that price changes for fine wool over the period were more severe than for medium wool, which, in turn, were more severe than those for coarse wool. It might, therefore, be expected that the down grading effect would have been more significant for fine wool than for coarse wool.

FIG. 4. Average monthly wool prices.

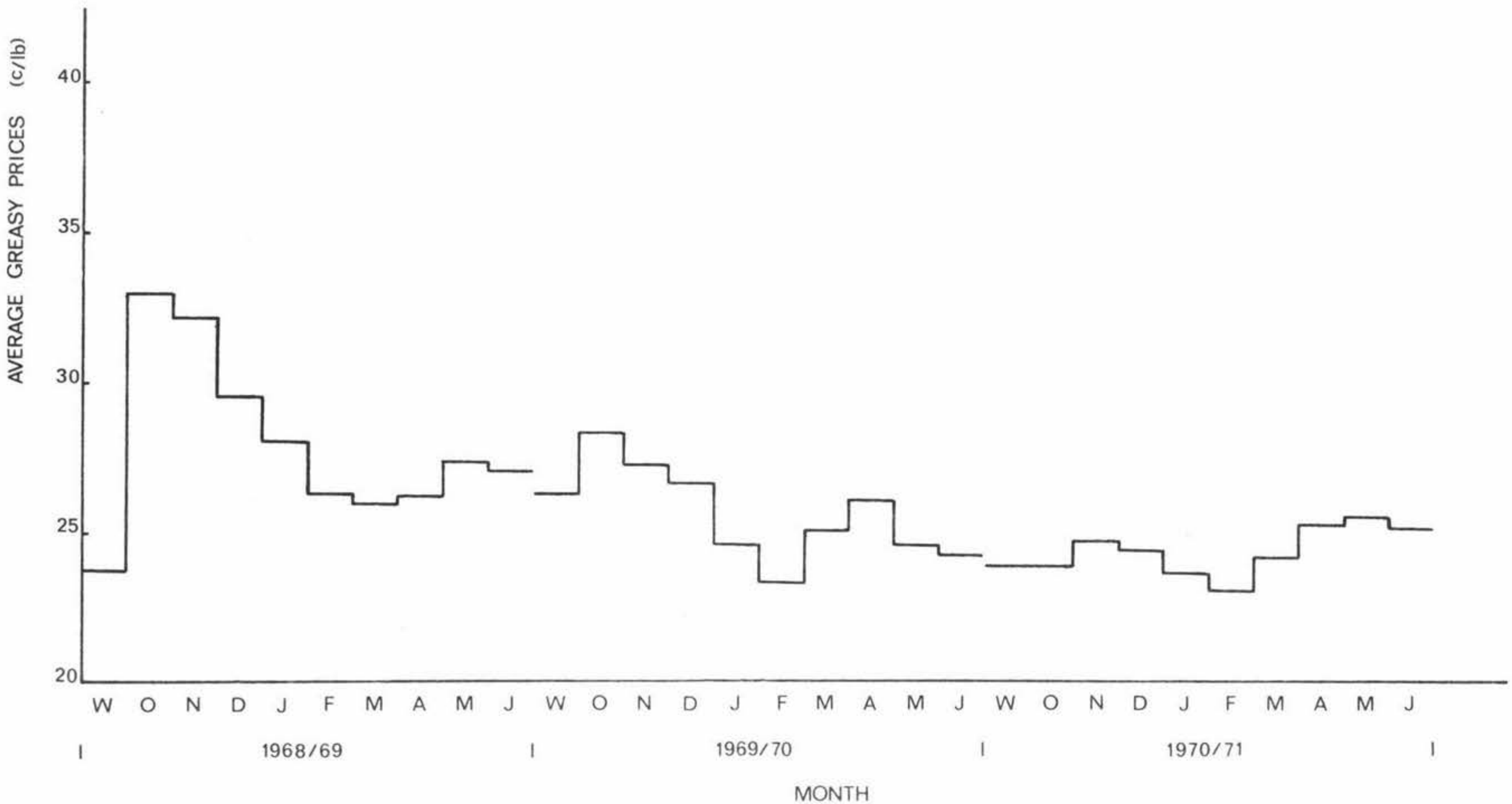


FIG. 5. Average monthly wool prices: fine, medium and coarse wools.

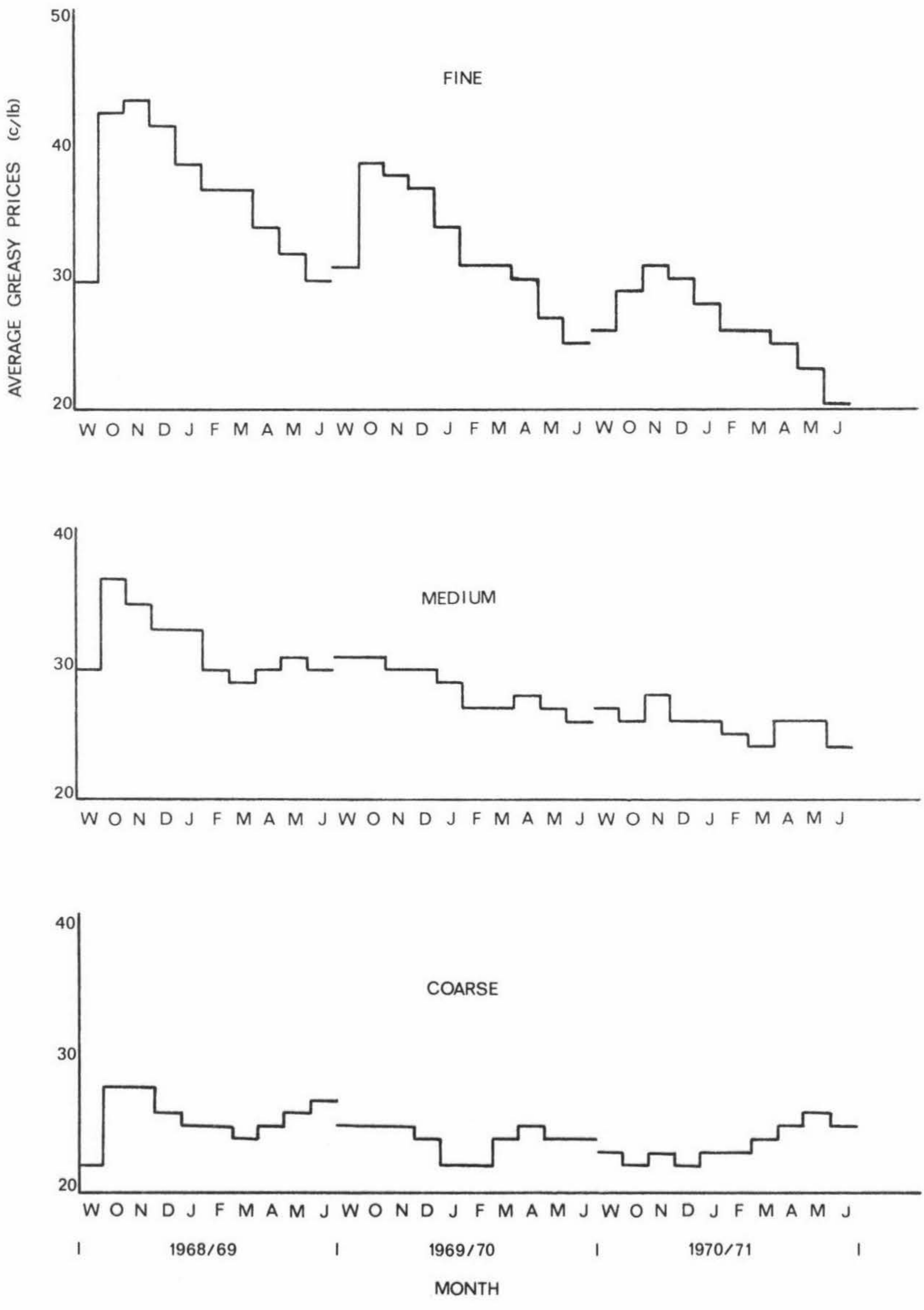


FIG. 6. Buyers' yield difference by sale: 1968/69, 69/70, 70/71.

