An analysis of price trends for Australian apparel wool by micron category

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Abstract

The recent decline in the price premium for fine wools above medium and strong wools has prompted wool producers to examine their wool production strategies. This may lead to some switching from fine wool back to medium wool. Estimates of trends in demand and of the responsiveness of wool prices for specific categories to changes in quantity are obtained to guide wool producers in their decision making.

Price trends for seven apparel wool types were examined and an econometric model was used to test whether such trends were important between 1977 and 1991. A dummy variable data pooling technique was used to estimate a demand and slope intercept for each of the micron categories using the 19 micron category as the base.

The results of the study are consistent with 'a priori' expectations. Demand for coarse wool is expected to decline while demand for medium and fine wool is expected to remain constant in the short term and to increase in the medium term.

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1. Introduction

The market indicator for Australian wool prices has fallen from 1003 cents per kilogram clean (c/kg) in the 1987-88 season to 557 c/kg during the 1991-92 season. This decline in wool prices has had a greater negative effect on incomes of fine wool producers than on incomes of coarse wool producers. The market indicator price for 19 micron wools has decreased by 60 per cent during the period from 1987-88 to 1991-92 while for 25 micron wools it has declined by only 33 per cent. This reduction in price premiums for fine wools may induce producers of this wool type to change the average fibre diameter of their flocks to favour medium micron wool types.

Fine wool producers are confronted with the decision of whether to increase or decrease production of fine wool at a time when price premiums continue to decline. Producers may alter the average fibre diameter of their clips by either purchasing replacement medium wool sheep or changing their flock breeding direction by using medium wool rams. Note that certain environmental restrictions limit economical fine wool production to slopes and tablelands districts and that coarse wool production is most suited to harsh fringe country.

This study is designed to focus upon the planning decisions of sheep breeders, rather than commercial wool producers, since breeders must determine the market requirements for future sheep stock using past and current market trends when determining the breeding direction of their flocks. Price trends are useful planning tools when past trends are expected to continue but may provide misleading information if not analysed in conjunction with changes in consumer tastes, technical change, international market conditions and marketing objectives.

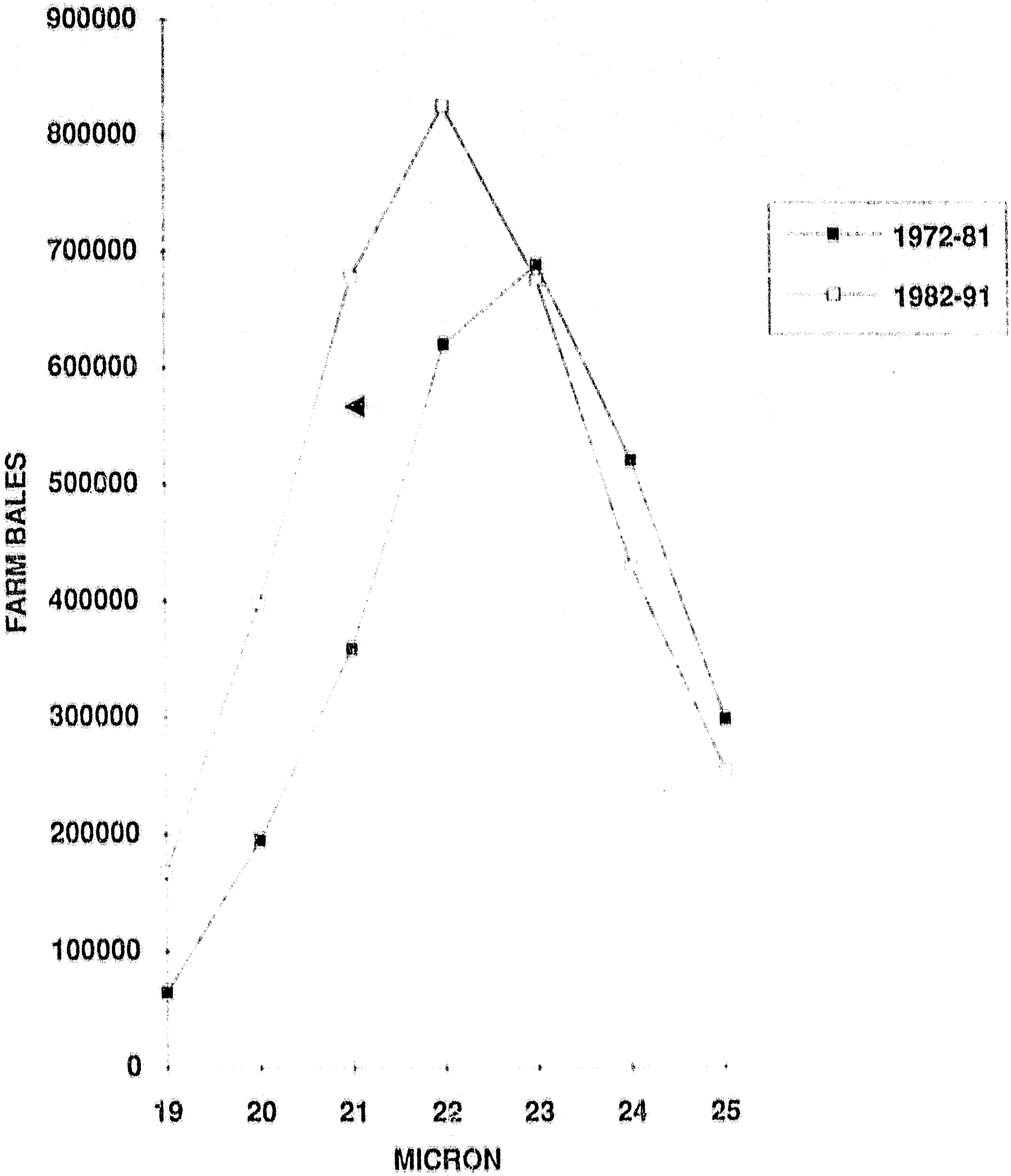
1.2. Aim of the study

The aim of this study is to identify and quantify price trends for apparel wool types and to use these trends as a basis for providing forecasts of demand for fine, medium and coarse apparel wool types. An econometric framework is used to test the significance of price trends for seven micron categories of apparel wool over a 15 year period.

1.3. Wool Supply

Figure 1 illustrates the supply of Australian wool by micron category. Two, ten year seasonal supply averages were graphed. The first for 1972-73 to 1981-82 and the second from 1982-83 to 1990-91. The graph clearly indicates that the supply of fine wool has increased and more importantly that the type of wool produced has clearly shifted away from the broad micron categories towards the fine end of the fibre diameter distribution.

TEN YEAR AVERAGE SUPPLY OF WOOL



1.4. Wool Prices

Nominal price variation between 19 and 23 micron wools during the past six years has been as high as 1400 cents in 1989, down to a low of 200 cents in 1992 (AWC 1992). The 19 micron indicator closed the 1990-91 season 36 per cent down on the season's opening price, while the 24 micron indicator rose 26 per cent over the same period. The rise in the broad micron indicator was due to increased purchases by China during the season (AWC 1992).

