33rd Annual Conference of the

Australian Agricultural Economics Society

Lincoln College, Christchurch, New Zealand, 7-9 February 1989

PRODUCT CHARACTERISTICS AND ARBITRAGE

IN THE AUSTRALIAN AND NEW ZEALAND WOOL MARKETS

C. Angel, S. Beare

Australian Bureau of
Agricultural and Resource Economics

Canberra

and T. Zwart

Lincoln College, Canterbury

New Zealand

*The physical characteristics of wool are important
determinants of its spinning properties, yarn quality and
end use. The degree to which wools from different countries
of origin may be substituted has important implications for
the domestic marketing policies of Australia and New
Zealand. The hypothesis examined in this paper is that
differences in wool prices can be explained by differences
in the physical characteristics of the wool and that
objective measures of these characteristics allow for
effective arbitrage between these markets. The alternative
hypothesis is that premiums or discounts exist owing to
country of origin. An hedonic price analysis was conducted
on wool prices in Australia and New Zealand using a balanced
sample of sale lot data from the 1986-87 selling season. In
the year examined there was no evidence of any price
premiums associated with country of origin.*

The physical characteristics of wool largely determine its spinning properties, the quality of yarn produced and its final use. Moreover, characteristics of wool vary with sheep breeds, production practices and climate. Wool exporting countries may exploit a comparative advantage in the production of different wool types. Given that substitution possibilities between different wool types are limited in the production of textiles, the degree of direct price competition between export suppliers may, for the most part, be determined by the existing or potential overlap in the profile of product characteristics. This paper examines the question of whether measured differences in wool characteristics explain price differentials and allow effective arbitrage between exporting countries.

The degree to which wools from different countries of origin may be substituted in the production of textiles has important implications for the domestic marketing policies of Australia and New Zealand. Australia and New Zealand are the world's largest exporters of apparel and non-apparel wool, respectively. In both countries, the industries operate price stabilisation schemes which may also stabilise prices received for wool by other suppliers. Stockholding associated with these schemes may replace stockholding by foreign suppliers. Australia and New Zealand promote wool with expenditures targeted at different textile end-uses. The leakage of benefits to other suppliers from these policies will be determined by the extent to which other suppliers can produce wools which are close substitutes for Australian and New Zealand wools.

Wool in Australia and New Zealand is sold under a sample description which includes both objective and subjective measurement. The principal measurements are related to fibre diameter, length, strength, clean yield, vegetable fault and colour. The hypothesis under consideration here is that wools with identical sample measurements are regarded by buyers as perfect substitutes and that these measurements allow for effective arbitrage between these markets. The alternative hypothesis is that premiums or discounts exist owing to country of origin. Such premiums could exist if sale lot descriptions are viewed to be incomplete or if different selling methods, handling facilities or transport offer a cost advantage. To evaluate the hypothesis, a hedonic price analysis of wool prices in Australia and New Zealand was conducted using a balanced sample of lot sale data from the 1986-87 selling season.

## Background

Many studies have examined the raw wool characteristics of most importance in processing (for example, Walls 1974; Turpie 1985; Rottenbury, Andrews and Brown 1983). The four major characteristics identified are fibre diameter, length, strength and vegetable matter.

### Processing and final demand

Fibre diameter has been shown to be the major factor influencing the processing and end-use performance of wool and wool textiles. For example, in the production of apparel yarns a decrease in fibre diameter can improve spinning performance by increasing the speed at which the wool may be spun. Yarn properties, such as evenness, may also improve when spinning finer wools. The diameter of fibre will be a major determinant of the end-use of the wool. Generally, wools used to produce carpets and other furnishings are of a higher micron count than wools used in apparel goods. Fibre diameter also has a significant effect on end-use properties such as drape in fabrics and resilience in carpets.

1

Increased fibre length may also improve the spinning performance of wool and to a lesser extent the properties of wool yarn. As with diameter, fibre length will influence the end-use of the wool. The length of the fibre is one of the major determinants of the particular method used in processing, that is, the worsted system (semi-worsted in carpet manufacture) or the woollen system. Generally, longer wools are used in the worsted system where the fibres become relatively parallel in the yarn while the woollen system is more suited to shorter fibres where the yarn fibres are more tangled. Yarns from the worsted system are used in the production of woven fabrics, used to make items such as suits, while yarns from the woollen system are used in the production of knitted goods such as jumpers. Fibre length also affects the quality of the final good. For example, longer fibres may improve fabric abrasion resistance and the strength of knitted fabrics (Turpie 1985). While fibre length and fibre diameter are important individual characteristics of the wool, they are not independent. Fibre length tends to decrease as wools become finer. Therefore, the interaction of these characteristics is also important.

Fibre strength is of greatest importance in the early stages of the processing system where weaknesses will result in increased fibre breakages during carding and, in the worsted system, during combing. Depending on the position of the break in the fibre, breakages will lead to a reduction in the mean fibre length of the wool, and an increase in noil (short fibres removed during combing) in the worsted system, depending on the position of the break in the fibre.