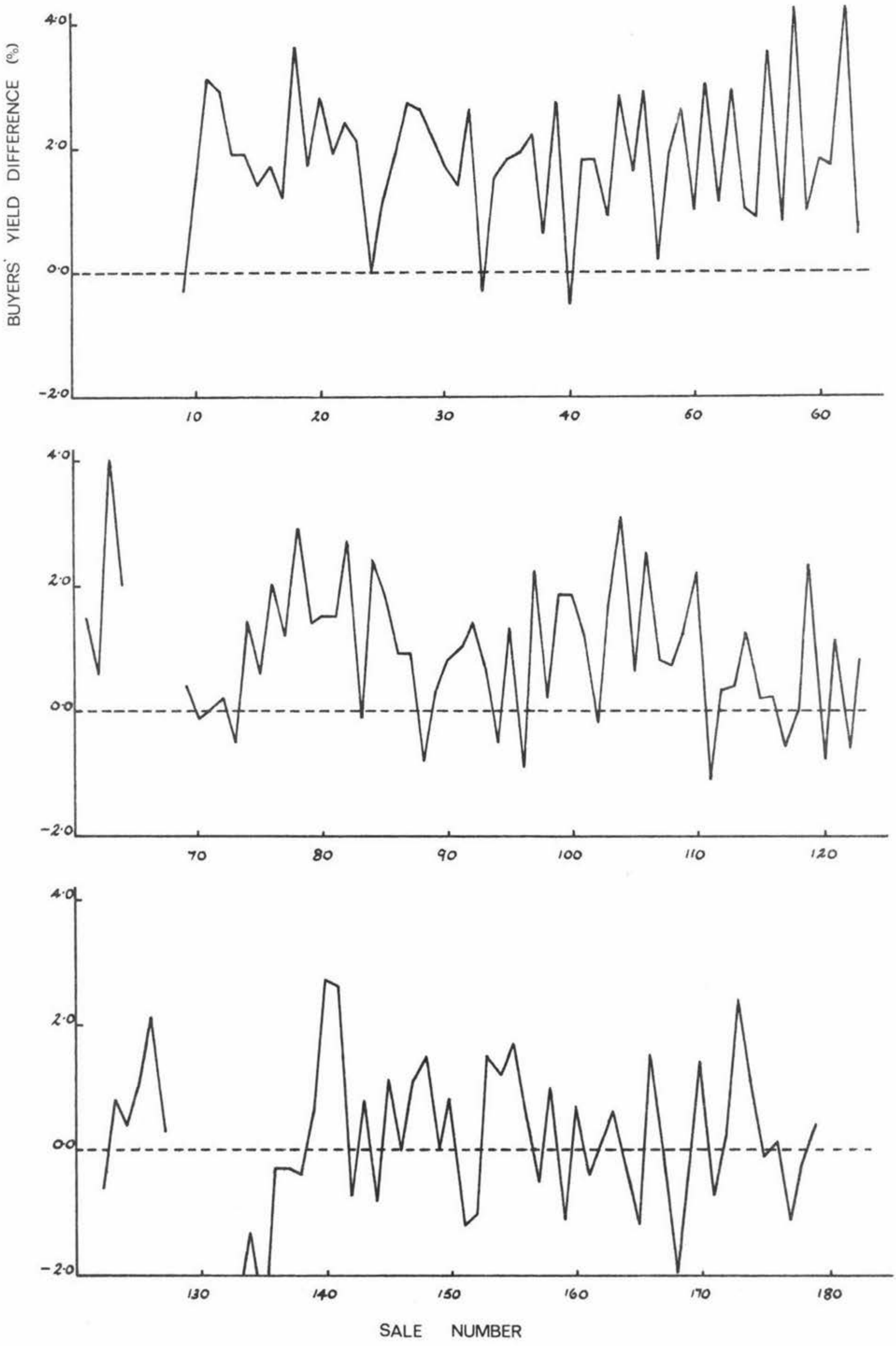
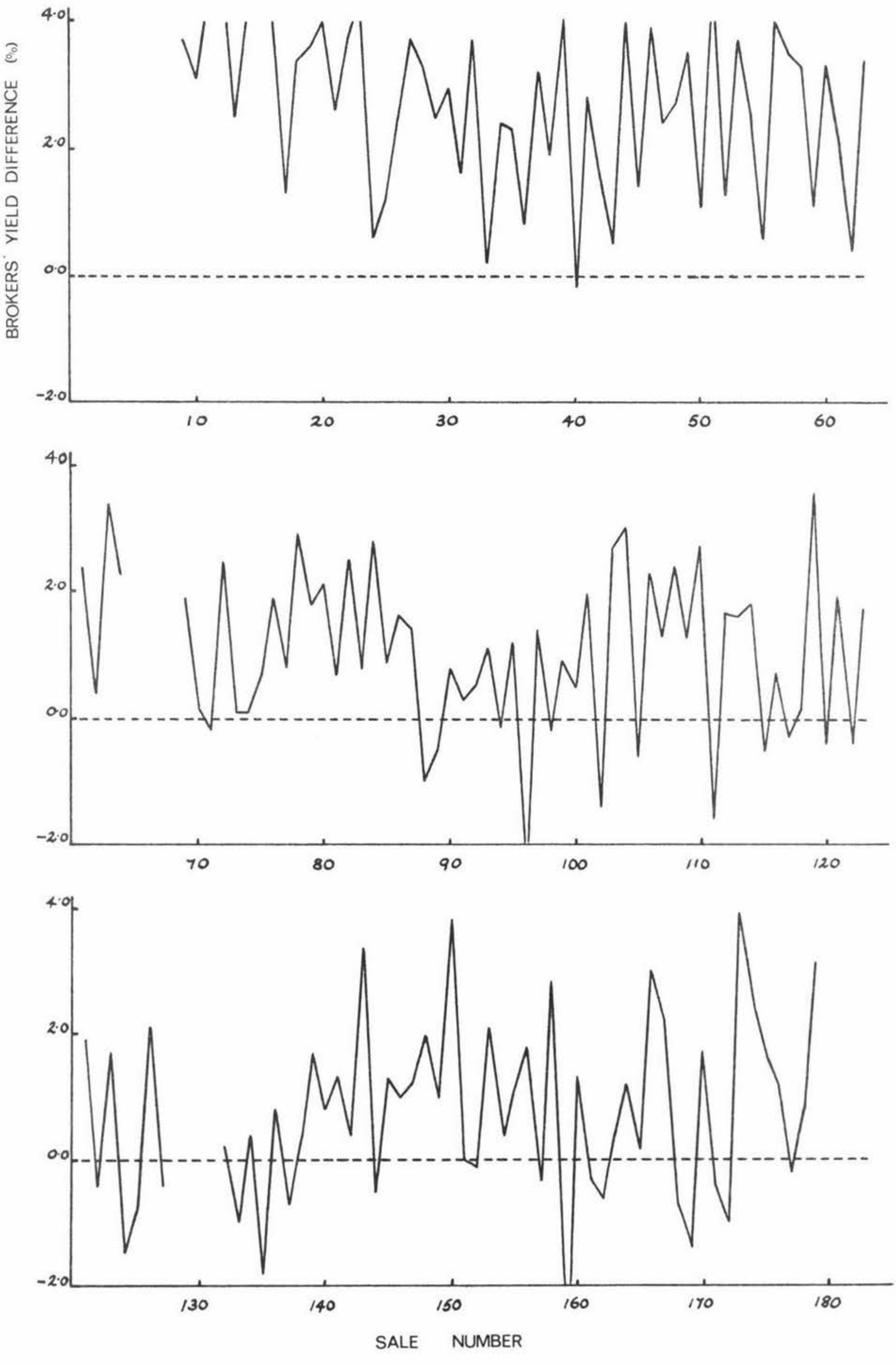


FIG. 6A. Brokers' yield difference by sale; 1968/69. 69/70. 70/71.



However, the upward trend in prices which followed this period is reflected in coarse wool prices but not in medium or fine wool prices (although the fall in medium wool prices is much less in 1970/71 than in the two previous seasons). Thus, it is possible that coarse wool prices are a more sensitive indicator of changes in demand than medium or fine wool prices. This would explain why the upgrading and/or downgrading effect appeared to become more pronounced as coarseness increased.

Within-quality groups between-centres the following observations about the relationship between yield and fibre diameter differences and weighted average price difference can be made: (see tables 48 to 50).

For the three fine wool centres, Christchurch, Timaru and Dunedin, the only significant regression coefficients are in Christchurch for the buyers' yield difference and in Dunedin for the brokers' yield difference. These coefficients are, however, positive and not negative. A positive coefficient implies that, as prices fall the difference between measured and appraised yield decreases, and vice versa as prices rise.

From the brokers' point of view it is possible to explain this observation by hypothesising that the brokers upgraded their yield appraisals when prices were falling (as they were over this period) in order to impress the buyers. If this is true and it occurred in Christchurch as well as in Dunedin (the regression coefficient for brokers' yield difference in Christchurch is quite large, i.e. 0.0463, but not significant) then it is possible that the buyers' yield estimates were affected by this action on the part of the brokers. This would partly explain the positive coefficient for the buyers' yield difference in this centre.

An explanation as to why appraisers' yield differences (or fibre diameter differences) should increase as prices move upwards is difficult to find.

For medium wool, the regression coefficients for buyers' yield difference are negative and significant in Napier, Timaru and Invercargill, and for brokers' yield difference in Napier and Invercargill. The coefficients for the buyers' fibre diameter difference are also significant in Wanganui, where $\hat{\beta}$ is positive, and Timaru, where $\hat{\beta}$ is negative.

For coarse wool, the coefficients for both buyers' and brokers' yield difference are negative and significant in Wellington and Invercargill. The coefficient for the buyers' fibre diameter difference is significant but positive in Auckland, while a similar situation exists for the brokers' fibre diameter difference in Napier.

From these results, which are summarised in tables 48 to 50, it is difficult to draw meaningful conclusions about the relationship between yield and fibre diameter difference and price changes within-wool-groups, between-selling-centres. The hypothesis, that appraisers downgrade and/or upgrade their estimates of yield and fineness in response to changing economic circumstances, is supported by negative, significant regression coefficients in various centres but there is no obvious pattern. For coarse and medium wool at least, this effect appears to be strongest in Invercargill, but also occurred in Napier, Wellington and Timaru.

In some centres the regression coefficients for yield and fibre diameter difference were significant and positive, implying that appraisals increased relative to measurements as prices fell and vice versa as prices rose. It is suggested that this is partly explained by attempts on the part of brokers to impress buyers in times of declining demand, attempts which also influenced the buying firm's estimates.