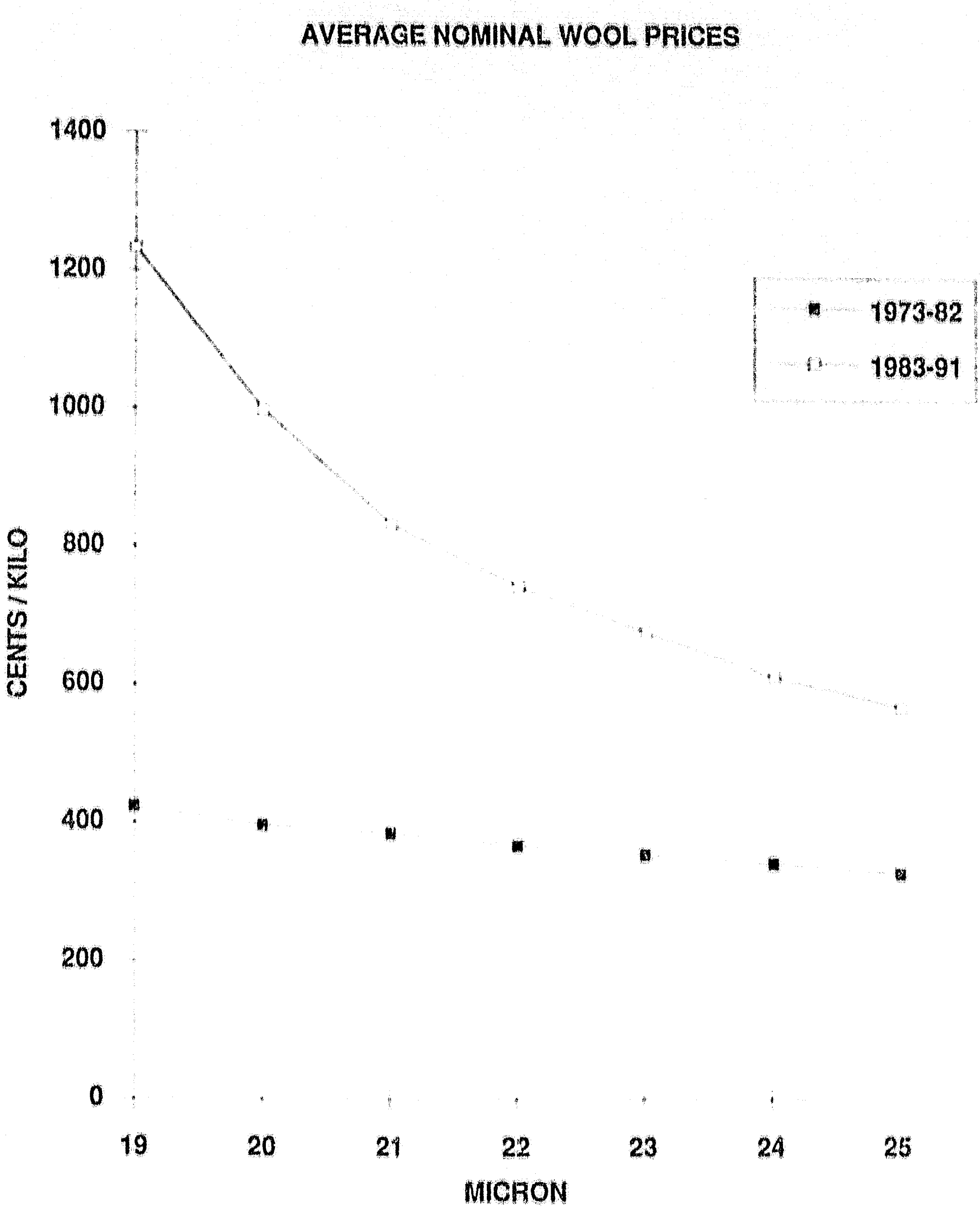
Average nominal wool prices for the period 1972-73 to 1982-83 and from 1983-84 to 1990-91 are shown in Figure 2. This graph shows that prices for fine wools have increased relatively more than the increase in broad wool prices over the two periods. Real prices for both time periods are shown in Figure 3. Only the prices for micron categories finer than 21 microns have increased over the two periods. This real increase in price for fine and medium wools was initially believed to be responsible for shifting the supply of wool toward the fine end of the distribution. However, the explanation for this shift is also believed to be a function of the preferred processing characteristics and comfort attributes of fine wool types which were heavily promoted by the IWS.

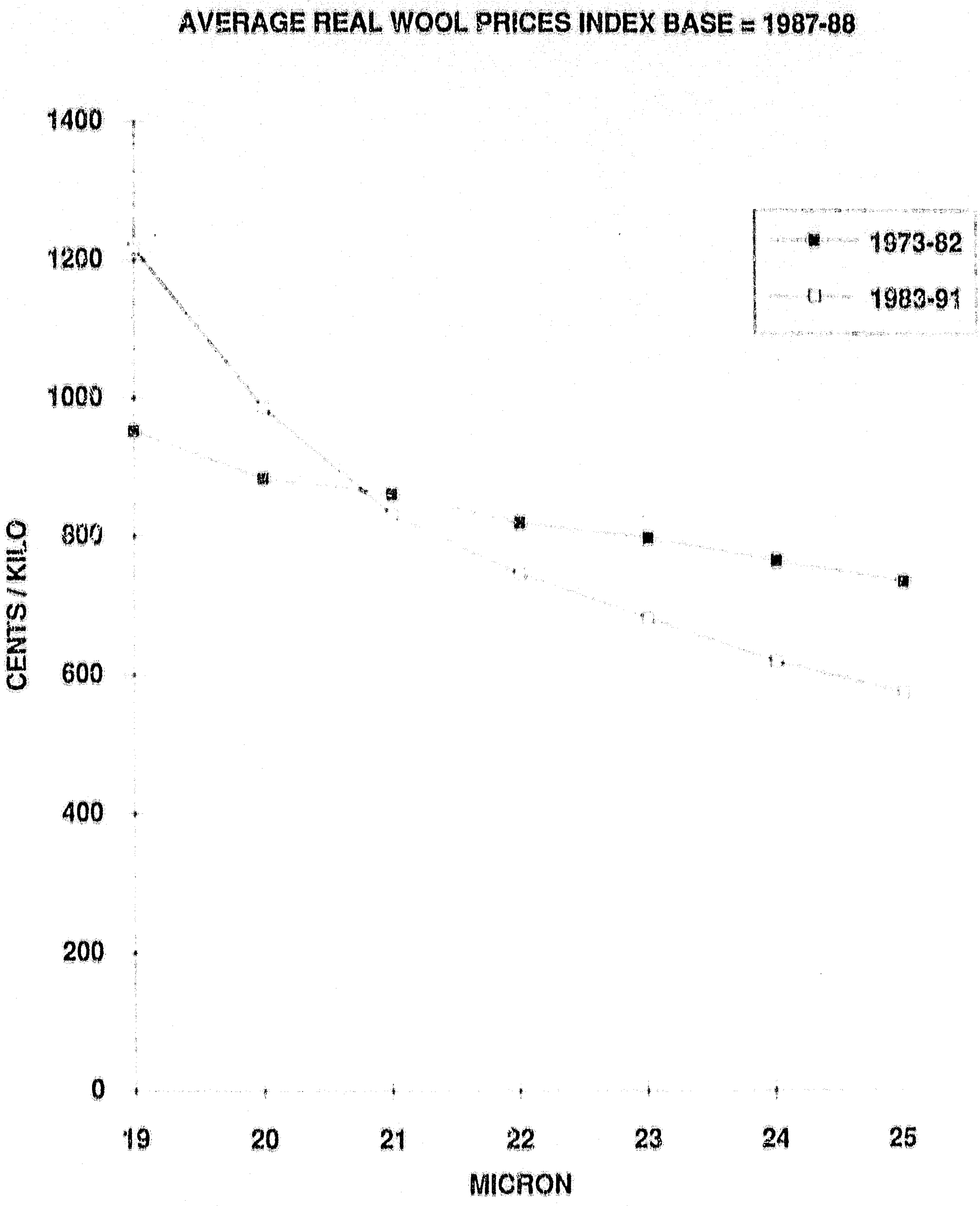
1.5. Previous Studies

The proliferation of econometric models to explain substitution among textile fibres has to some extent broadened the empirical knowledge of those analysts who have undertaken study within this field. However, the many studies in the field of fibre substitution are often in conflict. The results gained by analysts, using a range of variables, within different model structures has lead to large differences in estimates of demand and supply elasticities. It is impossible that each model structure could accurately predict trends in textile demand. Hence, the degree of substitution between wool types and competitive fibres remains in dispute.