Vegetable matter content and type is also most important in the early processing stage. While the level of vegetable matter affects the yield of the wool rather than quality, the type of vegetable matter may lead to both wool and machinery damage and may affect spinning performance and the quality of the processed good.

There are other raw wool characteristics which will influence the processing performance of the wool and the properties of the end product. The importance of these will vary between end-uses. For example, it is not desirable to have a high grease content in carpet wools following scouring as it may lead to accelerated soiling characteristics once the carpet is in service (Calver, Franklin-Backhouse, Jackson and Robinson 1988).

On the basis of the individual processor's different requirements to meet customer demands, buyers will purchase wool for the characteristics which are of the most importance in processing and end-use performance. There are price differentials for particular attributes of the wool. For example, there are premiums for finer wools while wools with high levels of vegetable matter are likely to be discounted.

Premiums and discounts for different wool characteristics will vary with shifts in demand for the final product. For example, fashion trends away from woollen knitwear towards cotton may partly the explain the gradual widening of price differentials between fine and coarse wools in recent years (Beare and Harris 1988). Similarly, technological changes, such as the development of lightweight wool fabrics, are likely to increase the demand for fine wools and, hence, attract a premium for this characteristic (Beare and Harris 1988).

Price premiums and discounts for individual wool characteristics will also vary over time as supplies of different wool types change. Wool

characteristics are not independent of each other. For example, as the wool
becomes finer, fibre length and fibre strength both tend to decrease.
Similarly, vegetable matter may vary with fibre diameter as sheep with
different micron ranges tend to be produced in different geographical
locations which, in turn, have different levels and types of vegetable
matter.

Supply

The micron profiles of Australia and New Zealand differ quite
significantly (see Figure 1) (Australian Wool Corporation 1987; New Zealand
Wool Board 1987). Australia is the largest producer of fine wools and New
Zealand is the largest producer of coarse wool. The climate and topography in
New Zealand and the small area of the average farm have favoured the
intensive production of prime lambs. Prime lamb production suits the short
period of high pasture availability in New Zealand. Returns to farmers are
generally greatest where prime lambs are finished during periods of abundant
feed before being sold to decrease stocking rates during periods of lower
feed availability. Nearly 75 per cent of sheep in New Zealand are Romney
Marsh and Romney Marsh cross breeds which are well suited to prime lamb
production and are more disease free in high rainfall conditions. These
breeds also provide strong wools, with around 75 per cent of the New Zealand
clip typically 33 micron and coarser. In Australia, conditions favour more
extensive agricultural industries and the majority of sheep are grown
primarily for their wool. Over three quarters of the Australian flock are
purebred merino, and typically around 75 per cent of wool is 23 micron and
finer.

The different breed compositions of Australia and New Zealand flocks also
determine the mean fibre length of each country's wool clips. The majority of
sheep in New Zealand are long wool breeds producing wools of around 200 mm in
length, if shorn annually. However, the practice of second shearing in New

FIGURE 1 - Fibre Diameter Profiles of Wool Production 1986-87.



3
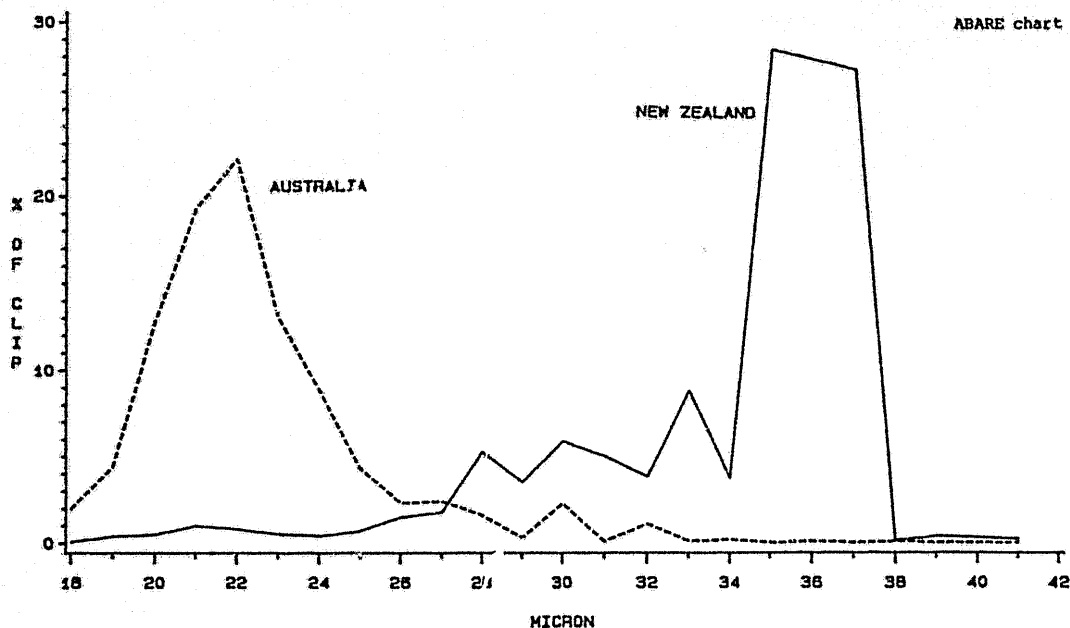
Zealand reduces the length of the clip. In Australia, the finer wool breeds which dominate the flock have annual fibre lengths ranging between approximately 70 and 100 mm. Average vegetable matter content also differs between Australia and New Zealand. The drier Australian climate results in a higher level of vegetable matter in Australian wools compared with those in New Zealand.