TABLE 48

Regression Coefficients and their Standard Errors

FINE WOOL	Buyers			Brokers		
Centre	No. of Lots	Yield Difference	Fibre Diameter Difference	No. of Lots	Yield Difference	Fibre Diameter Difference
Christchurch	268	.0644****	.0405	149	.0463	-.0399
s.e.		.0183	.0536		.0331	.0525
Timaru	87	-.0122	.0104	67	.0079	.0011
s.e.		.0192	.0151		.0219	.0110
Dunedin	335	.0043	-.0049	252	.0692***	-.0079
s.e.		.0169	.0097		.0183	.0074

**** denotes $p < 0.001\%$

TABLE 49

Regression Coefficients and their Standard Errors

MEDIUM WOOL	Buyers			Brokers		
Centre	No. of Lots	Yield Difference	Fibre Diameter Difference	No. of Lots	Yield Difference	Fibre Diameter Difference
Auckland	129	-.0229	-.0045	127	-.0387	.0392
s.e.		.0230	.0239		.0210	.0344
Napier	111	-.0547*	-.0084	94	-.0552*	-.0176
s.e.		.0209	.0345		.0258	.0334
Wanganui	59	-.0539	.1176*	54	-.0065	.0890
s.e.		.0316	.0476		.0272	.0448
Wellington	70	-.0147	-.0357	66	-.0313	.0053
s.e.		.0186	.0402		.0214	.0035
Christchurch	105	.0192	-.0319	99	.0213	-.0640
s.e.		.0363	.0840		.0437	.0863
Timaru	100	-.0321*	-.0873*	98	.0163	-.0586
s.e.		.0152	.0348		.0189	.0410
Dunedin	140	.0184	-.0167	130	.0467	-.0343
s.e.		.0263	.0516		.0289	.0593
Invercargill	52	-.1032***	.0807	44	-.1081**	.0340
s.e.		.0291	.0633		.0314	.0623

* denotes $p < .1\%$; ** denotes $p < .05\%$; *** denotes $p < .01\%$

TABLE 50

Regression Coefficients and their Standard Errors

COARSE WOOL	Buyers			Brokers		
Centre	No. of Lots	Yield Difference	Fibre Diameter Difference	No. of Lots	Yield Difference	Fibre Diameter Difference
Auckland	180	-.0258	.1091***	178	-.0239	.0074
s.e.		.0197	.0276		.0178	.0043
Napier	130	-.0241	.0032	128	-.0009	.0707**
s.e.		.0231	.0095		.0195	.0267
Wanganui	91	.0461	.0032	89	.0336	.0090
s.e.		.0258	.0075		.0260	.0050
Wellington	102	-.0378*	.0050	102	-.0367*	.0085
s.e.		.0181	.0071		.0166	.0045
Christchurch	52	.0754	-.0846	51	.0450	-.0386
s.e.		.0541	.1337		.0612	.0254
Timaru	52	-.0345	.0011	46	.0031	-.0311
s.e.		.0221	.0102		.0269	.0495
Dunedin	84	.0695	.0388	83	.0685	.0082
s.e.		.0475	.0757		.0456	.0153
Invercargill	67	-.0705**	.0075	67	-.0812**	-.0023
s.e.		.0260	.0072		.0297	.0101

* denotes $p < .1\%$; ** denotes $p < .05\%$; *** denotes $p < .01\%$

4.4 OBJECTIVE MEASUREMENT, TOTAL INCOME AND THE EQUITY OF INCOME DISTRIBUTION:

Outline:

It has previously been suggested that, on average, appraisal errors are randomly distributed.[28] Thus valuations based on objective measurement would not affect the total income of wool growers. The entire income of individual growers would, however, be altered according to the direction of appraisal bias. Recent work by Tier and Shepherd,[29] however, has indicated that a premium may exist for pre-sale tested wool; implying that, as well as promoting more equitable income distribution, objective measurement could also increase the sum of all growers' incomes.

In this section, the expected returns to the wool industry from valuations based on measured yield and fibre diameter are compared with the returns expected from valuations based on appraisal, and the questions of total income and income distribution investigated.

4.4.1 Introduction:

At this point it must be made clear that this section is based on a number of important assumptions and generalisations. These should be kept in mind when interpreting the results and making conclusions from them. These assumptions are as follows:

1. That objective measurement of greasy wool features is an appropriate basis for selling wool.

2. That the buying firm's appraisals are those on which the lot prices are based. This is not necessarily true; the buying firm's appraisals may or may not agree with those of the buyers who actually bought the lots.

3. That the situation for binned lots can be generalised to all modes of offering. There is evidence to show that binned lots sell at a discount compared to other modes of offering because of conservative valuations from buyers of binned wool.[30] Binned lots are more variable

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28. Whan, R.B. and Moffat, D.H.; "Some Differences Between Estimated and Tested Yields for Greasy Wool Sold in Australia", J.Text.Inst., 59:1, p.39, 1968.

29. Tier, T.J. and Shepherd, M.A.; "An Analysis of the Price Premium Paid for Pre-Sale Tested Greasy Wool", Quart.Rev.Agric.Econ., 25:1, p.50, 1972.

30. B.A.E.; Economics of Bulk Classing of Wool, Wool Economic Research Report No.2, August, 1960.

than comparable growers' lots and buyers have difficulty estimating yields and fibre diameters of wools from different sources. Buyers also allow for a greater moisture content in rehandled wool.

On the basis of these facts alone the valuation of binned lots on the basis of objective measurement could be expected to result in a net gain to growers in general. The same cannot, however, be said for growers' lots and other modes of offering.

4. That the value of an additional percent of measured yield is the same as that of an additional percent of appraised yield, and similarly for an additional unit of fibre diameter and its appraised equivalent.

5. That the value of an additional percent of yield or micron of fibre diameter calculated in this analysis from data for the 1968/69, 1969/70 and 1970/71 seasons can be applied to other seasons.

In a season such as 1972/73, when demand was high, the values could be expected to be higher, for example. However, the order of these coefficients would not be expected to change significantly between seasons.

6. That the sample distributions used are an accurate representation of the bulk of the clip.

7. This analysis is only concerned with six buyer-appraised quality numbers. These quality numbers represent 66% of the wool sold at auction in New Zealand during the 1971/72 season, (based on Wool Commission appraisal; see table 51). Any figure estimating the total cost/gain to the wool industry from objective measurement based on this proportion of the total clip is liable to error on this count.

8. That the cost of pre-sale testing is ignored.

4.4.2 Objective Measurement, Total Income and the Equity of Income Distribution:

From Chapter Three, Section 3.2.2, the partial regression coefficients for buyer yield and buyer average quality number are:

buyer yield: $\hat{\beta} = 0.43$

buyer average quality number: $\hat{\beta} = 1.33$

That is, on average, one percent of yield is worth 0.43 cents per pound (0.95 cents per kilo) to the buying firm, and one unit of quality number worth 1.33 cents per pound (0.604 cents per kilo).

Using these coefficients and the distributions of buyer-appraised yield about measured yield and of measured fibre diameter within buyer-appraised quality numbers (given in tables 24 and 30) the costs and gains from under- and over-appraisal were calculated.

These costs and gains were calculated simply as: $\Sigma_i \hat{\beta} C_i P_i$

where:

C_i = the percentage by which a lot is over- or under-yielded, or the number of quality number units by which a lot is over- or under-appraised;

P_i = the proportion of lots in category C_i.

For each of the buyer-appraised quality numbers: 58's, 56's, 52's, 50's, 46/48's, 44/46's; the total loss/gain from valuations based on measured yield and fibre diameter were calculated. These calculations and their results are given in tables 52 and 53.

TABLE 51

Qualities of Greasy Wool Sold at New Zealand Auctions 1971/72 Seasons

Quality Group	Metric Tons	% of Total Sales
60/64's and up	2,134	1.3
60's	1,291	0.8
58/60's, 58's and 56/58's	10,561	5.5
50/56's and 56's	12,816	6.8
52's	6,885	3.3
50's	12,283	6.3
48/50's	20,268	10.0
46/50's and 48's	47,260	22.0
46/48's	56,233	26.0
44/46's and lower	39,445	18.0
Total	209,174	100%

Source: New Zealand Wool Commission; op.cit.

TABLE 52

The Equity of Income Distribution with Valuations Based on Measured Yield

Quality Number	Gain From Buyer Under-Yielding (c/kilo)	Loss From Buyer Over-Yielding (c/kilo)	Total Gain Per Kilo From Measurement	Metric Tons Sold in 1971/72 Season	Total Gain To Wool Industry From Measurement
58/58	.0593	.4664	-.4071	10,561[a]	-$ 42,430
56/56	.0906	.3334	-.2428	12,816[b]	-$ 31,113
52/52	.1687	.2523	-.0836	6,885	-$ 5,757
50/50	.1775	.2115	-.0340	12,283	-$ 4,178
46/48	.3624	.0836	.2788	56,233	$209,266
44/46	.4185	.0464	.3721	39,455	$146,828
					$272,616

a. 58's 58/60's and 56/58's

b. 56's and 50/56's

TABLE 53

The Equity of Income Distribution with Valuations Based on Measured Fibre Diameter

Quality Number	Gain From Buyer Under-Appraisal	Loss From Buyer Over-Appraisal	Total Gain Per Kilo From Measurement	Metric Tons Sold in 1971/72 Season	Total Gain To Wool Industry From Measurement
58/58	.4252	.2126	.2126	10,561[a]	$ 22,454
56/56	.3163	.3323	-.0160	12,816[b]	-$ 2,043
52/52	.4822	.3852	.0970	6,885	$ 6,674
50/50	.5698	.2397	.3301	12,283	$ 40,536
46/48	.3848	.4442	-.0594	56,233	-$ 33,408
44/46	.4513	.2029	.2484	39,455	$ 97,994
					$132,207

a. 58's, 58/60's and 56/58's

b. 56's and 50/56's

At present buyers (and brokers) tend to over-estimate the yield of fine wools/low yielding wools and under-estimate the yield of coarse wools/high yielding wools. The amount by which extreme yields differ from the mean is also generally under-estimated.[31] For the New Zealand clip, when the proportion of coarse and fine lots is taken into account, it is possible that net returns based on measured yield would be higher than those based on subjective yield appraisal, for binned wool at least.