For raw wool Beare and Meshios (1990) argue that wools are only direct substitutes over an estimated range of 4 microns. This result implies that broad combing wools are not substitutes for medium or fine combing wools. Thus, within the apparel range of wool types there would be three distinct products, each facing a different level of competition for cotton and synthetic fibres.

Previous studies on substitution between wool and synthetics have been concerned with fibre products at various stages of processing. Wool, cotton and synthetics only become substitutes or complements within the apparel market once the natural fibres have been processed to the yarn stage. Measures of processing performance are more comparable at the


AVERAGE NOMINAL WOOL PRICES
1400
1200
1000
800
600
400
200
0
CENTS / KILO
19
20
21
22
23
24
25
MICRON
1973-82
1983-91


AVERAGE REAL WOOL PRICES INDEX BASE = 1987-88
1973-82
1983-91
CENTS / KILO
1400
1200
1000
800
600
400
200
0
19
20
21
22
23
24
25
MICRON

yarn stage due to the uniform fibre specification for such yarns. Thus, the yarn or retail stage of production is suggested to be a suitable level at which to measure the degree of substitution between fibres. Quiggin (1981) supports this argument by suggesting that wool processing up to the yarn stage is characterised by resource fixity, due to wool specific machinery. Beyond the yarn stage processing machinery and marketing channels may be used for other fibres.

Substitution between various grades of wool and synthetic fibres is generally believed to be price driven. Hence, the main demand shifter for a certain category of wool will be its closest substitute micron category or synthetic fibre. The factors responsible for the price variation between fibres seems to differ depending upon the stage in the processing chain at which the study was conducted and the period over which prices change. The studies summarised below reflect these points.

Quiggin (1981) has distinguished three major sources of risk and instability in the price of wool. The first of these sources included, supply instability resulting from climatic conditions or input costs. Second, instability in demand for wool textiles, due to the price of synthetics, or general economic conditions in major consumer countries. Finally, instability which arises from fluctuations in exchange rates. Fluctuations in final demand and exchange rates were found to be the major sources of price instability within Quiggin's study.

Watson and Parish (1982) also claim that demand fluctuations are the major source of instability in wool prices. Fluctuations in wool prices were asserted to have three major effects on the wool industry which include:

1. there were the effects of variable prices on the efficiency of production and the welfare of growers;

2. stability in the Australian economy as a whole was regarded as vulnerable to extreme fluctuations in its major export industry;

3. It is argued that wool's competitive position vis-a-vis synthetic fibres was jeopardised by the greater price risks involved in handling wool (p331).

These industry problems resulting from demand variability were used as justification for establishing the AWC RPS. The first and third price effects remain of concern to Australian wool producers. However, the second effect of price instability on the Australian economy has become less significant since wool is no longer a major source of export earnings.

Veldhuizen and Richardson (1983) studied price competition between wool and synthetics at the yarn stage in Japan, Germany and Italy. A significant conclusion within that study was that wool prices in both absolute and relative terms significantly influenced consumption of wool in each of the three countries examined. A further conclusion of the study was that, the differential between wool and synthetic prices is the most important factor in identifying economic substitution possibilities.

Watkins (1987) found that demand variability was the major cause of price variation. The linear model used by Watkins examined the significance of price as a function of exchange rates, income, synthetic fibre price, mill consumption and quantity traded. Variability in exchange rates and mill consumption were found to be a relatively unimportant source of demand variability. Alternatively, variation in the price of synthetics was found to be an important cause of demand variability.

Piggott (1987) examined statistical evidence on sources of market instability for six grades of wool including four combing and two carding categories to determine whether demand was the primary source of instability in the Australian wool market during the 1960's. The results of that study indicate, for medium and coarse combing wools the direct supply contribution to price variance exceeded the direct demand contribution. Alternatively, for superfine and fine combing wools the direct demand effect exceeded the direct supply effect. In general the demand effect was found to be more destabilising than supply although the demand effect was often small.

Ball, Beare and Harris (1989) also examined substitution at the yarn stage to determine the significance of time lags between real price rises and changes in the demand for apparel wool. Ball, *et al* used a dynamic trans-log derived demand system of equations rather than single equation techniques used by Veldhuizen and Richardson. The results of their study suggest that in the short run there is minimal price induced substitution. However, they argue that such substitution may take place in the long run.

Short and Beare (1990) analysed substitution between wool, cotton and synthetic fibres at the retail level. Their study focused upon the retail level since they claim that the raw fibre level was inappropriate when there were distortions such as tariffs in retail markets for apparel. The model used by Short and Beare is estimated using the value shares of expenditure in different end uses as a function of prices in alternative end uses within a pooled model structure. The own-price elasticity estimates for wool from the model were generally price elastic. The cross-price elasticities were generally high. However, the degree of fibre substitution was believed to be imperfect.

1.5. Summary

From the background information presented one may begin to understand the complexities that a sheep breeder must take into account when planning breeding strategies so as to maximise income over a period of three to five seasons. Factors that need to be considered are the technical constraints of producing a different grade of wool and the length of delays in changing wool types. Consumer tastes and the focus of international marketing strategies are variables which are inherently difficult to measure for forecasting purposes. Alternatively, price trends and the relative prices between various wool grades and synthetic fibres may provide a measured by which to forecast demand for different wool grades over the next five seasons. The data and model structure are outlined below. Model validation tests, results and their implication to sheep breeders are then presented.

2. Model Specification and Data

An econometric approach is used within this study to identify price trend factors across micron categories. The econometric model utilises a data pooling technique previously used by Simmons (1980), Dewbre, *et.al* (1986) and Ball *et.al* (1989) among others. The pooled data model is use to investigate the hypothesis that, the price trend coefficients for the fine and medium micron categories are not 10 per cent greater then the price trend coefficients for broad micron wools.

Within the present study, seven micron categories of wool ranging from 19 to 25, for each of 15 average annual price observations, were pooled to produce the dependent variable data series. The cross-section or explanatory variable data included a quantity variable for each micron category, an intercept coefficient and a slope coefficient. The general form of the economic relationship between the price and quantity of wool is given by the expression:

$$P = f(Q, D, DQ) \qquad (1)$$

Where P represents price, Q representing quantity, D is micron count and DQ is an interaction term.

3. Assumptions

Prices and quantities are assumed to be determined recursively. That is, price is determined by the quantity supplied within a particular season which is assumed to be inelastic with respect to current prices due to the twelve month cycle of wool production. Producers are assumed to base their annual wool supply for the following season almost entirely on the price received in the previous year. Auction prices for the current period are assumed to be a function of three factors. According to Hindy and Huang (1992), these include:

1. variations in future supplies as determined by endowment and technology;
2. variations in demand for future consumption as determined by preferences for consumption at different times and in different states; and
3. evolution of information about future events (p 781).