The different clip profiles mean that each country's wool is channelled into the production of different types of end-use items. As a result of the dominance of coarse wools in the New Zealand clip, the production of carpets, blankets and other non-apparel wool items represents an estimated 74 per cent of end-uses of New Zealand wool. In Australia, the dominance of fine wools predisposes most of the clip to the production of apparel items.

### Hedonic Price Models

The hypothesis that a good is valued for its quality or utility-bearing (hedonic) characteristics has been well advanced in economics. Characteristic demand models were derived within a utility maximisation framework by Theil (1951-52) and Houthakker (1951-52). A consumer's utility was assumed to be a function of both quantity and quality characteristics. Within these analyses the prices of product characteristics are explicitly assumed within the budget constraint Lancaster (1971) reformulated the characteristic demand problem by assuming that consumers select a combination of products to achieve an optimal set of characteristics. Here, the budget constraint contains only product prices. Characteristic prices are derived from first order conditions:

(1)     $P_i = \Sigma (\delta x_j/\delta q_i)(\delta E/\delta x_j)$

where:

P_i is the price of the ith product
$x_j$ is the jth product characteristic
$q_i$ is the quantity of the ith product
E  is total expenditure.

The first term is the marginal yield of the jth characteristic from the ith product. The second term is simply the marginal value of the jth characteristic, which can be interpreted as an implicit price.

Ladd and Zober (1977) considered that the physical attributes of a product may not correspond directly to utility bearing characteristics of goods, as they are perceived by consumers. The problem is similar to that considered by Ladd and Martin (1976) in extending characteristic demand to the derived demand for factor attributes. It is necessary to assume that a functional relationship, consistent with the requirements of a production function, exists between physical input attributes, intermediate and product characteristics. Given that marginal rates of transformation can, in principle, be derived from a production process, the implicit price equation may be rewritten:

(2)     $P_i = \Sigma [(\delta E/\delta x_j)(\delta x_j/\delta y_j)](\delta y_j/\delta q_i)$

$= \Sigma [(\delta E/\delta x_j)(\delta x_j/\delta y_j)]y_j$

where $y_j$ is the jth measured attribute of the input. The term enclosed in square brackets is the implicit or hedonic price of the measured attribute.

The marginal value of the jth characteristic, as well as the marginal rate of transformation, may be dependent upon the level of other complementary or substitute characteristics. For example, vegetable fault may be more heavily discounted in fine as opposed to coarse wools, as its removal may result in a greater degree of breakage. Thus, the hedonic price relationships may be nonlinear in the measured attributes.

A number of hedonic analyses have been conducted on wool prices in Australia (Skinner 1965; Simmons 1980; Davidson and Bond 1984; Bramma, Curran and Gilmour 1985). The results of these studies, in summary, indicate that fibre diameter and yield were the most important attributes affecting wool prices. Significant relationships were also found for measures related to length, strength, vegetable fault and colour. The relationships between graded attributes of wool and wool prices were, in some cases, nonlinear. Furthermore, these relationships have changed over time, as factors affecting the supply and demand for quality characteristics in wool have changed.

## Analysis

Weekly data on wool lots sold in Australia and New Zealand for the 1986-87 season were obtained from the Australian Wool Corporation and the New Zealand Wool Board. The Australian data available for the analysis were all of the wool sale lots that were objectively measured for fibre diameter, fibre length, fibre strength, yield, and vegetable fault. Fibre length and strength are additional objective measurements and were available for approximately 5 per cent of total Australian wool sales. The New Zealand data available for the analysis was a sample of sales, consisting of every 100th sale lot over the year. The data provided by the New Zealand Wool Board had measurements for fibre diameter, length, yield, vegetable fault and colour. Both data sets contained price, sale date and lot size information. In 1986-87, prices for almost all categories of Australian and New Zealand wool were above their respective floor prices. Hence, the price differences between similar wools from each country were not influenced by intervention in either country.

In matching the Australian and New Zealand data sets, only measurements on fibre diameter, fibre length, yield and vegetable fault were retained. Yields were used to convert prices to a clean equivalent basis and weekly exchange rates were used to convert New Zealand prices to Australian dollars. The fibre diameter composition of the Australian and New Zealand samples differed greatly. Furthermore, the composition of sales varied between sale weeks. Consequently, the sample was balanced by fibre diameter category and sale week. Fibre diameter classes were defined over one-micron intervals from 18.5 microns to 30.5 microns. For each stratum, all the observations were selected for the data set containing the minimum number of observations. An equal number of observations were taken from the remaining data set using a stratified random sampling procedure. Descriptive statistics for the sample are presented in Table 1.