From table 52, growers whose wool was 50's or finer would have suffered a financial loss from valuation based on measured yield. The size of this loss increasing as quality number increases. On the other hand, growers whose wool was 46/48's or coarser would have benefitted financially, with the profit increasing as quality number decreases. When the volume of wool of different quality numbers sold is taken into account, then the net affect would have been a gain to the industry of some $272,000.

In the case of fibre diameter, there is no identifiable pattern of over- or under-appraisal. Table 53 indicates that growers of 56's and 46/48's would have lost money from valuations based on objective measurement of fibre diameter, while growers of 58's, 52's, 50's and 44/46's would have profitted.

The net affect, after considering the volume of each quality group of wool sold, would be a net gain to the industry of $132,000. Thus, the total profit to the wool industry from objective measurement of yield and fibre diameter for these six quality numbers in one season would have been just over $400,000.

It is important at this stage to recognise what this figure of $400,000 means. It is an estimate based on several critical assumptions. Never-the-less, the effects of relaxing these assumptions can be postulated and related to the total net gain figure calculated here.

The three critical assumptions are:

1. That the buying firm's appraisals are those on which the lot prices are based.

2. That the situation for binned lots can be generalised to all modes of offering.

3. That results representing 66% of the wool sold at auction can be extrapolated to the total volume sold at auction.

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31. See Sections 4.2.2 and 4.2.3.

It is considered that the remaining assumptions are justified and that the cost of pre-sale testing is ignored.

As Whan and Richardson[32] point out, in an ascending auction such as a wool auction each lot is sold to the highest bidder (i.e. the one with the largest positive error; assuming identical limits) at, or one bid above, the second highest valuation. Since the buying firm in this analysis was not the purchaser of all the lots considered here there is likely to be error introduced into the analysis at this point.

For the lots on which the buying firm was outbid, either its buying limits or its appraisals of yield and/or quality number were less than that of the purchaser. In those cases where the latter occurred it is impossible to say whether higher or lower prices would have resulted from valuations based on objective measurement, since the purchaser's appraisals could have been higher or lower than the measured values. However, it can be said that this situation would tend to reduce the value of over-appraisal and increase the cost of under-appraisal; thus the effect of not using the true purchaser's appraisals is to inflate the value of the total net gain calculated in this section above its true value.

As previously explained, binned lots tend to be more cautiously appraised (particularly with regard to yield) and valued than other lots. Thus, inferring the same degree of under-appraisal to all modes of offering also inflates the value of the total net gain above its true value. This effect is governed by the percentage of binned lots offered. In 1971/72 this percentage was 34%, so, for the remaining 66% of lots offered as growers' lots, interlots or reclassed lots, the benefit from objective measurement would not be as great as indicated from these results for binned lots.

The total profit figure calculated in this analysis is based on a sample of lots representing 66% of the total sales at auction during 1971/72. Of the remaining 34%, 22% were 46/50's and 48's, 10% 48/50's and 2% 60's and higher. Considering the pattern of yield appraisal for different quality numbers, it is reasonable to assume that a large proportion of these lots would be under-yielded. Thus, for yield, the total net gain over the entire clip is likely to be more than proportionately higher than the profit calculated for 66% of the total. For fibre diameter it is impossible to say whether or not lots with quality numbers not considered here are likely to be over- or under-appraised.

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32. Whan and Richardson; op.cit.

Thus, the effect of two of the three main assumptions in this section is toinflate the value of the total net gain to growers above its true value. The effect of the other main assumption is to under-estimate the net gain over the whole clip. On balance, the conclusion that can be drawn from these conflicting forces is that there would have been a net increase in returns to the wool industry from valuations on the basis of objective measurement of yield and fibre diameter.

This conclusion is supported by Australian work discussed previously in Chapter Two.[33] Tier and Shepherd,[34] for example, found a statistically significant premium of 1.32 cents per pound paid for pre-sale tested wool over untested wool. The authors suggest that as more testing is done prior to sale, the impact of the factors leading to a premium for tested wool may decline owing to the correction of bias in visual appraisal. However, the constant value associated with the price premium can be expected to increase as more pre-sale testing is done and buyers are able to amalgamate complete mill consignments on the basis of test certificates.

The question of whether or not the increase in returns for tested wools would be sufficient to offset the cost of testing remains to be investigated. At the time of Tier and Shepherd's experiment (1971) the cost of testing was estimated at 1.13 cents per pound; less than the premium for tested wool.

It must also be remembered that this analysis does not include the potential cost saving benefits from objective measurement when combined with sale by small sample. A marketing system based on pre-sale testing and sale by small sample or description could reduce marketing costs through more efficient clip preparation, transportation, handling, storage and selection mill lots.[35] For the Australian wool market, Whan[36] estimates these cost saving benefits at $17.90 per bale, independent of the possible increase in returns from pre-sale testing.

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33. See Chapter Two, Section 2.6.2.

34. Tier, T.J. and Shepherd, M.A.; "An Analysis of the Price Premium Paid for Pre-Sale Tested Greasy Wool", Quart.Rev.Agric.Econ., 25:1, p.50, 1972.

35. The general implications of pre-sale testing and sale by sample and an indication of the associated costs and benefits is given in: Whan, R.B.; "Potential Savings from the Sale of Wool by Sample and Measurement", Quart.Rev.Agric.Econ., 24:4, p.206, 1971.

36. Whan, ibid.

Regardless of the financial benefits or otherwise from pre-sale testing, the fact remains that objective measurement would ensure that wool desired by the trade be rewarded accordingly. Growers whose wool was lower yielding and/or coarser than it looked would no longer profit at the expense of growers whose wool was higher yielding and/or finer than it appeared and who, at present, are being penalised for it.

CHAPTER FIVE

SUMMARY AND CONCLUSIONS

5.1 INTRODUCTION:

The five major objectives of this thesis, first stated in Chapter One, were:

a. To isolate the sources of binned wool price variation and to determine the extent to which these prices are explained by appraised and measured greasy wool characteristics.

b. To determine the relative economic importance of greasy wool characteristics for binned wool.

c. To examine the relationships between appraisals and between appraised and measured binned wool characteristics.

d. To investigate the effect of economic circumstances on appraisal.

e. To examine the effect of objective measurement on the equity of income distribution among growers.

This chapter summarises the results of study based on these objectives and concludes with an appraisal of the implications of these results for the wool industry.

5.2 SUMMARY AND CONCLUSIONS:

Of the total price variation of a sample of wool types, 60% was accounted for by the between-types source, 20% by the within-types between-seasons source and 5%, 13% and 5% respectively by the within-seasons between-centres, within-centres between-sales and within-sales between-lots sources. This analysis thus attempts to quantify the sources of variation of binned wool prices.

The size of the between-seasons, between-centres and between-sales sources is not necessarily an indication of an inefficient market. Provided this variation can be explained in terms of easily identifiable changes in the general price level then it is acceptable. If, however, this variation is random, as the Wool Marketing Study Group has suggested, then the market is inefficient because prices do not reflect 'true' market value and growers cannot accurately interpret the market's requirements.

The problem with the approach used in this type of analysis is that the demand effect is confounded by the appraisal effect (the assumption being that all lots of the same type are identical). Thus an attempt was made to estimate the size of the appraisal source in the variance of prices for lots of the same type.

The estimate of the variance within-types between-appraisers was 0.6 cents per pound clean, however, this value was not significant and contributed less than 1% to the total price variation. This result undoubtedly underestimates the size of this source of price variance because of the use of regression in estimating appraisers' valuations. Hence, a modified estimation technique was suggested.

Investigation of the within-sale between-lot source of price variation confirmed the hypothesis, that the appraisers closest to purchase (in this case the buying firm's appraisers) should explain most of the variation of prices from their monthly average, and measured data least. The respective multiple correlation coefficients for the buying firm, the brokers and the measured data were 0.75, 0.72 and 0.57.

For yield, a one percent increase in the buying firm's appraisal would have resulted in an increase of 0.40 cents per pound greasy in DMAP (Deviation from monthly average price). The same increase in brokers' yield appraisal and measured yield would have increased DMAP by 0.41 cents per pound and 0.09 cents per pound respectively.

A one unit increase in appraised quality number was worth 1.31 cents per pound on the basis of the buyers' appraisals and 1.35 cents per pound on the basis of the brokers' appraisals. A one micron increase in measured fibre diameter would have decreased DMAP by 1.25 cents per pound.

The sign and size of these coefficients for yield and fineness are readily explainable in terms of the processing importance of these two characteristics.

Although the effect of fibre diameter spread on processing performance is negligible, except in extreme cases, a unit increase in the buyers' and brokers' quality number ranges would have decreased DMAP by 0.43 cents per pound and 0.21 cents per pound.

In textile manufacturing, increasing staple length is desirable provided it does not mean a change in the system of processing or that it does not interfere with the performance of machinery. For the lots analysed in this study, an increase of one inch in average buyer-appraised staple length would have increased DMAP by 0.89 cents per pound. The same increase in average broker-appraised length or measured length would have increased DMAP by 0.70 cents per pound and 2.02 cents per pound respectively. However, the size and level of significance of these coefficients is probably due mainly to the strong association between length and yield rather than to a direct effect of length on sale price.