Hence, when wool buyers set their maximum price they should take into account, stocks of wool held by other buyers and processors, the amount of wool available for sale now, and wool which is yet to be sold in future periods. Furthermore, the second price determinant implies that the price of wool in each micron category is determined not only by the quantity supplied of the micron category wool in different time periods but, also by the quantities supplied of other micron wools and the relative price of synthetic fibre substitutes. To include all of these variables in one aggregate equation model would lead to multicollinearity among the quantity variables. This in turn may lead to misleading results. The problem has been partly overcome through the use of the data pooling technique. The dummy variable model structure allows prices to be determined for each micron category without causing a large degree of multicollinearity (Pindyck 1988).

For this study the possibility of substitution of similar micron wool from other countries such as South Africa has been disregarded owing to the fact that data on individual micron categories for that country are not readily available. Data for international stocks of raw and semi processed wool are also disregarded for similar reasons. These assumptions are not expected to bias the results of this study significantly since Australian wool production is relatively large compared to the wool production and stock holding capacities of foreign countries. Davidson, MacAulay and Kaine-Jones (1988) assessed whether demand for wool from any other major producing countries had an impact on the Australian market. South African wool prices were included within their study to represent foreign wool prices. The results of their study indicated that prices for South African wool were insignificant in the combing wool demand equation.

All prices were deflated to 1991-92 prices using the consumer price index (CPI). Deflating all prices by the CPI negates the need to include a price index such as the CPI as a separate explanatory variable. This conversion was deemed necessary since it was assumed that consumers respond to real rather than nominal prices.

The affects of exchange rates on wool prices were controlled for by multiplying the real price variable by the Trade Weighted Index (TWI) of the Australian dollar. This TWI includes the five major currencies and their respective weights. These weights were as follows, Japanese yen (25.09 per cent), U.S. dollar (19.57 per cent), U.K pound sterling (5.68 per cent), New Zealand dollar (5.27 per cent and West German mark (5.15 per cent) (ABARE 1991).

The inverse demand model, or price equations for each of the seven micron categories are assumed to be linear across the variables. A linear functional form was selected for this study due to the simplicity of such models. The examination of intercept and slope parameters across the micron categories can be more easily interpreted from the linear specification rather than non-linear forms. Previous studies of the Australian wool market have indicated that there is little variation in the results from linear and non-linear functional forms (Campbell *et.al* 1980).

The use of annual data over the period 1977-91 provides the best possible homogeneous time period for this study. The decision to limit the period of the study was based upon three factors. The first was that prior to 1976-77 synthetic fibres were going through a period of rapid development. During this time, early synthetic fibres such as rayon were being replaced by more technologically advanced fibres such as polyester. Second, the establishment of the RPS may have induced substantial structural change within the industry during its infant years. Third, the end of the RPS in June of 1991 may have also contributed to structural change within the industry. Hence, these periods have been eliminated from the study.

The econometric version of the model is explicit about the model parameters and the relationships within the pooled data. The double summation sign indicates that each variable is summed for each micron category and for each year. This relationship is shown in mnemonic notation as follows:

$$\sum_{i=1}^{n} P_{it} = a_i + \sum_{i=1}^{n} \sum_{k=1}^{m} d_k X_{ikt} + \sum_{i=2}^{n} b_i D_{it} + \sum_{i=2}^{n} \sum_{k=1}^{m} l \, D_{it} X_{ikt} + \sum_{i=1}^{n} g \, P_{it-1} + u_{it} \qquad (2)$$

where; $i = 1 - n$, number of micron categories of wool
$k = 1 - m$, number of exogenous variables
$t = 1 - 15$, annual observations

The dependent variable P denotes price, X denotes exogenous variables, P_{t-1} denotes lagged prices and u is a random error variable which includes unexplained variation. The individual error components are assumed to be uncorrelated with each other and not autocorrelated across either time-series, or cross-sectional data. The parameters to be estimated are a, b, d, l and g. D is a zero-one variable which allows for changes in the price variable and between micron categories. Hence, D equals one for a specific micron category over the range of t years and is equal to zero elsewhere.

This model structure enables a direct comparison of the estimated intercept and slope coefficients b and l across the range of six micron categories. More importantly, it allows one to determine whether a source of variation across micron categories is connected with either the intercept, the slope or both. Pooled data models have two benefits over single equation models. First, only a single regression is required rather than one for each micron category. Second, pooled data increases the degrees of freedom which in turn increases the precision of the estimated parameters. The limitation of using pooled data is that, the coefficients attached to the dummy variables must always be interpreted in relation to the base group, in this case the 19 micron category (Gujarati 1988).

3.1 Model variables

3.1.1 Price

The price data used within this model were derived as an annual average of weekly prices which appear in the AWC Annual Price Summary. It must be noted that these are market indicator prices for their respective micron categories. The market indicator price for a particular micron category is a weighted average of several wool types which vary in style, length, clean yield, vegetable matter and colour (D'Arcy 1981). Prices were not available in this form for wools finer than 19 microns. Fibres less than 19 microns represent less than three per cent of the total Australian clip and are not considered within this study (AWC b. 1991).

Wool sold at auction represents between 80 and 90 per cent of the total wool sold in Australia (AWC a.1991). The remainder of the clip is sold by private treaty merchants particularly in Western Australia. Price data for these wools are not readily available, however, the merchant price is assumed to be the same as the auction price after allowing for appropriate discounts in handling and transport charges.

3.1.2 Quantity

The quantity data for this study were derived from a weighted average of first hand wool sold at auction by micron grade (AWC b.1991), multiplied by the total wool received by brokers for each wool selling season (N.C.W.S.B.A.1991). The first hand greasy wool sold at auction data does not include plucked and dead wool or wool previously bought at auction to avoid double counting (AWC b.1991). Wool received by brokers data were not available for individual micron categories. This data is preferred to wool sold at auction data to control for market distortions caused by RPS purchases of quantities available for sale.

The volume measure for wool was calculated from the number of farm bales produced annually and expressed in tonnes. This process involved multiplying the number of bales by annual average bale weights and dividing the result by a 1000. This data transformation was necessary to have all variables expressed in tonnes.

3.1.3 Intercept coefficients

The intercept dummy variables are used to examine the average difference in price between each micron category and the price of the 19 micron indicator after taking average differences in prices arising from differences in the other exogenous variables into account. A comparison of these intercepts shows whether price premiums are paid for various micron grades.

3.1.4 Slope coefficients

The inclusion of a slope dummy variable allows one to determine the change in the interaction between price and quantity over different micron categories in relation to the base micron category.

3.1.5 Lagged Price

The lagged real price variable was included within the model to measure the significance of past prices in forming the current period price. The lagged price is thought to be a significant variable since the stock holding capacity of buyers and processors means that it is unlikely that these consumer groups will respond completely to price changes within the period in which they occur (Dewbre, Vlastuin and Ridley 1986). Furthermore, six to eight months lags are a common feature in the wool processing industry hence, processors must base a large portion of their price expectations on the price paid in the previous year.

3.2 Other Variables

The final model includes polyester prices and a time trend. The economic reasons for including these two additional variables are outline below.

3.2.1 Polyester

The demand effects of substitutes and complements are relatively difficult to measure (Tomek and Robinson 1987). For the textile market, cotton and synthetic fibres share approximately 94 per cent of the total market, hence wool prices are not expected to influence the price or quantity of these two textiles. However, the relative price of these two products may be expected to influence demand for wool. For the present study the supply and price of synthetics is assumed to be predetermined.

The type 54, 1.5 denier Dacron from the United States Department of Agriculture (USDA) Cotton and Wool Situation, was use to represent price data for synthetic fibres. The measure of price and quantity for polyester was changed from US cents per pound to Australian cents per kilogram.