Within the micron range selected from the sample data used in the analysis, the mean fibre length was greater in the Australian wools than in those of New Zealand. This is likely because of the presence of wool from sheep shorn twice a year, and because the selected micron range could have limited the number of the longer wools from the sample. The Australian wools in the sample averaged 96 mm and New Zealand wools averaged 65 mm. The

5

TABLE 1

Descriptive Statistics for the Sample Data

| Variable | Unit | Mean | | Standard deviation | |
|---|---|---|---|---|---|
| | | Australia | New Zealand | Australia | New Zealand |
| Micron count | $\mu m$ | 24.2 | 24.2 | 3.3 | 3.5 |
| Vegetable matter | % | 1.4 | 0.6 | 2.3 | 0.5 |
| Length | mm | 95.4 | 64.7 | 14.3 | 16.2 |

average level of vegetable matter in the sample data for Australian wool was approximately 1.3 per cent and the New Zealand levels only averaged around 0.6 per cent.

In the combined data set, clean equivalent prices were normalised by subtracting weekly means. This eliminated the purely temporal variance component of the data. Prices were then regressed against fibre diameter, length, vegetable fault and a binary country of origin variable. The binary variable took a value of one if the wool originated in New Zealand and zero otherwise. A quadratic response surface was chosen as the functional form for the regression. The binary variable was included as a constant term and an interactive term with fibre diameter. Interactive terms for the remaining variables were not included as the sample was not balanced with respect to these effects.

There are two potential sources of bias in the estimated price relationships which may, in turn, affect conclusions regarding price differentials between Australian and New Zealand wool. The first may result from the omission of a relevant variable, such as strength, which is on average greater in one of the two samples. This could lead to a sample selection bias as only Australian wools with 'additional measurements' were included in the sample. If wools suspected of being tender are not subjected to additional measurement the average strength in the Australian sample may be greater than in a random sample of New Zealand wool, resulting in a false price premium.

The second potential source of bias is in the choice of a smooth functional form. The suitability of wool for different end-uses (fibre diameter), different spinning systems (fibre length) and different methods of top preparation (vegetable fault) may create discrete thresholds for different characteristics. Consequently, discontinuities may exist in the price relationships for these characteristics. There is a large difference in the mean fibre lengths of the Australian and New Zealand samples. A bias in length premiums could again lead to false price premiums by country of origin. However, a quadratic function may still yield a good approximation of average length premiums within the various spinning systems.

The regression results are presented in Table 2. Initially, two of the quadratic terms for vegetable fault were dropped to reduce collinearity between the explanatory variables. A joint F test of the excluded effects indicated that these terms were not significantly different from zero at the 36 per cent level. In both the full and reduced models, individual t-

statistics for the binary country of origin variable are not significant. A joint F-test of the intercept and slope effects of country of origin was made. The results lead to the failure to reject the null hypothesis of no effect. There is a 99 per cent chance that the sample would be observed given the null is true. There are a number of factors influencing the power of the test. The sample is reasonably large, with 271 observations, and the confidence level at which the null hypothesis would be rejected is low. There remains a reasonable degree of collinearity between the explanatory variables, as indicated by the variance inflation factors, which would tend to reduce the power of the test. However, variance inflation factors are roughly of the same order for all the variables and significant effects were estimated for fibre diameter, length and vegetable fault. Thus, while noting the qualifications mentioned previously, it is reasonable to conclude that there is no evidence of country of origin effects on Australian and New Zealand wool prices.

The final model reported in Table 2 is the preferred form of the hedonic price model. Residual plots against time and fibre diameter are presented in Figures 2 and 3 respectively. There is no apparent systematic variation in the Australian and New Zealand residuals over the season. The variance of the residuals does appear to decline with increasing fibre diameter.

Contours of the response surface for the 1986-87 season are shown in Figures 4 through 6. The domains of the response surfaces were restricted to areas where sample coverage was adequate. In Figure 4, the range of data estimated for the response surface is represented by the hatched area. Generally, there are substantial premiums for finer wools. Price premiums for finer wools increase as fibre diameter declines. However, there is a critical point in the estimated response surface at around 28.5 microns, above which prices begin to increase with increased fibre diameter. Presumably, this represents a point of overlap between wools put to different end-uses. While the number of sample observations above 28 microns in diameter was too small to draw any strong inferences, the result suggests that the relationships governing premiums for fibre diameter change for non-apparel end-uses such as carpets.