Recent research has discounted traditional belief in the importance of uniformity in fibre length and it is now accepted that there is an optimum fibre length distribution for best spinning performance and yarn properties. A unit increase in buyer-appraised staple length range would have reduced DMAP by 0.75 cents per pound and the fact, that length variation does have an important influence on price, is confirmed by the observation that a one unit increase in measured length standard deviation would have reduced DMAP by 7.24 cents per pound. However, for the lots analysed, a similar change in the brokers' appraisal of staple length range would have had no significant effect on DMAP. This suggests that the brokers were unable to effectively appraise a parameter of economic importance to one particular buying firm.

The implication of this result is that less length variation would have been desirable. However, this situation may be a reflection of the long held belief in the desirability of staple length uniformity rather than a reflection of the processing importance of length variation.

In terms of their relative economic value to appraisers, average quality number was found to be approximately three times as important as yield which, in turn, was approximately twice as important as average length. Quality number range and staple length range were relatively unimportant.

The relative economic importance of the five fleece characteristics concerned was similar for both the buying firm and the brokers, except that the buying firm attached relatively more importance to features other than quality number.

Logically the wool trade should pay for wool features in correct proportion to their importance in terms of processing performance. The relative economic value of alternative wool characteristics should be clearly apparent to growers so that they can concentrate on those features sought by the trade.

Although results such as those summarised here cannot show whether or not the wool trade is placing the correct emphacis on wool features, information on the relative economic value of alternative characteristics at least enables growers and breeders to concentrate on those characteristics held to be important.

Over a six-month period during the 1969/70 season, the economic importance of yield to the buying firm and the brokers appeared to decrease sharply. If this was in fact the case then it represents an anomalous situation, since yield is a fundamental processing property, second in economic importance only to quality number. The explanation of this phenomenon clearly requires further investigation but, regardless of its cause, this situation illustrates the problem currently faced by growers in interpreting the value of their clips and the requirements of the wool trade.

Comparisons between the means of appraised and measured characteristics revealed no significant differences. This indicates that, on average over a large number of lots, there is close agreement between the buying firm's and brokers' appraisals and between appraisals and measurements of the same characteristics. However, correlation coefficients show that, on individual lots, the agreement between appraisers is less satisfactory and, individually, their estimates may be in error when compared to measured data.

This latter observation was confirmed by examination of the distributions of appraised yield about measured yield and measured fibre diameter within appraised quality numbers. For the buying firm, only 10% to 16% of their yield appraisals agreed with the measured value while only 20% to 35% of measured fibre diameters fell in the quality number range assessed by the buyers. Similarly, for the brokers, only 10% to 25% of their yield appraisals and 15% to 40% of their quality number appraisals were 'correct'.

Furthermore, these appraisal errors were not necessarily random. Although there was no identifiable pattern of over- or under-appraisal by brokers or the buying firm for fineness, there was a distinct trend in over- and under-yielding. Appraisers clearly tend to over-estimate the yield of fine wools and under-estimate that of coarse wools. As far as yield is concerned it was found that appraisers also tend to appraise towards the mean so that high yielding wools (which tend to be coarse since there is a strong positive association between yield and fibre diameter) are generally under-yielded and low yielding wools (which tend to be fine) over-yielded.

Thus, while in total appraisal errors may cancel out and total revenue to growers is possibly unaffected, the equity of income distribution among individual growers is not. The nature of binned lots, containing as they do wool from a number of different sources, ensures that there is a good chance that the brokers' and buyers' estimates of yield and fineness will be close to the actual averages of these characteristics. However, growers whose wool is low yielding and/or coarser than it looks will benefit financially at the expense of growers whose wool is high yielding and/or finer than it appears. In addition, the possibility of variation in brokers' and buyers' appraisals means that growers may be forced to make ill informed judgements about the textile industry's quality requirements.

Examination of the impact of economic circumstances on appraisal revealed that both the buyers and the brokers significantly up or downgraded their estimates of yield over the period 1968/69 to 1970/71 in response to changing prices. This effect became more pronounced as coarseness increased but appeared to decrease over time. There was no evidence to suggest a similar situation for the appraisers' estimates of fineness, however.

It is suggested that the explanation of this phenomenon from a buyer's point of view is that, when demand is declining and prices are falling, he can become more critical in his appraisal and so downgrade wool without fear of being caught with forward orders which he is unable to fill. When demand is increasing and prices are rising, increased competition does not allow the buyer to be so critical if he is to fill his orders, hence there is an incentive for him to upgrade wool.

Brokers are strongly influenced by buyers in their classing practices since buyers are their customers. Thus, it is reasonable to expect brokers to respond directly and quickly, in a similar manner as suggested for buyers, to changes in prices and become more or less critical in their classing as prices fall and rise.

This hypothesis is well supported by actual wool prices for the 1968/69, 1969/70 and 1970/71 seasons and the patterns of yield appraisal over this period.

Finally, an attempt was made to quantify the effect of objective measurement on the sum of all growers' incomes and the equity of income distribution among growers. For six quality numbers, during the 1971/72 season, valuations based on measured yield and fibre diameter would not only have altered income distribution so that wool desired by the trade was rewarded accordingly, but would also have increased total returns to the New Zealand wool industry by some $400,000. The validity of this figure for total net gain to the wool industry from valuations based on objective measurement should be treated with some caution since it is based on several critical assumptions. Never-the-less there is no doubt that objective measurement would have improved the equity of income distribution among growers.

5.3 IMPLICATIONS FOR THE NEW ZEALAND WOOL INDUSTRY:

An efficient market is one which accurately reflects the current value of individual sale lots. In such a market the value of sale lots would be well known and any unexplained price variation would be small. However, this thesis provides ample evidence to support the conclusion that, measured by these criteria, the present wool auction system has many inefficiencies.

Not only does it frequently fail to accurately translate the wool textile industry's quality requirements into price, but random price fluctuations which occur obscure trends and eliminate premiums paid for special qualities of wool. Thus, a grower who is attempting to improve his clip gets a very poor guide, in terms of prices received, as to the direction in which changes should be made.

The income of both buyer's and growers is subject to risk as a result of random price variation in the market. This risk contributes to buyers' costs and creates an uncertain environment for farm development.

In addition, appraisal errors, which are often biased in one direction or another, disturb the equity of income distribution among growers and may even result in a loss in growers' total income.

Much of the inefficiency of the present wool market is due to the fact that subjective standards are used for appraisal and that these standards are only loosely associated with the important textile properties of wool.

For example, at present wool buyers pay higher prices for more highly crimped wools irrespective of their mean fibre diameter, in spite of the fact that it is diameter and not crimp which is important in processing. This situation only serves to emphasise the need for the introduction of objective measurement of important processing properties into wool marketing.

Provided confidence exists in the reliability of objective measurement, pre-sale sampling and testing would provide a basis for the valuation of wool that is impartial, subject to less error than one based on subjective appraisal, and one that identifies the wool properties that are valuable to processors. More specifically, the use of objective test results for valuing purposes could lead to:

1. Large savings in wool handling methods through sale by small sample and, eventually, sale by description alone.

2. A decrease in unexplained wool price variation by the removal (or, at least, the substantial reduction) of the appraisal component of valuation, and hence a reduction in the error of estimation on individual lots.

3. Better informed response from growers to the wool textile industry's requirements.

4. A more equitable distribution of income among wool growers and possibly an increase in auction prices for wool.

5. A reduction of buyers' risk associated with the purchasing and processing of greasy wool.

6. Economics in processing by the selection of mill lots on the basis of objective measurement.

7. Elimination of the uncertainties caused by changes in the moisture content of wool during storage and a decrease in buyer discrimination against binned and blended wools.

8. More efficient wool classing and sheep selection programmes.

If large-scale testing was introduced, it would be expected that the unit cost of sampling and laboratory work would be reduced. In particular, the handling charges that now form the main component of the cost of testing would be reduced by sampling all bales as they arrive at brokers' stores.

It is only a matter of time before the outstanding technical problems associated with objective measurement are solved. Thus, the only obstacle to the introduction of objective measurement lies in gaining the confidence of buyers and sellers in the new methods involved.

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APPENDIX A.

TABLE A.1

Standard Deviations of Appraised Yield and Price : 1968/69 Season

Centre/Sale (1968/69)	7:2	5:2	1:2	2:2	6:2	8:2	4:2	3:2	5:3	1:3	7:3	2:3	8:3	4:3	3:3	5:4	6:3	7:4	2:4	8:4	1:4	4:4	7:5	3:4	5:5	1:5	2:5	8:5
Buyer Yield	5.08	4.60	4.26	3.02	2.94	3.09	4.20	3.28	4.55	5.87	4.81	2.97	3.06	4.30	4.02	4.70	3.18	4.72	3.19	3.05	5.13	4.78	4.64	3.74	4.67	5.13	4.53	3.08
Broker Yield	5.56	4.86	5.09	3.43	3.34	3.10	4.18	3.58	4.03	5.47	5.34	2.87	2.79	4.44	3.52	5.01	2.58	5.56	3.17	2.58	4.76	4.46	5.18	3.46	3.90	5.29	3.23	3.25
Sale Price	7.94	6.59	5.67	5.49	5.81	3.85	5.11	4.08	6.10	5.68	6.95	4.42	3.51	4.51	3.68	6.35	5.37	7.41	4.56	3.44	4.87	4.43	7.66	3.76	6.04	4.96	5.41	3.78