Cotton was initially included within this study as a substitute since a number of studies found that cotton and wool were weakly correlated substitutes. Cotton was found not to be a significant variable in this study in preliminary tests. Traditionally, the majority of cotton end uses are not the same as for apparel wools although more recently both wool and cotton end-uses have become increasingly similar. Nevertheless, over the period of the study the end-uses for these two products are assumed to be dissimilar. Thus the cotton variable was excluded from further examination.

Rayon was excluded as a substitute variable within the model for three reasons. First, rayon has a low price relative to most grades of apparel wool and polyester. Second, rayon has been superseded by polyester fibres for a significant period of the study. Third, rayon has recently been used more as a blending product or as complement to all other fibres rather than a substitute and its contribution to the model seemed doubtful (Ball, Beare and Harris 1989).

3.2.2 Time Trend Variable

The specification of a trend coefficient relies upon the assumption that a past trend will continue in the near future. The strength of this assumption relies upon the number of annual observations from which the trend coefficient is derived. In this study the price variable is assumed to increase in constant absolute amounts in each time period. This implies that consumer tastes, preferences, technology or income have changed in a continuous and regular fashion over the 15 year period. Clearly, if this is not true then one or more of these factors must have changed over time. Realistically, more than one of these factors may alter over time however, the major difficulty lies in determining exactly which of these factors have contributed to any variation in the trend and the magnitude of that change. It may also be true that a change in one variable may be offset by an equal and opposite change in a second variable, thus the trend may remain constant. However, this is unlikely given the length of the time series.

The coefficients within the theoretical model described above are estimated using ordinary least squares. Model validation tests and estimation results are now presented.

4. Results

4.1 Model testing

The results of the econometric model are presented and discussed with a view to rejecting or accepting the null hypothesis of this study. That is, the coefficients for the 19, 20, and 21 micron wools prices are not 10 per cent greater than the same coefficients for the 22, 23, 24 and 25 micron categories.

A summary of the model statistics including the variable coefficients, associated t-values and standard errors, the R-square, adjusted R-square, log of the likelihood function (ML), F-values, Durbin-Watson values and the number of degree of freedom for three model specifications are illustrated in Appendix 1. The first model illustrates the estimation results for a base model. This model is shown as (2) in the previous chapter.

The second model specification includes the polyester price variable, added to model 1. The third model specification includes the time trend variable which has been further added to model 2. Individual time trends for each of the seven micron categories were later independently added to model 2. These individual trends are important to determine whether or not the various micron grade prices have changed significantly over the 15 year period of the study. Results for these individual trend variables are presented below. Throughout the following discussion the full time trend refers to a (1 x k) vector which includes the time trend for each micron category stacked within one variable. Individual time trends are (1 x n) vectors for each micron category presented as separate variables.

The coefficient on the quantity variable has the correct sign and a significant t-value, with a small standard error in all equations. Likewise the coefficient on the lagged price variable also has the correct sign, significant t-value, low standard error and its magnitude indicates that the model is dynamically stable.

The method of maximum likelihood (ML) is used to estimate the unknown parameters in such a manner that the probability of observing the given parameters are as high as possible. High ML values are consistent with normally distributed data. The ML estimator of the variance does not take into account the number of degrees of freedom available for the model, whereas the OLS estimator does. Hence, the ML estimator is bias in small samples but this bias tends toward zero in large samples. The log of the likelihood function is calculated and reported within the standard output from the "Shazam" program. These ML values are summarised for each model in Appendix 1. Within this study the ML test is used to determine whether or not the addition of one or more variables to a model will improve the maximum value. The ML test is conducted in a similar way to the standard F-test. The ML values for both the unrestricted model (UML) and the restricted model (RML) are derived by estimating the regression with and without the new variable.

The addition of the polyester variable to the first model was found to be significant at the five percent level since the ML statistic = 15.148 is greater than $ML_{0.05}$ with df 1, = 6.314. The coefficient for polyester was positive as expected however the t-value was not significant. The t statistic = 1.24 is not greater than $t_{0.05}$ with df 88 = 2.00. Alternatively the F-test was highly significant, F statistic = 13.973 is greater than $F_{0.05}$ with df 1, 90 = 3.95.

The ML value for the addition of the time trend was also found to be significant. The coefficient for the full time trend was negative. Once again the t-value was not significant. However, the F-test was highly significant which indicates that the addition of the trend variable to the model is worthwhile.

The addition of the polyester variable and the full time trend increased both the R^2 and adjusted R^2 in each model. In model 3 the ML tests for these two variables were positive but their t-values were not significant. Nevertheless, both the F-tests were highly significant. Hence, from these results one may conclude that model 3 is the preferred model. The complete specification for model 3 is shown below:

$$\sum_{i=1}^{n} P_{it} = a_i + \sum_{i=1}^{n}\sum_{k=1}^{m} d_k X_{ikt} + \sum_{i=2}^{n} b_i D_{it} + \sum_{i=2}^{n}\sum_{k=1}^{m} l D_{it} X_{ikt} + \sum_{i=1}^{n} gP_{it-1} + \sum_{i=1}^{n} f T_{it} + \sum_{i=1}^{n} p S_{it} + u_{it} \qquad (3)$$

where; i = 1 - n , number of micron categories of wool

k = 1 - m, number of exogenous variables

t = 1 - 15, annual observations

and where P = price, X = quantity, P_{t-1} = lagged prices, T = full time trend, S = Polyester (synthetic) and u is a random error variable. The parameters to be estimated are a, b, d, l, g, f and p. D is a zero-one variable. A summary of the results for this model specification is presented below for convenience.

Table 1
Summary of Model Results.

$R^2 = 0.75$	Ad-$R^2 = 0.71$	ML = -617.131	DW = 1.93	D-H = 0.2
RHO = 0.02		Jarque-Bera = 337.24 with 2 df		

4.2 Model analysis

Having accepted the third specification as being the preferred model further tests of model specification are now presented. Although, the R^2 for the model is close to 0.75, this does not necessarily guarantee that there is not a better functional form for this model.

The Ramsey Reset tests indicates that the model could have been better specified either by choosing an alternative functional form or alternatively adding a further explanatory variable. All three of the power estimates have significant F-statistics at the five per cent level. Although this result indicates that there is scope for improvement in this model the test itself does not provide any indication of the appropriate transformation procedure to rectify the problem. If the model structure were changed in favour of a polynomial functional form then further problems may arise. In polynomial regressions the variables tend to be highly correlated thus model specification is traded-off against multicollinearity. An undirected search for an alternative functional form or an additional variable may lead to specification bias. Hence, the model specification was retained.

The "Runs" or Geary test, is a basic test for serial correlation or (autocorrelation). The test result clearly indicates that autocorrelation is not a problem for this model, ie. Runs = 1.079 which lies in the five per cent interval of plus or minus 1.96. When a lagged dependent variable is included within the model as an explanatory variable it can lead to autocorrelation among the error terms. Standard tests for autocorrelation may be biased as test statistics under these circumstances (Gujarati 1988). The Durbin H-statistic (D-H) may circumvent the problem by using estimated r values to account for bias. This test confirms that autocorrelation is not a problem in the present model. The Durbin-H statistic is given by the following equation:

$$D\text{-}H = (1 - DW/2) / \sqrt{\frac{1}{n + S^2}}$$

D-H = 0.260 which lies between plus or minus 1.98, thus one may conclude that D-H is asymptotically normally distributed with zero mean and unit variance. The Jarque-Bera test for normality also confirms the previous finding of normally distributed residuals. The

"Goldfield-Quandt" test indicates that there is no hetroscedasticity. That is, the variances are statistically different from one another. Finally, the sequentirl "Chow" test indicates that there has been no structural change over the sample period.