Price premiums for fibre length and discounts for vegetable fault increase as fibre diameter decreases. Fine wools spun on the worsted system generally produce a high quality fabric with a soft smooth texture. Longer, combing type, wools are desired for processing on the worsted system. As mean fibre length tends to decrease with decreasing fibre diameter, an increased premium for length in finer wools would be expected. The strength of raw wool declines with decreasing fibre diameter. Removal of vegetable matter is more likely to damage finer wools, resulting in a discount rate which is nonlinear with respect to fibre diameter.

Price premiums for greater fibre length increase at a decreasing rate. This suggests that, in agreement with other studies, spinning characteristics of longer wools improve at a declining rate. However, as noted, there may be a specification problem with a continuous premium for fibre length, as length largely determines the system on which the wool is spun. Fibre length is likely to have a different effect on spinning in the worsted and woollen systems.

The discount rate on vegetable fault was constrained to be linear. However, as mentioned earlier, most of the sale lot observations contained only light vegetable fault. More severe discounts may apply to heavily faulted wools. Interactive effects between vegetable matter and length were

## TABLE 2

### Regression Results

| Variable | Model 1 | | | Model 2 | | | Model 3 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Coefficient | t-statistic | Variance inflation factor | Coefficient | t-statistic | Variance inflation factor | Coefficient | t-statistic | Variance inflation factor |
| Mic | -2.84 | 13.70 | 394.22 | -2.87 | 13.98 | 387.34 | -2.85 | 14.06 | 381.24 |
| Veg | -0.95 | 2.91 | 253.38 | -0.90 | 4.24 | 106.34 | -0.8 | 4.30 | 90.20 |
| DNZ | -0.78 | 0.82 | 188.43 | -0.62 | 0.66 | 182.55 | | | |
| Length | 0.09 | 3.37 | 258.16 | 0.10 | 3.98 | 228.59 | 0.11 | 7.46 | 84.42 |
| Mic*DNZ | 0.03 | 0.74 | 185.85 | 0.02 | 0.61 | 179.95 | | | |
| $Mic^2$ | 0.05 | 11.36 | 441.15 | 0.95 | 11.70 | 431.48 | 0.05 | 12.32 | 403.05 |
| Mic*Length | -0.001 | -0.70 | 363.89 | -0.001 | 0.95 | 332.83 | -0.001 | 2.46 | 121.94 |
| $Length^2$ | -0.0004 | -4.57 | 59.52 | -0.0004 | 4.84 | 56.39 | -0.0004 | 4.92 | 53.71 |
| Veg*mic | 0.02 | 1.43 | 239.40 | 0.03 | 3.57 | 104.13 | 0.03 | 3.57 | 89.50 |
| $Veg^2$ | 0.01 | 1.33 | 16.03 | | | | | | |
| Veg*Length | 0.003 | 1.06 | 128.02 | | | | | | |
| $R^2$ | 0.81 | | | 0.81 | | | 0.81 | | |
| F* | | | | 1.05 | 0.36 | | 0.27 | 0.99 | |