Centre/Sale (1968/69)	4:5	6:4	3:5	5:6	1:6	2:6	7:6	4:6	8:6	1:7	5:7	2:7	3:6	7:7	4:7	6:5	1:8	5:8	8:7	2:8	5:9	1:9	7:8	3:7	4:8	8:8	2:9	1:10
Buyer Yield	4.43	2.75	3.34	4.67	5.30	3.62	4.65	4.91	3.55	5.56	4.49	3.67	3.37	4.55	4.56	4.54	5.41	4.58	3.63	5.05	4.28	5.38	4.53	3.40	7.65	2.97	7.80	5.71
Broker Yield	4.39	2.03	3.39	4.17	5.35	3.15	4.92	4.76	3.04	5.39	4.34	3.45	3.68	5.15	5.50	3.79	5.38	3.90	3.53	4.72	5.71	4.81	4.85	3.92	6.38	3.41	6.05	5.31
Sale Price	4.19	5.85	2.57	7.18	4.54	4.40	8.66	3.82	3.85	4.89	6.82	3.58	2.80	6.37	3.62	5.66	4.67	6.03	2.99	3.80	5.33	4.21	5.87	3.29	4.57	3.04	5.65	4.32

TABLE A.2

Standard Deviations of Appraised Yield and Price : 1969/70 Season

Centre/Sale (1969/70)	6:1	7:1	8:1	5:1	7:2	5:2	1:2	2:2	6:2	8:2	4:2	3:2	5:3	1:3	7:3	2:3	8:3	4:3	3:3	5:4	6:3	7:4	2:4	8:4	1:4	4:4	3:4	5:5
Buyer Yield	3.82	1.97	5.51	3.80	3.26	3.63	1.08	1.50	3.44	1.95	1.46	1.27	3.36	0.97	3.07	1.83	1.39	1.44	1.55	3.46	3.80	3.58	2.08	1.45	1.28	1.72	2.29	3.59
Broker Yield	4.04	2.91	4.34	3.96	3.47	4.07	2.10	1.63	3.39	1.92	1.74	1.49	3.27	1.31	3.61	1.87	1.34	1.56	1.62	4.22	3.68	3.54	1.95	1.67	1.21	1.73	1.74	3.57
Sale Price	4.70	3.01	7.16	5.28	6.26	5.64	3.83	3.11	5.53	1.76	3.04	2.35	5.81	3.70	6.19	3.22	2.15	3.30	3.69	5.32	4.79	7.45	3.64	2.65	4.43	3.19	3.46	5.42

Centre/Sale (1969/70)	1:5	7:5	2:5	8:5	4:5	6:4	3:5	1:6	5:6	2:6	7:6	4:6	8:6	1:7	5:7	3:6	7:7	2:7	6:5	1:8	4:7	8:7	2:8	5:8	1:9	7:8	3:7	2:9	1.10
Buyer Yield	1.35	3.09	2.09	1.55	1.90	3.65	1.86	1.48	4.08	2.21	3.29	2.97	1.79	1.82	3.68	2.56	2.87	2.10	3.95	1.74	5.15	3.70	2.89	3.74	4.07	3.26	3.39	2.95	4.41
Broker Yield	1.83	3.26	1.45	1.45	1.56	3.76	2.47	1.82	4.13	1.51	4.47	2.67	1.72	2.61	5.53	3.31	3.11	1.82	3.68	2.33	5.07	4.01	1.98	5.07	4.50	2.69	3.60	2.24	4.72
Sale Price	3.65	6.83	2.98	2.97	2.05	5.10	2.43	2.37	4.36	2.36	5.81	3.51	1.87	1.97	4.21	2.10	4.12	1.83	2.74	2.52	4.06	2.80	2.38	3.94	3.33	4.75	1.73	1.72	3.25

TABLE A.3

Standard Deviations of Appraised Yield and Price : 1970/71 Season

Centre/Sale (1970/71)	6:1	8:1	7:1	5:1	7:2	5:2	1:2	6:2	2:2	8:2	4:2	3:2	5:3	1:3	7:3	2:3	8:3	4:3	3:3	5:4	6:3	7:4	2:4	8:4	1:4	4:4	3:4	5:5	1:5
Buyer Yield	3.51		4.62	3.80	5.32	3.57	3.50	2.22	4.13	5.13	3.36	2.66	3.06	4.51	4.56	3.51	4.41	4.32	2.98	2.82	3.45	5.76	3.60	4.00	3.46	4.02	4.07	2.67	3.70
Broker Yield	4.03		4.80		6.21	5.24	3.70	3.25	3.97	5.15	2.70	3.00	3.99	3.39	4.86	3.17	5.17	3.27	3.72	4.00	4.13	4.88	3.03	4.26	3.67	3.25	4.34	4.27	3.17
Sale Price	4.04		5.14	4.24	5.50	4.21	4.10	3.33	3.69	3.08	3.78	3.05	3.45	4.55	3.85	3.59	3.33	4.20	3.48	4.08	4.10	3.69	3.21	2.77	3.88	3.44	3.32	2.14	2.87

Centre/Sale (1970/71)	7:5	2:5	8:5	6:4	4:5	3:5	1:6	5:6	2:6	7:6	4:6	8:6	1:7	5:7	3:6	7:7	2:7	6:5	1:8	4:7	8:7	2:8	5:8	1:9	7:8	3:7	4:8	8:8	2:9	1:10
Buyer Yield	4.57	3.88		4.01	3.67	3.48	4.03	3.02	5.19	4.02	3.77		4.40	3.17	2.71		5.78	4.38	4.48				2.54	3.95		4.81				
Broker Yield	3.90	3.38		4.49	3.80	1.94	3.97	2.70	3.24		3.20		4.96	2.49	3.13			4.25	5.15				3.13	3.89		4.99				
Sale Price	3.48	2.87		3.31	2.57	2.08	2.77	1.88	3.35	2.57	2.17		2.20	1.63	1.52		3.72	3.08	2.28				1.67	2.79		3.26				

APPENDIX B.

TABLE B.1

Correlation Coefficients : 1968/69 (2368 lots)

	Buyer Yield	Buyer Avg. Q.No.	Buyer Q.No. Range	Buyer Avg. Length	Buyer Length Range	Broker Yield	Broker Avg. Q.No.	Broker Q.No. Range	Broker Avg. Length	Broker Length Range	Meas. Yield	Meas. Fibre Dia.	Meas. Length
Buyer Avg. Q. No.	-.342												
Buyer Q. No. Range	-.268	-.251											
Buyer Avg. Length	.312	-.252	-.293										
Buyer Length Range	.097	-.142	.016*	.309									
Broker Yield	.894	-.390	-.196	.270	.098								
Broker Avg. Q. No.	-.333	.958	-.272	-.185	-.126	-.387							
Broker Q. No. Range	-.180	-.259	.411	-.267	-.048*	-.130	-.265						
Broker Avg. Length	.311	-.322	-.253	.748	.028*	.283	-.300	-.253					
Broker Length Range	.044*	-.128	.009*	.101	-.011*	.057	-.139	.075	.126				
Measured Yield	.806	-.485	-.069	.197	.127	.786	-.479	-.016*	.208	.069			
Measured Fibre Dia.	.301	-.835	.203	.141	.017	.349	-.847	.286	.316	.104	.424		
Measured Length	.311	-.362	-.236	.760	-.004*	.292	-.334	-.222	.861	.143	.222	.347	
Measured Length S.D.	-.057	-.320	.099	.361	.027*	-.050*	-.303	.075	.454	.152	.003*	.256	.498

* Denotes non-significant at 5% level.

TABLE B.2

Correlation Coefficients : 1969/70 (2005 lots)

	Buyer Yield	Buyer Avg. Q.No.	Buyer Q.No. Range	Buyer Avg. Length	Buyer Length Range	Broker Yield	Broker Avg. Q.No.	Broker Q.No. Range	Broker Avg. Length	Broker Length Range	Meas. Yield	Meas. Fibre Dia.	Meas. Length
Buyer Avg. Q. No.	-.448												
Buyer Q. No. Range	.077	-.308											
Buyer Avg. Length	.315	-.418	-.147										
Buyer Length Range	.212	-.286	.037*	.416									
Broker Yield	.841	-.555	.138	.326	.221								
Broker Avg. Q. No.	-.432	.953	-.329	-.367	-.267	-.537							
Broker Q. No. Range	.069	-.278	.264	-.140	-.050*	.094	-.327						
Broker Avg. Length	.239	-.419	-.112	.816	.298	.287	-.376	-.132					
Broker Length Range	.007*	-.022*	-.016*	.060	-.019*	-.028*	-.010*	.026*	.075				
Measured Yield	.750	-.567	.149	.267	.210	.758	-.560	.132	.224	-.016*			
Measured Fibre Dia.	.451	-.863	.268	.406	.227	.540	-.873	.238	.451	.038*	.567		
Measured Length	.290	-.530	-.043	.779	.293	.346	-.488	-.079	.860	.094	.300	.553	
Measured Length S.D.	.150	-.423	.079	.392	.158	.206	-.418	.092	.459	.053*	.189	.416	.574

* Denotes non-significant at 5% level.

TABLE B.3

Correlation Coefficients : 1970/71 (1384 lots)

	Buyer Yield	Buyer Avg. Q.No.	Buyer Q.No. Range	Buyer Avg. Length	Buyer Length Range	Broker Yield	Broker Avg. Q.No.	Broker Q.No. Range	Broker Avg. Length	Broker Length Range	Meas. Yield	Meas. Fibre Dia.	Meas. Length
Buyer Avg. Q. No.	-.571												
Buyer Q. No. Range	-.006*	-.369											
Buyer Avg. Length	.373	-.437	-.091										
Buyer Length Range	.286	-.412	.106	.381									
Broker Yield	.895	-.628	.072*	.374	.301								
Broker Avg. Q. No.	-.543	.963	-.397	-.402	-.401	-.608							
Broker Q.No. Range	.003*	-.266	.268	-.118	.008*	.037*	-.259						
Broker Avg. Length	.343	-.444	.003*	.765	.311	.374	-.444	-.061*					
Broker Length Range	-.014*	-.020*	.075	.009*	-.022*	-.052*	-.006*	.202	.079				
Measured Yield	.806	-.646	.141	.308	.274	.824	-.626	.132	.316	.014*			
Measured Fibre Dia.	.550	-.888	.318	.406	.385	.608	-.897	.252	.463	.005*	.615		
Measured Length	.410	-.541	.029*	.747	.308	.429	-.530	.018*	.798	.051*	.373	.563	
Measured Length S.D.	.147	-.498	.257	.356	.226	.168	-.488	.157	.385	.092	.218	.443	.478

* Denotes non-significant at 5% level.