Multicollinearity between two or more explanatory variables is measured in degrees, rather than either its presence or absence. The two distinguishing features of multicollinearity are that the R^2 value is high, while many t-values are low or insignificant and the pair-wise correlation coefficient between two variables is in excess of 0.8 (Gujarati 1988). The suggestion is that multicollinearity between the full time trend and the polyester variable may be excessively high. The R^2 value for this model is 0.75, and there are only six out of sixteen variables which have significant t-values. Also, the correlation matrix of coefficients for model 3, revealed that the time trend and the polyester variables were positively correlated. The correlation coefficient was 0.794. Although this correlation value is close to 0.8, it is not considered to be excessively high. However, the relatively high correlation does have some influence on the model results.

When the polyester variable was removed from model 3, this caused the time trend coefficient to become significant and its -value increased to -3.64. Similarly in model 2 the polyester variable was significant without the full time trend. Furthermore, the standard errors for each variable decreased when the second variable was removed, this is also a sign that collinearity is present within the model (Pindyck and Rubinfeld 1988). This analysis suggests that the t-values for both variables are biased downward.

The treatment for collinearity is to remove one of the offending variables on the assumption that the model would be equally well estimated with only one of the collinear variables. For this model the removal of either the time trend of the polyester variable is not a viable alternative, since both variables are assumed to be essential to the model. Providing that the collinear variables are identified and the interpretation of the model results take account of this, then the conclusions for the model should remain valid (Gujarati 1988).

An exploratory test of the correlation between the individual time trends and the full time trend was conducted to determine which of the individual time trends were more significant contributors to the correlation in the full time trend. The results of this analysis indicated that the 21 micron trend was a minor contributor and the 24 and 25 micron trends were the major contributors to this correlation.

4.3 Analysis of the time trends

Individual time trend variables were substituted in place of the full time trend in model 3 to test the null hypothesis for this study. The results are presented in Table 2. The individual trend coefficients were positive for each of the fine micron categories and negative for each of the medium and coarse categories. The magnitude and direction of these real price trends coefficients are consistent with the diagrammatical trends illustrated within Figure 3 in the wool price section in part 1.

Table 2
Time trend coefficients

Micron	Coefficients	t-values	Standard Error	F-values
19	9.801	1.465	6.689	4.379
20	1.605	0.211	7.575	0.071
21	-4.933	-0.541	9.119	0.572
22	-2.882	-0.364	7.910	0.285
23	-0.750	-0.105	7.102	0.000
24	-5.569	-0.856	6.505	1.508
25	-9.169	-1.417	6.467	4.080

The t-statistics indicate that the individual trend factors across each micron category are not statistically significant over time. However, the F-values are significant at the 5 per cent level for both the 19 and 25 micron categories. But, neither are significant at the 1 per cent level. This result could be a function of the collinearity problem identified above.

4.4 Hypothesis result

The majority of the trend coefficients are not significant either with respect to t-values or the F-values. Hence, the null hypothesis of the study must be accepted. That is, the price trend coefficients for the 19, 20 and 21 micron wools are not 10 per cent greater than the trend coefficients for the 22, 23, 24 and 25 micron wools.

Hence, one may conclude for the 20, 21, 22, 23 and 24 micron categories that trend factors have been constant over time. However, this conclusion is not true for the 19 and 25 micron categories. Trend factors such as consumer tastes, preferences, income or technology have had a positive influence on the price for 19 micron wools. Alternatively, these same factors have had a negative influence on the price of 25 micron wools. This result may explain why the supply distribution has shifted toward the fine end of the distribution. Having accepted the null hypothesis, the focus of the study is now to determine the intercepts and slopes for the demand curve of each micron category.

4.5 Intercept and slope coefficients

The intercept and slope coefficients now become the focus of this study. These are shown in Table 3 below. The dummy variable model structure has been used to estimate the intercept and slope coefficients for the 20, 21, 22, 23, 24, and 25 micron categories. The 19 micron category intercept and slope variables are used as a base. The intercept coefficient for the 19 micron category is given by the constant term and the slope coefficient is given by the quantity variable.

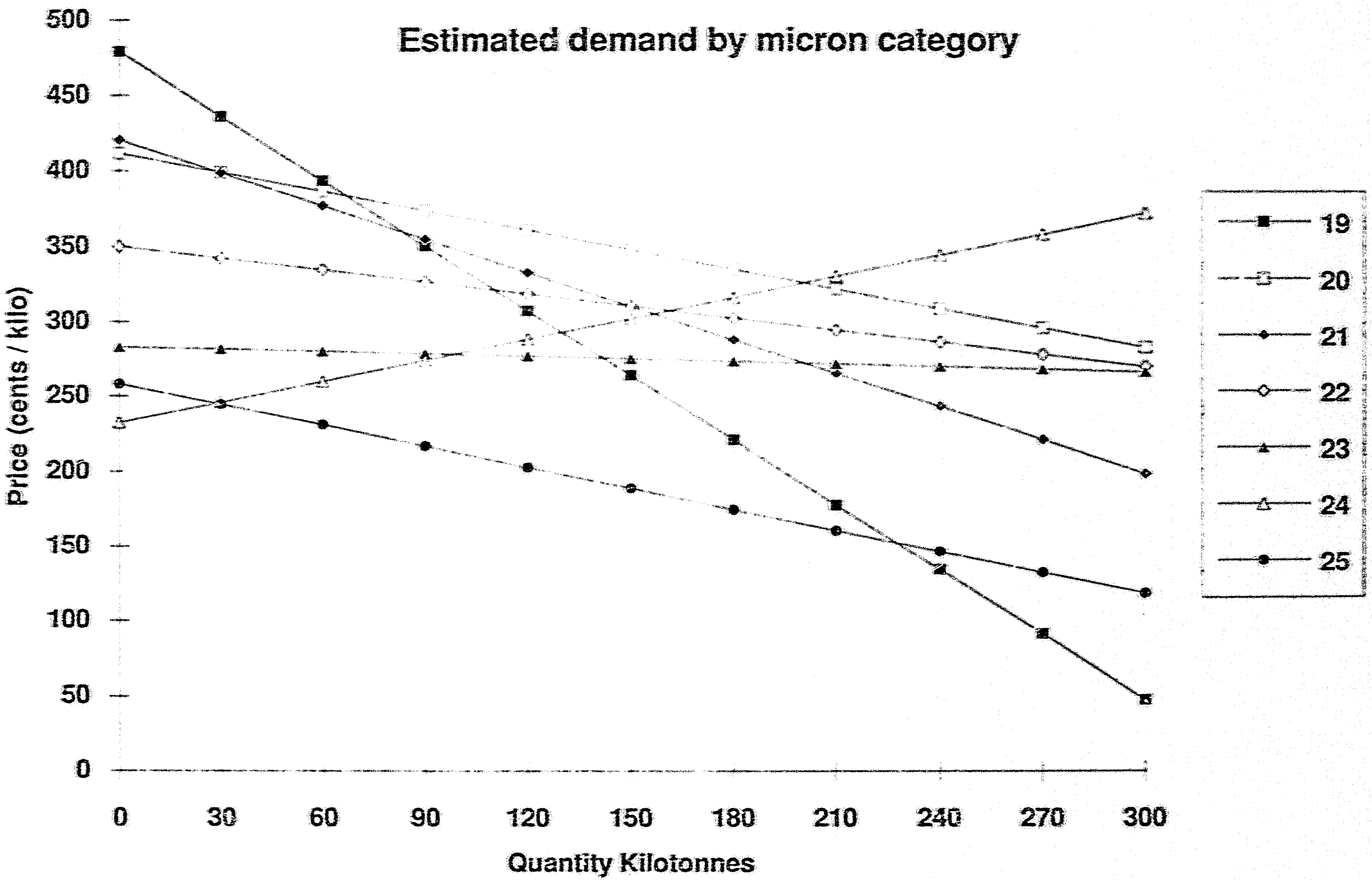
Table 3
Intercept and Slope Coefficients