FIGURE 2 - Residual Plot against Week.
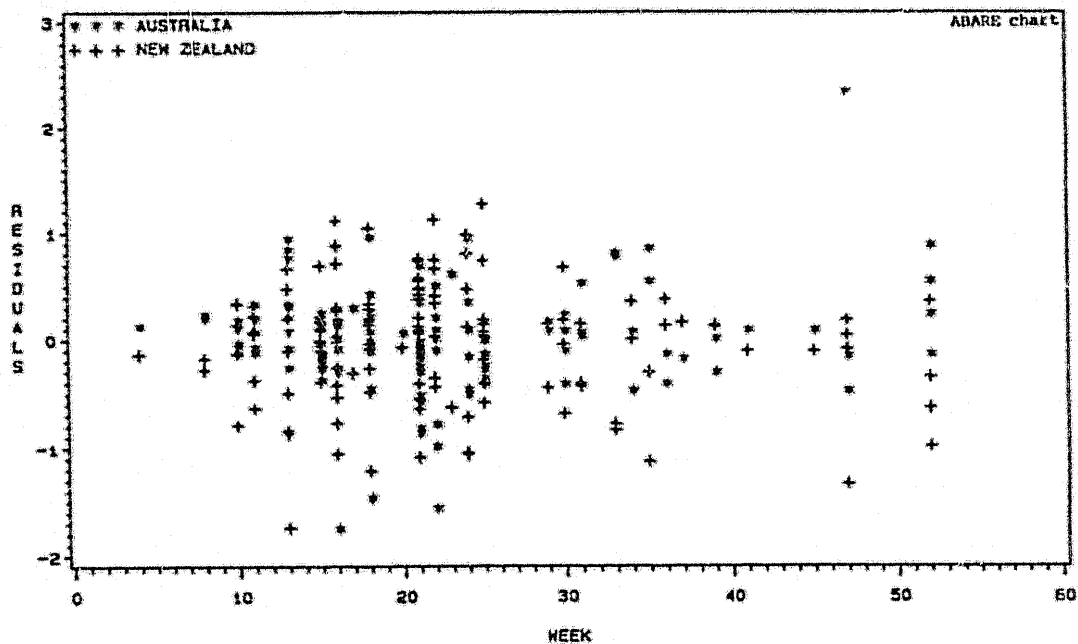


FIGURE 3 - Residual Plot against Fibre Diameter.
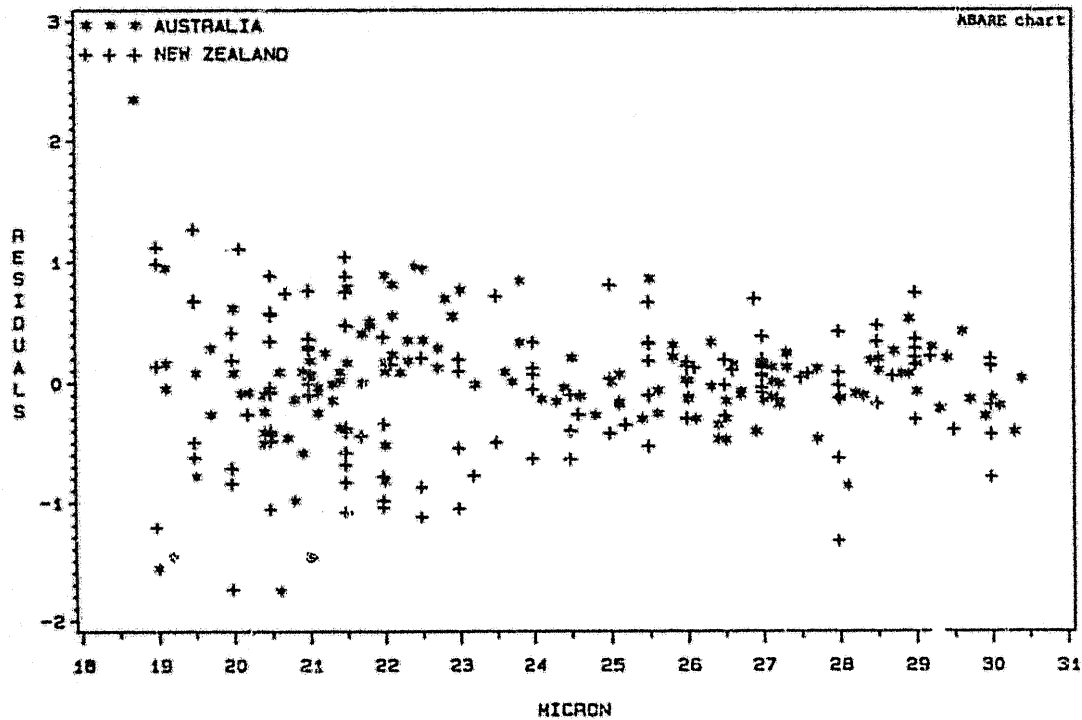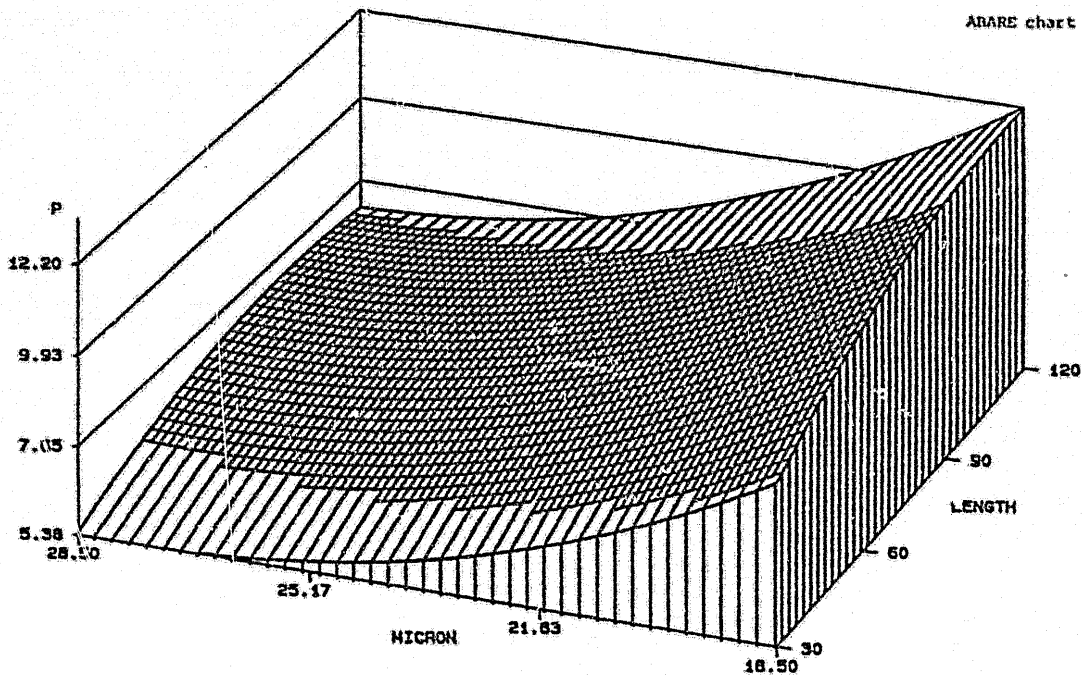
## FIGURE 4 - Response Surface Between Micron and Length.