TABLE B.4

Correlation Coefficients : Auckland (906 lots)

	Buyer Yield	Buyer Avg. Q.No.	Buyer Q.No. Range	Buyer Avg. Length	Buyer Length Range	Broker Yield	Broker Avg. Q.No.	Broker Q.No. Range	Broker Avg. Length	Broker Length Range	Meas. Yield	Meas. Fibre Dia.	Meas. Length
Buyer Avg. Q. No.	-.079*												
Buyer Q. No. Range	-.395	-.170											
Buyer Avg. Length	.259	-.122	-.329										
Buyer Length Range	-.104	-.089	.046*	.139									
Broker Yield	.907	-.106	-.348	.181	-.118								
Broker Avg. Q. No.	-.043*	.894	-.192	-.092	-.036*	-.086							
Broker Q. No. Range	-.125	-.297	.309	-.240	-.041*	-.090	-.312						
Broker Avg. Length	.260	-.058*	-.343	.794	.008*	.214	-.044*	-.264					
Broker Length Range	-.004*	-.121	-.016*	.141	.000*	-.017*	-.098	.093	.130				
Measured Yield	.766	-.235	-.206	.118	-.074*	.754	-.208	-.033*	.108	.000*			
Measured Fibre Dia.	.084*	-.721	.155	.154	-.022*	.146	-.737	.279	.191	.113	.212		
Measured Length	.221	-.136	-.302	.781	.000*	.170	-.121	-.216	.853	.161	.085*	.219	
Measured Length S.D.	-.133	-.173	-.026*	.445	.099	-.159	-.156	-.063*	.470	.207	-.177	.142	.537

* Denotes non-significant at 5% level.

TABLE B.5

Correlation Coefficients : Napier (770 lots)

	Buyer Yield	Buyer Avg. Q.No.	Buyer Q.No. Range	Buyer Avg. Length	Buyer Length Range	Broker Yield	Broker Avg. Q.No.	Broker Q.No. Range	Broker Avg. Length	Broker Length Range	Meas. Yield	Meas. Fibre Dia.	Meas. Length
Buyer Avg. Q. No.	.045*												
Buyer Q. No. Range	-.328	-.246											
Buyer Avg. Length	.238	-.331	-.236										
Buyer Length Range	.077*	-.226	-.036*	.288									
Broker Yield	.836	-.056*	-.293	.212	.107								
Broker Avg. Q. No.	.077*	.922	-.282	-.295	-.187	-.022*							
Broker Q.No. Range	-.175	-.239	.321	-.184	-.111	-.175	-.245						
Broker Avg. Length	.187	-.357	-.203	.845	.311	.161	-.345	-.195					
Broker Length Range	.020*	-.011*	.127	.000*	-.053*	-.046*	.033*	.196	-.032*				
Measured Yield	.618	-.192	-.137	.108	.120	.607	-.141	-.006*	.077*	.062*			
Measured Fibre Dia.	-.043*	-.744	.178	.254	.160	.090*	-.762	.182	.320	-.091*	.141		
Measured Length	.246	-.408	-.193	.819	.263	.233	-.388	-.105	.826	.040*	.155	.371	
Measured Length S.D.	-.034*	-.226	.035*	.419	.146	-.071*	-.231	.080*	.434	.183	-.008*	.144	.501

* Denotes non-significant at 5% level.

TABLE B.6

Correlation Coefficients : Wanganui (731 lots)

	Buyer Yield	Buyer Avg. Q.No.	Buyer Q.No. Range	Buyer Avg. Length	Buyer Length Range	Broker Yield	Broker Avg. Q.No.	Broker Q.No. Range	Broker Avg. Length	Broker Length Range	Meas. Yield	Meas. Fibre Dia.	Meas. Length
Buyer Avg. Q. No.	.034*												
Buyer Q. No. Range	-.362	-.120											
Buyer Avg. Length	.222	-.321	-.249										
Buyer Length Range	.086*	-.122	-.124	.532									
Broker Yield	.791	-.189	-.246	.183	.053*								
Broker Avg. Q. No.	.061*	.874	-.148	-.261	-.112	-.172							
Broker Q. No. Range	-.245	-.183	.231	-.149	-.155	-.116	-.215						
Broker Avg. Length	.121	-.382	-.213	.749	.209	.122	-.327	-.083*					
Broker Length Range	-.128	-.029*	-.022*	.048*	-.046*	-.105	-.038*	.074*	.134				
Measured Yield	.650	-.093*	-.167	.068*	.050*	.624	-.094*	-.091*	.018*	-.111			
Measured Fibre Dia.	.008*	-.746	.076*	.283	.021*	.197	-.768	.231	.373	.024*	.126		
Measured Length	.119	-.397	-.180	.703	.127	.113	-.033*	-.063*	.821	.125	-.030*	.421	
Measured Length S.D.	-.151	-.197	.039*	.358	.073*	-.160	-.151	.024*	.447	.089*	-.175	.152	.527

* Denotes non-significant at 5% level.

TABLE B.7

Correlation Coefficients : Wellington (614 lots)

	Buyer Yield	Buyer Avg. Q.No.	Buyer Q.No. Range	Buyer Avg. Length	Buyer Length Range	Broker Yield	Broker Avg. Q.No.	Broker Q.No. Range	Broker Avg. Length	Broker Length Range	Meas. Yield	Meas. Fibre Dia.	Meas. Length
Buyer Avg. Q.No.	-.260												
Buyer Q.No. Range	-.317	-.204											
Buyer Avg. Length	.352	-.422	-.186										
Buyer Length Range	.171	-.165	-.023*	.432									
Broker Yield	.891	-.233	-.283	.306	.139								
Broker Avg. Q.No.	-.223	.938	-.233	-.388	-.182	-.195							
Broker Q.No. Range	-.233	-.144	.297	-.180	-.119	-.209	-.153						
Broker Avg. Length	.262	-.445	-.127	.800	.182	.214	-.413	-.150					
Broker Length Range	-.096*	.055*	.030*	-.098*	-.136	-.123	.101*	.245	.026*				
Measured Yield	.754	-.328	-.139	.219	.163	.696	-.293	-.146	.170	-.163			
Measured Fibre Dia.	.138	-.738	.161	.326	.053*	.130	-.744	.177	.415	-.117	.238		
Measured Length	.305	-.535	-.136	.778	.157	.251	-.507	-.083*	.843	-.077*	.227	.519	
Measured Length S.D.	-.115	-.311	.092*	.410	.010*	-.102*	-.295	.086*	.481	-.003*	-.111	.290	.548

* Denotes non-significant at 5% level.

TABLE B.8

Correlation Coefficients : Christchurch (665 lots)

	Buyer Yield	Buyer Avg. Q.No.	Buyer Q.No. Range	Buyer Avg. Length	Buyer Length Range	Broker Yield	Broker Avg. Q.No.	Broker Q.No. Range	Broker Avg. Length	Broker Length Range	Meas. Yield	Meas. Fibre Dia.	Meas. Length
Buyer Avg. Q. No.	-.583												
Buyer Q. No. Range	.039*	-.354											
Buyer Avg. Length	.526	-.576	-.017*										
Buyer Length Range	.234	-.286	.113	.445									
Broker Yield	.849	-.700	.173	.527	.252								
Broker Avg. Q. No.	-.585	.974	-.376	-.572	-.297	-.705							
Broker Q. No. Range	.112	-.283	.266	.170	.129	.200	-.304						
Broker Avg. Length	.551	-.669	.057*	.720	.196	.598	-.683	.098*					
Broker Length Range	-.104	.110	.051*	-.002*	.048	-.136	.108	.117	.004*				
Measured Yield	.809	-.725	.178	.543	.296	.857	-.720	.222	.582	-.123			
Measured Fibre Dia.	.574	-.929	.332	.510	.233	.673	-.933	.247	.669	-.091*	.700		
Measured Length	.528	-.718	.142	.702	.158	.592	-.732	.150	.838	.026*	.580	.699	
Measured Length S.D.	.147	-.435	.174	.351	.108	.217	-.448	.156	.395	.022*	.242	.407	.524

* Denotes non-significant at 5% level.

TABLE B.9

Correlation Coefficients : Timaru (509 lots)

	Buyer Yield	Buyer Avg. Q.No.	Buyer Q.No. Range	Buyer Avg. Length	Buyer Length Range	Broker Yield	Broker Avg. Q.No.	Broker Q.No. Range	Broker Avg. Length	Broker Length Range	Meas. Yield	Meas. Fibre Dia.	Meas. Length
Buyer Avg. Q. No.	-.483												
Buyer Q. No. Range	.063*	-.375											
Buyer Avg. Length	.509	-.562	.012*										
Buyer Length Range	.345	-.406	.155	.469									
Broker Yield	.833	-.629	.186	.523	.381								
Broker Avg. Q. No.	-.457	.965	-.397	-.529	-.409	-.630							
Broker Q. No. Range	-.049*	-.270	.236	-.034*	.014*	.076*	-.292						
Broker Avg. Length	.426	-.630	.127	.710	.314	.526	-.632	.012*					
Broker Length Range	.071*	-.196	-.054*	.127	.053*	.112*	-.175	.043*	.176				
Measured Yield	.765	-.587	.174	.507	.351	.817	-.573	.039*	.480	.097*			
Measured Fibre Dia.	.500	-.930	.349	.540	.383	.636	-.937	.266	.631	.187	.581		
Measured Length	.494	-.726	.147	.732	.331	.577	-.708	.064*	.788	.204	.528	.717	
Measured Length S.D.	.140	-.462	.209	.405	.167	.257	-.451	.143	.480	.125	.211	.421	.615

* Denotes non-significant at 5% level.