Micron	Intercepts	Std-error	Slopes	Std-error
19 Base	479.30	113.18	-0.0014	0.0007
20	-67.17	73.98	0.0010	0.0010
21	-58.31	88.54	0.0007	0.0007
22	-128.87	110.88	0.0011	0.0009
23	-195.82	93.84	0.0014	0.0009
24	-247.09	105.39	0.0019	0.0015
25	-220.56	90.44	0.0009	0.0023

The estimated intercept and slope coefficients must be analysed with respect to the base 19 micron category. The following example is provided to illustrate the intercept values for the 20 micron coefficient. The base intercept is 479.30, and the 20 micron intercept is - 67.17, thus, 479.30 - 67.17 = 412.13. Therefore, the actual intercept for 20 micron wool is approximately 412 cents per kilogram. The estimated intercepts and slopes for each micron category are illustrated diagrammatically in Figure 4.

The coefficient values for the intercept variables differ greatly in magnitude. Only the t-values for the base 19 and the 23, 24 and 25 micron variables are significant. Several micron intercepts appear in reverse order to that expected. For example, the 21 micron intercept is greater than the 20 micron intercept. Likewise, the 25 micron intercept is greater than the 24 micron intercept. Furthermore, the slope coefficient for the 24 micron category is positive, which is the opposite to that expected.

Figure 4.



Estimated demand by micron category
Price (cents / kilo)
500
450
400
350
300
250
200
150
100
50
0
0
30
60
90
120
150
180
210
240
270
300
Quantity Kilotonnes
19
20
21
22
23
24
25

The intercept coefficients for the 20, 21 and 22 micron categories do not have significant t-values. The fact that the intercepts for these wools are not significant suggests that the prices for these wools are not statistically different from the price for the 19 micron category. Figure 4, shows that the intercepts for the various micron categories are different to the 19 micron intercept. However, the 20, 21, 22 intercepts are not significant since the standard error of the 19 micron intercept overlaps the coefficients of these other micron categories.

The slope of each of the seven micron categories are also shown diagrammatically in Figure 4. With the exception of the 19 micron category, none of the slope coefficients have significant t-values. Although the majority of the slope coefficients appear different from one another in figure 4, the error around the 19 micron coefficient is large relative to the remaining slope coefficients, hence these variables are not significant.

The above discussion of the intercept and slope coefficients leads to several important conclusions about the price structure for each micron category. First, there is a significant difference in the real price intercepts between the fine micron category and the coarse micron groups. Second, only the slope coefficient for the 19 micron wool was found to be significantly different from the other categories. Hence, the price-quantity ratio should be constant over time for the other micron groups. More specific information regarding slope variation between micron groups can be derived from price flexibilities.

4.6 Price flexibilities

A price flexibility coefficient shows the percentage change in the price of wool associated with a one per cent change in quantity with all other factors held constant. The mean price elasticity is, in some cases, approximated by the reciprocal of the flexibility. The price flexibility coefficient is complicated within this study, since the price of synthetics and a lagged dependent variable are included in the model as explanatory variables. Tomek and Robinson (1987) claim that:

> "If the cross effects are zero, then the reciprocal of the flexibility is a good approximation of the elasticity"(p67).

As previously mentioned the coefficient for polyester was found to be significant for this study thus, the cross effects will not be zero. Hence, the reciprocal of the price flexibility coefficient may not be an appropriate indicator of the lower limit of the price elasticity of demand. Price flexibilities were derived using the following formula:

$$F_i = \left(\frac{DP}{DQ}\right)\left(\frac{\bar{Q}}{\bar{P}}\right)$$

Where $i = 1 - n$ micron categories and $\bar{Q}$ and $\bar{P}$ are the respective own price elasticities. The elasticity coefficients are simply estimated as, $E_i = \frac{1}{F_i}$. The price flexibilities and elasticities derived for each micron category are below listed in Table 4.

Table 4.
Flexibility and Elasticity Coefficients

Micron	Flexibilities	Elasticities
19	- 0.050	- 20.135
20	- 0.042	- 23.894
21	- 0.128	- 7.783
22	- 0.060	-16.773
23	- 0.010	-104.594
24	+ 0.053	+18.782
25	- 0.030	- 33.031

The above own price elasticities for demand are larger than the majority of published own price elasticities. Beare and Meshios (1990), estimated a range of own price elasticities using mean values. Their results ranged from -1.02 for the 19 micron category to -2.00 for the 25 micron category. Dewbre *et.al* (1984) suggest that the demand for Australian wool lies in the range -0.6 to -0.8. Similarly, O'Donnell (1992) found that -0.5 was an appropriate estimate of the raw wool demand elasticity. These elasticity results suggest that the derived reciprocal of the price flexibility is not a good approximation of the own price elasticities when compared to alternative studies.

The price flexibilities shown in table 4 are less than one in absolute value thus, prices would be inflexible with a one per cent change in quantity. Inflexible prices are consistent with an elastic demand curve. From the results above one may conclude that the demand for wool across micron grades is relatively elastic. The demand for 21 and 22 micron grades being relatively less elastic than the other micron grades of wool.

4.7 General Conclusions

The results of this study indicate that the full time trend was significant and negative. The individual trends for the majority of apparel wools are either negative or constant over time. Exploratory tests indicated that the 24 and 25 micron categories are the major contributors to this overall negative trend. The 19 micron indicator was found to be positive and significant over time.

The polyester price was believed to be collinear with the full time trend. The positive association between polyester prices and wool prices was found to be significant. However the degree of association between these prices is believed to be distorted by the medium to high degree of collinearity within the model.

The hypothesis of this study was accepted on the grounds that the majority of price trends were not significant therefore one could not determine whether the trends were statistically different over time.

The intercept and slope variables clearly indicated that prices for coarse wools were significantly different to prices for fine wools. However, the coefficients of medium wools were insignificant and were found to be less elastic than other grades of wools. The general conclusion is that fine wool prices have been increasing, medium wool prices are constant and broad wool prices are decreasing over time.

5. Implications for Sheep Breeders

The price received by wool producers during the 1991-92 season favoured those producers targeting either 22 or 23 micron wool types as seen in Table 5 below. Producers targeting 19 and 20 micron types were earning approximately five dollars per head less than medium wool producers.

ABARE ARQ 1992 has forecaste wool production to fall by approximately two per cent during the current 1992-93 season. The largest fall in wool production is expected within the pastoral zones of New South Wales, South Australia and Queensland which supplies wool within the medium and strong micron grades.

Table 5
1991-92 Gross Wool Returns by Micron Grade

Micron	Clean Price(a) c/kg	Clean Weight(b) Kgs/head	Gross Returns $/head
19	801	2.5	20.02
20	681	2.8	19.06
21	630	3.6	22.68
22	588	4.2	24.70
23	544	4.3	23.39
24	507	4.5	22.81
25	478	4.5	21.51

Source: (a) ABARE CSB 1992 p50, (b) Cottle 1991 p56

Wool incomes have been estimated using the derived demand flexibilities for the 1992-93 season assuming that wool production falls by only one per cent during the season. Table five below shows that the middle micron grades remain relatively more profitable than either of the fine wool grades. With a two per cent decrease in supply of middle micron grades the price of these wools would be expected to increase even further. However, the large volume of medium and strong wool which must be sold from the wool stock pile is expected to reduce these prices to levels below fine wool prices for at least the next two to three seasons.