ABARE chart

P

12.20

9.93

7.65

5.38

28.50

25.17

21.83

18.50

MICRON

120

90

60

30

LENGTH

## FIGURE 5 - Response Surface Between Micron and Veg.

ABARE chart

P

10.74

9.03

7.31

5.60

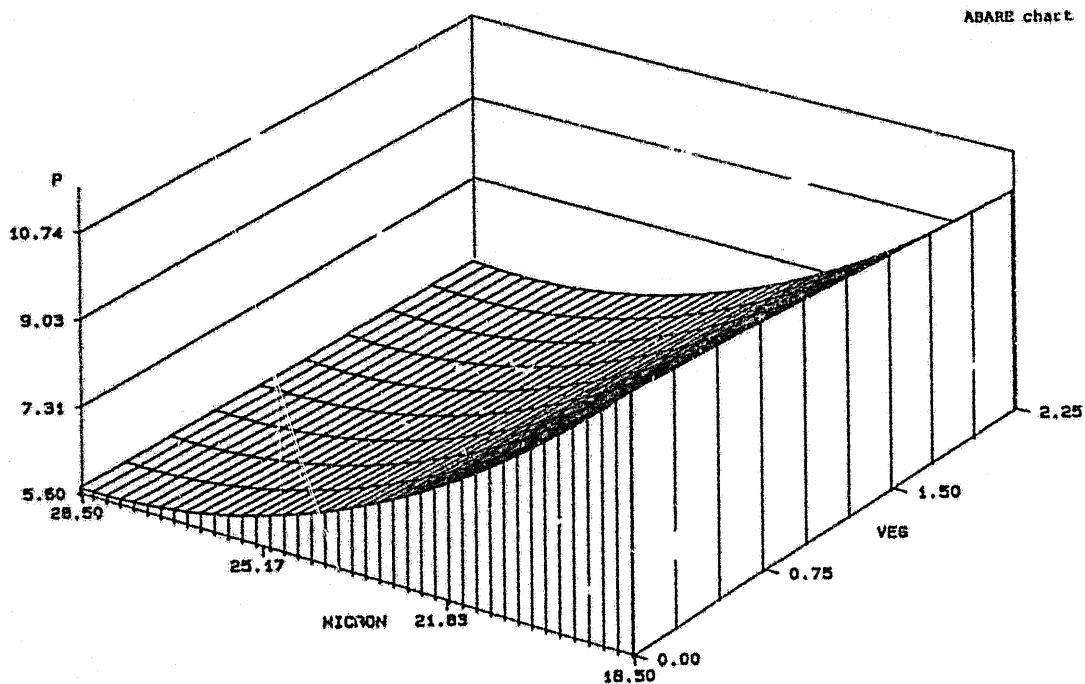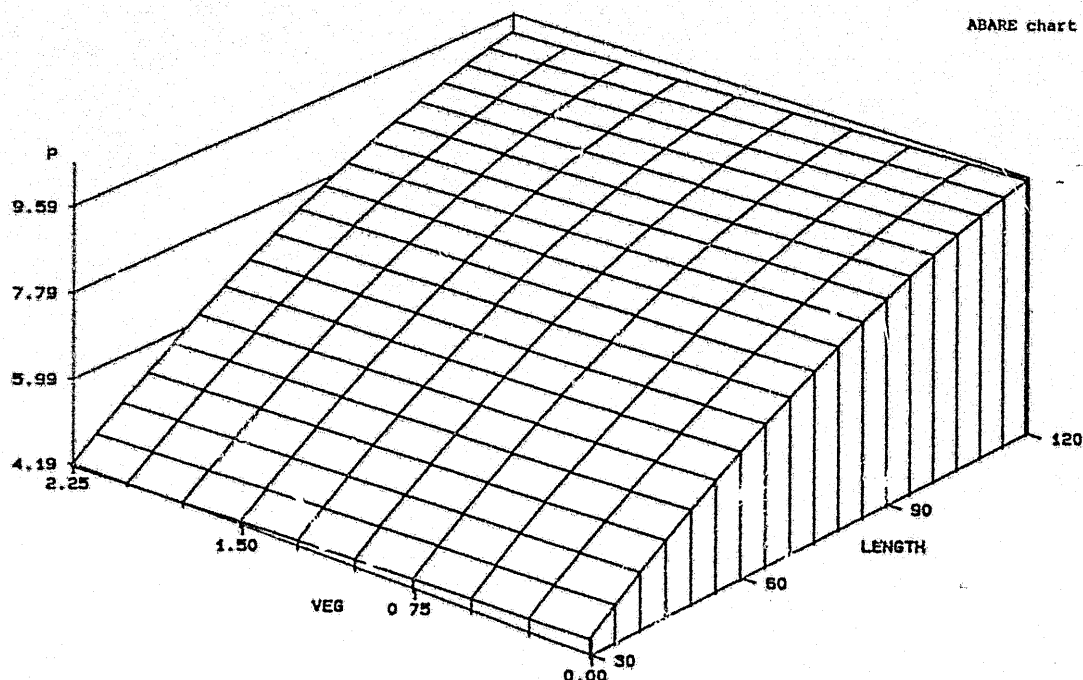28.50