TABLE B.10

Correlation Coefficients : Dunedin (977 lots)

	Buyer Yield	Buyer Avg. Q.No.	Buyer Q.No. Range	Buyer Avg. Length	Buyer Length Range	Broker Yield	Broker Avg. Q.No.	Broker Q.No. Range	Broker Avg. Length	Broker Length Range	Meas. Yield	Meas. Fibre Dia.	Meas. Length
Buyer Avg. Q. No.	-.666												
Buyer Q. No. Range	-.043*	-.268											
Buyer Avg. Length	.617	-.653	-.001*										
Buyer Length Range	.280	-.383	.178	.452									
Broker Yield	.879	-.735	.043*	.608	.314								
Broker Avg. Q. No.	-.659	.976	-.291	-.636	-.375	-.735							
Broker Q. No. Range	-.068*	-.229	.295	-.089	-.004*	-.006*	-.225						
Broker Avg. Length	.569	-.639	-.163	.705	.241	.559	-.639	-.059*					
Broker Length Range	.116	-.096	.026*	.056*	.030*	.102	-.103	.046*	.070*				
Measured Yield	.819	-.745	.087	.640	.336	.817	-.746	.010*	.591	.143			
Measured Fibre Dia.	.687	-.935	.220	.605	.326	.736	-.943	.188	.664	.113	.741		
Measured Length	.650	-.760	.054*	.772	.268	.663	-.758	.024*	.825	.091	.709	.768	
Measured Length S.D.	.198	-.478	.189	.379	.188	.233	-.480	.169	.421	.055*	.310	.444	.523

* Denotes non-significant at 5% level.

TABLE B.11

Correlation Coefficients : Invercargill (577 lots)

	Buyer Yield	Buyer Avg. Q.No.	Buyer Q.No. Range	Buyer Avg. Length	Buyer Length Range	Broker Yield	Broker Avg. Q.No.	Broker Q.No. Range	Broker Avg. Length	Broker Length Range	Meas. Yield	Meas. Fibre Dia.	Meas. Length
Buyer Avg. Q. No.	-.017*												
Buyer Q. No. Range	-.366	-.031*											
Buyer Avg. Length	.300	-.142	-.356										
Buyer Length Range	.182	-.020*	-.097*	.329									
Broker Yield	.828	-.193	-.308	.290	.189								
Broker Avg. Q. No.	-.008*	.927	-.036*	-.046	.028*	-.193							
Broker Q. No. Range	-.368	-.309	.270	-.126	-.056*	-.231	-.342						
Broker Avg. Length	.159	-.271	-.270	.629	-.080*	.170	-.232	.009*					
Broker Length Range	-.040*	-.191	-.009*	.074*	-.035*	-.045*	-.223	-.077*	.141				
Measured Yield	.678	-.210	-.269	.282	.159	.654	-.175	-.155	.183	.001*			
Measured Fibre Dia.	.066*	-.730	-.041*	-.070*	-.150	.194	-.769	.233	.237	.153	.166		
Measured Length	.245	-.334	-.322	.612	-.131	.256	-.293	-.067*	.831	.152	.238	.310	
Measured Length S.D.	-.252	-.228	.055*	.248	-.134	-.197	-.209	.208	.420	.155	-.137	.127	.429

* Denotes non-significant at 5% level.

APPENDIX C.

TABLE C.1

Means and Standard Deviations of Appraised and Measured Binned Wool Characteristics

	Buyer Yield (%)	Buyer Avg. Q.No.	Buyer Q.No. Range	Buyer Avg. Length (in)	Buyer Length Range (in)	Broker Yield (%)	Broker Avg. Q.No.	Broker Q.No. Range	Broker Avg. Length (in)	Broker Length Range (in)	Meas. Yield (%)	Meas. Fibre Dia. (microns)	Meas. Staple Length (in)	Meas. Length S.D.
All Data (5757 lots)														
Mean	75.53	48.80	1.64	4.21	1.57	74.92	49.23	2.53	4.66	1.86	76.58	33.27	4.59	0.90
S.D.	4.21	3.85	1.45	1.06	0.59	4.25	4.00	1.35	1.12	1.13	4.73	3.50	0.94	0.22
1968/69 (2368 lots)														
Mean	75.61	48.51	1.87	4.20	1.62	74.79	48.97	2.51	4.72	1.85	77.38	33.49	4.60	0.91
S.D.	4.58	3.56	1.52	1.19	0.73	4.53	3.51	1.21	1.26	1.07	4.71	3.26	1.01	0.24
1969/70 (2005 lots)														
Mean	75.93	48.05	1.59	4.26	1.57	75.85	48.32	2.64	4.73	1.83	76.83	34.31	4.68	0.89
S.D.	3.43	3.74	1.32	0.99	0.48	3.39	3.99	1.52	1.06	1.07	4.24	3.38	0.91	0.21
1970/71 (1384 lots)														
Mean	74.80	50.39	1.34	4.15	1.48	73.79	51.01	2.43	4.45	1.92	74.85	31.39	4.45	0.89
S.D.	4.49	4.02	1.46	0.89	0.41	4.56	4.24	1.33	0.90	1.29	4.99	3.33	0.80	0.22

TABLE C.2

Means and Standard Deviations of Appraised and Measured Binned Wool Characteristics

1968/69 - 1970/71	Buyer Yield (%)	Buyer Avg. Q.No.	Buyer Q.No. Range	Buyer Avg. Length (in)	Buyer Length Range (in)	Broker Yield (%)	Broker Avg. Q.No.	Broker Q.No. Range	Broker Avg. Length (in)	Broker Length Range (in)	Meas. Yield (%)	Meas. Fibre Dia. (microns)	Meas. Staple Length (in)	Meas. Length S.D.
Auckland (906 lots)														
Mean	76.56	48.17	2.08	3.55	1.56	76.06	48.23	3.05	3.95	1.63	78.27	32.95	4.00	0.87
S.D.	4.32	2.22	1.42	1.12	0.63	4.31	2.79	1.67	1.13	0.89	4.22	2.77	0.88	0.21
Napier (770 lots)														
Mean	76.41	47.50	1.65	4.46	1.60	76.02	47.82	2.54	4.94	1.95	78.25	34.74	4.82	0.94
S.D.	3.28	2.54	1.38	1.06	0.38	3.09	2.58	1.40	1.02	1.38	3.29	2.58	0.89	0.23
Wanganui (731 lots)														
Mean	76.10	47.12	1.90	4.12	1.63	74.81	47.66	2.99	4.59	2.00	77.69	34.46	4.54	0.97
S.D.	3.05	2.32	1.30	0.97	0.63	3.20	2.59	1.29	1.07	1.28	3.26	3.00	0.89	0.22
Wellington (614 lots)														
Mean	76.49	47.74	2.04	4.17	1.59	75.55	48.04	2.83	4.62	1.81	77.64	33.68	4.54	0.93
S.D.	4.19	3.07	1.36	1.09	0.63	3.94	3.22	1.41	1.12	1.08	4.38	2.95	0.92	0.22

TABLE C.3

Means and Standard Deviations of Appraised and Measured Binned Wool Characteristics

1968/69 - 1970/71		Buyer Yield (%)	Buyer Avg. Q.No.	Buyer Q.No. Range	Buyer Avg. Length (in)	Buyer Length Range (in)	Broker Yield (%)	Broker Avg. Q.No.	Broker Q.No. Range	Broker Avg. Length (in)	Broker Length Range (in)	Meas. Yield (%)	Meas. Fibre Dia. (microns)	Meas. Staple Length (in)	Meas. Length S.D.
Christchurch (665 lots)															
	Mean	71.86	51.44	1.14	4.18	1.47	71.52	52.11	1.88	4.58	1.75	71.96	30.76	4.55	0.85
	S.D.	4.09	4.17	1.46	0.80	0.58	4.29	4.04	0.93	0.82	0.52	4.76	3.14	0.73	0.20
Timaru (509 lots)															
	Mean	73.99	50.00	1.18	4.28	1.50	73.46	50.65	2.29	4.58	1.77	73.67	31.98	4.62	0.85
	S.D.	3.94	4.23	1.38	0.80	0.47	3.90	4.25	1.25	0.88	0.41	4.51	3.37	0.77	0.21
Dunedin (977 Lots)															
	Mean	75.22	50.95	1.14	4.43	1.50	74.41	51.37	2.31	4.78	2.02	75.59	31.75	4.63	0.82
	S.D.	4.76	5.06	1.42	0.93	0.51	4.90	5.26	1.13	1.06	1.60	4.91	4.27	0.91	0.22
Invercargill (577 lots)															
	Mean	77.08	46.97	2.06	4.66	1.69	77.18	47.56	2.19	5.46	1.91	78.79	34.99	5.30	0.98
	S.D.	2.96	2.64	1.44	1.16	0.79	3.13	2.59	1.01	1.20	0.76	3.12	2.56	0.91	0.23