Table 6
Estimated 1992-93 Gross Wool Returns by Micron Grade

Micron	Clean Price(a) c/kg	Clean Weight(b) Kgs/head	Gross Returns $/head
19	841	2.5	21.02
20	709	2.8	19.85
21	710	3.6	25.56
22	623	4.2	26.16
23	549	4.3	23.60
24	480	4.5	21.60
25	492	4.5	22.14

Source: (a) Estimated using 1991-92 prices and derived flexibility coefficients, (b) Cottle 1991 p56

The AWC is obligated to the Australian Government to repay funds borrowed to support the wool stockpile over the next five seasons. This repayment schedule is presented in Table 7 below. The AWC must schedule repayments and prepare promotion strategies to maximise returns to both wool producers and the Government during this time.

Table 7
The AWRC debt reduction schedule

Season	Minimum Repayment $m
1991-92	20
1992-93	300
1993-94	400
1994-95	550
1995-96	550
1996-97	Any remaining debt

Source: Beare, Fisher and Sutcliff (1991) p9.

This repayment schedule requires substantial funding during the third, fourth and fifth seasons. The obvious source of repayment being the receipts from the disposal of stockpiled wools. The IWS has altered it marketing focus to increase demand for medium and strong wool types so that market prices are not driven to extremely low levels. A successful IWS marketing campaign would increase demand for these wool types without creating excessive demand which may lead to unrealistic high prices.

Prices for fine wools will not be greatly affected by the stock pile activities since it has been established that medium and coarse wools are not close substitutes for fine wools. Also, the stock pile does not contain a large volume of sound fine wool. Hence fine wool prices should remain relatively stable until such time as the world economy has been revitalised.

The threat from synthetic fibres has declined with the fall in wool prices and the expectation that they may remain low for several seasons. The ratio of wool prices to synthetic fibre prices was approximately 2.5:1 in 1991-92. The ratio is expected to fall to 2.2:1 during the current season (AWC 1992). This will be the lowest price ratio since the 1972-73 season. Fine wool producers may stand to loose market share from new "microfibres" which emulate several positive characteristics of natural fibres. These fibres are presently highly priced against fine wool however they may pose a threat in the near future. Cotton prices have fallen to become very competitive against medium and coarse wools within the casual wear market. This may further depress prices for these wools over the next two seasons.

6. Conclusion

The aim of this study was to identify and quantify price trends for apparel wool types and to use these trends as a basis for providing forecasts of demand for fine, medium and coarse apparel wool types. Price trends were analysed but they were not found to be significantly different when grouped into the fine and medium-strong categories. The derived price trend coefficients did not fully concur with 'a priori' expectations in that many of the middle micron trend coefficients were not statistically significant. Only the trends for 19 and the 25 micron categories were found to be significantly different. Hence, the results of the price trend analysis would not prove to be reliable for forecasting purposes.

The null hypothesis of this study was accepted since there was insufficient evidence to suggest statistically that the price trend coefficients for the collective fine and coarse wools were different from one another. Nevertheless, both ends of the wool spectrum did have significant price trends and the intercept coefficients for broad wool prices were also found to be significant.

Price trends for the 19 and 25 micron categories were found to be significant. The reason why other five micron categories were not significantly different may be that these other wools are close substitutes, or the collinearity problem between the polyester variable and the time trend was more significant than tests indicated or alternatively that the model was mis-specified. The large standard errors found for the non-significant micron categories tends to suggest that these wools are indeed substitutes. This confirms similar findings by Beare and Meshios (1989) that middle micron wools are close substitutes. The fact that 19 and 25 micron demand intercepts were found to be significant suggests that those wools are not substitutes. The announced change in AWC policy toward increased promotion of middle micron wools was expected to increase demand for medium wools until such time as the AWC wool stock pile is sold. However, the increase in demand is expected to be absorbed by wool released from the stockpile. Other indicators of trends suggest that consumer preferences and technology may remain in favour of finer wool types.

From this study coarse wool producers would be advised to switch toward producing middle micron wools since demand for coarse wool is declining. These producers should aim to minimise the average fibre diameter of their clips where possible, allowing for environmental constraints. Those producers constrained to producing middle micron wools may see demand for their product rise over the next five to six seasons. However, once the AWC stockpile has be sold the expectation is that promotion may again focus upon high quality, high priced finer wools. Thus, long run production intentions should continue to be directed at producing both finer wool types and wools which have lower standard deviations in average fibre diameter. Fine wool producers would be advised to maintain the direction for fine wool production and continue to strive for quality rather than quantity.

APPENDIX I

MODEL 1

VARIABLE	CONSTANT	QTY	D1	D2	D3	D4	D5	D6
Coefficient	454.520	0.003	45.714	105.600	14.095	-90.645	-144.290	-153.140
Std-error	74.051	0.001	72.314	82.110	112.360	95.984	109.470	95.275
t-value	6.138	-5.189	0.632	1.286	0.126	-0.944	-1.318	-1.607

VARIABLE	DQ1	DQ2	DQ3	DQ4	DQ5	DQ6	LAG-PRICE
Coefficient	0.000	0.000	0.001	0.002	0.002	0.000	0.591
Std-error	0.001	0.001	0.001	0.001	0.002	0.002	0.085
t-value	0.265	0.560	1.420	1.530	0.913	0.089	6.926

R-SQUARE	0.711	ML	-625.680	F-Value	15.841
aR-SQUARE	0.666	DW	2.165	Deg-Free	104

MODEL 2

VARIABLE	CONSTANT	QTY	D1	D2	D3	D4	D5	D6
Coefficient	367.830	-0.002	-42.507	-21.572	-109.720	-196.120	-240.580	-213.120
Std-error	73.104	0.001	71.701	84.100	110.270	94.182	105.650	90.589
t-value	5.032	-3.366	-0.593	-0.257	-0.995	-2.082	-2.277	-2.353

VARIABLE	DQ1	DQ2	DQ3	DQ4	DQ5	DQ6	LAG-PRICE	POLY
Coefficient	0.001	0.001	0.001	0.002	0.002	0.001	0.464	70.733
Std-error	0.001	0.001	0.001	0.001	0.002	0.002	0.087	19.032
t-value	0.925	1.005	1.536	1.830	1.316	0.345	5.335	3.717

R-SQUARE	0.750	ML	-618.106	F-Value	17.810
aR-SQUARE	0.708	DW	1.945	Deg-Free	104

MODEL 3

VARIABLE	CONSTANT	QTY	D1	D2	D3	D4	D5	D6
Coefficient	479.030	-0.001	-67.170	-58.318	-128.870	-195.820	-247.090	-220.560
Std-error	113.180	0.001	73.980	88.549	110.880	93.841	105.390	90.447
t-value	4.233	-2.041	-0.908	-0.659	-1.162	-2.087	-2.345	-2.439

VARIABLE	DQ1	DQ2	DQ3	DQ4	DQ5	DQ6	LAG-PRICE	POLY
Coefficient	0.001	0.001	0.001	0.001	0.002	0.001	0.467	38.864
Std-error	0.001	0.001	0.001	0.001	0.002	0.002	0.087	31.238
t-value	0.998	0.936	1.218	1.419	1.222	0.426	5.392	1.244

VARIABLE	TIME
Coefficient	-7.250
Std-error	5.647
t-value	-1.284

R-SQUARE	0.755	ML	617.131	F-Value	16.922
aR-SQUARE	0.710	DW	1.932	Deg-Free	104

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