25.17

21.83

18.50

MICRON

2.25

1.50

0.75

0.00

VEG

10

FIGURE 6 - Response Surface Between Veg and Length.



not significant. However, this may again apply only over a limited range of vegetable fault. In longer wools, spun on the worsted system, more vegetable matter can be removed by combing. Shorter wools with a high degree of vegetable fault may require carbonising. Again, changes in processing systems may introduce discontinuities into discounts for vegetable fault.

## Conclusions

The results of this analysis suggest that wool is traded in highly efficient markets. In the year examined, differences in wool prices could be explained by differences in the physical attributes of wool that affect its spinning characteristics and suitability for different end-uses. This does not imply that different wool types produced in different locations are of similar quality; only that price differences can be explained by the different characteristics of the wool. Existing grading standards allow for effective arbitrage between geographically distinct markets.

There is no evidence of any price premiums associated with country of origin. Price differentials between Australian and New Zealand wool can be adequately explained by differences in fibre diameter, fibre length and vegetable fault. Transport and other handling cost differences between Australia and New Zealand do not appear to be significant However, price differentials may exist between other competing wool exporters as a result of these types of costs. The degree of competition between export suppliers may depend on two sets of factors. The first are the characteristic profiles of production and product transformation possibilities in different countries. The second are the substitution possibilities which exist between these characteristics in textile production and final demand.

The substitution possibilities between wools of different fibre diameter and length may be quite limited. Wools of different fibre diameter are generally used in the production of yarns for different end-uses. Long and short fibres are generally spun on different systems, which yield yarns with distinctively different qualities. Historical observation of the fibre diameter profile in Australia suggests that adjustments to differences in relative prices are also limited. Geographical location and climate determine strong comparative advantages in the production of different wool types, leading to relatively inflexible product transformation possibilities. Consequently, price competition between wool exporting countries may be confined by the existing degree of overlap in their respective production profiles.

# References

Australian Wool Corporation (1987), _Australian Wool Sale Statistics: Statistical Analysis No. 17A_, Melbourne.

Beare, S. and Harris, D. (1988), 'Fibre competition in the US apparel market', _Quarterly Review of the Rural Economy_ 10(3), 261-68.

Bramma, K., Curran, B. and Gilmour, B. (1985), Non-linearity and market segmentation in hedonic price analysis of greasy wool. A BAE paper presented to the 29th Annual Conference of the Australian Agricultural Economics Society, Armidale, 12-14 February.

Calver, R., Franklin-Backhouse, J., Jackson, J. and Robinson, G. (1988), _Australia's carpet wools_. Carpet Institute of Australia Limited, Australian Wool Corporation and Victorian Department of Agriculture and Rural Affairs, Melbourne.

Davidson, B. and Bond, G. (1984), 'Price relativities within the wool market', _BAE Wool Situation and Outlook 1984_, AGPS, Canberra, 20-25.

Houthhakker, H.S. (1951-52), 'Compensated changes in quantities and qualities consumed', _Review of Economic Studies_ 19(3), 155-64.

Ladd, G.W., and Martin, M.B. (1976), 'Prices and demands for input characteristics', _American Journal of Agricultural Economics_ 58(1), 21-30.

Ladd, G.W. and Zober, M. (1977), 'Model of consumer reaction to product characteristics', _Journal of Consumer Research_ 4(2), 89-101.

Lancaster, K. (1971), _Consumer Demand : A New Approach_, Columbia University Press, New York.

New Zealand Wool Board (1987), _New Zealand Wool Board Statistical Handbook 1986-87 Season_, Wellington.

Rottenbury, R.A., Andrews, M.W., and Brown, G.H. (1983), 'Association between raw wool characteristics and processing top', _Textile Research Journal_ 53(1), 29-35.

Simmons, P. (1980), Determination of grade prices for wool', _Review of Marketing and Agricultural Economics_ 48(1), 37-46.

Skinner, J.N. (1965), 'Some factors affecting the clean price of greasy wool', _Australian Journal of Agricultural Economics_ 9(2), 176-187.

Theil, H. (1951-52), 'Qualities, prices and budget enquiries,' _Review of Economic Studies_ 19, 129-47.

Turpie, D.W.F. (1985), 'Raw wool properties that count most in processing', _Golden Fleece_ 15(2), 37-39.

Wells, G.W. (1974), 'Wool characteristics of processing importance', _Wool Technology and Sheep Breeding_ 21(1), 27-31.