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DEMAND PARAMETERS IN THE WOOL PROCESSING INDUSTRY

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Mullen, Alston and Wohlgenant found that the distribution of productivity gains at different points in the wool marketing chain was sensitive to the responsiveness of demand for inputs and products to price changes. When processors were able to substitute between inputs, particularly between Australian and other wool, Australian woolgrowers ranked farm level research ahead of other types of research that resulted in equal percentage cost reductions. However the share of efficiency gains to consumers and input suppliers depends on the relative elasticities of product demand and input supply. Similarly how input suppliers share efficiency gains depends on the degree of substitution possible between inputs in the production process. When substitution effects are larger than scale effects some input suppliers may actually lose when new technology is introduced by other input suppliers.

Whilst other market parameters and issues such as the relative productivity of research resources in different stages of the marketing chain and the rate and extent of the adoption of new technology in these sectors are important, it is clear that demand conditions play a key role in determining how Australian woolgrowers share in the benefits from productivity gains in the different sectors of the wool chain. This paper reports an analysis of the derived demand for wool tops and of the demand for the inputs in wool top processing. (Clearly this work has wider applications than just the returns to research question.) Attention is focussed on the wool top industry because Mullen, Alston and Wohlgenant found this to be an appropriate point at which to assess the returns to Australian woolgrowers from farm research relative to research at other points in the marketing chain.

While few if any empirical estimates of these parameters are available, we do have expectaitons about reasonable values for these parameters.

Expectations about demand parameters in the wool chain

When inputs are substitutes, the change in the demand for one input from a price change of another consists of a scale effect, directly related to the elasticity of demand for the product, and an offsetting substitution effect. In the context of the present study, input substitution needs to be considered in both the textile and wool top production sectors. In both sectors there may be opportunities for substitution between the raw material, wool top or wool, and processing inputs.

Conventionally the raw material and processing inputs are assumed to be used in fixed proportions but Ferguson and Diewert(1981) both made a strong case for a limited degree of input substitution at an industry level as the proportion of output produced by firms using different technologies altered in response to changes in relative input prices. Little empirical work has

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been done in this area but Mullen, Wohlgenant and Farris estimated a lower bound to the elasticity of substitution between cattle and other inputs in US beef processing of 0.1. Generally it is expected that in the case of relative price changes between raw materials and processing inputs, scale effects will dominate substitution effects but some estimates of demand elasticities have been so low that it would be unwise to dismiss substitution effects as being inconsequential.

The opportunities for substitution between wool from different sources in the production of wool top and between wool top and other fibres in the production of textiles are much greater. A widely held view is that wool suitable for topmaking from Australia and other countries are close substitutes. In contrast is the Armington view that importers do differentiate between sources of raw material.

Recent empirical studies by Dewbre et. al. and Simmons and Ridley found suprisingly low levels of substitutability between wool from different countries. Dewbre et. al., using an Armington approach, estimated an elasticity of substitution between wool types in the Japanese wool market of 1.68. In the US market the elasticities of substitution between domestic and imported wool and between imported wools were 1.43 and 0.64 respectively. The largest elasticity estimated by Simmons and Ridley was 0.6 between wool from South Africa and Argentina. These empirical estimates contrast too strongly with a view that wool from different countries is highly substitutable. Such low estimates may arise from assumptions made in estimating Armington models or perhaps more likely, because of the highly aggregated nature of the data. Mullen, Alston and Wohlgenant used a value of 5.0 for the elasticity of substitution between Australian and other wool which is similar to estimates of the elasticity of substitution between grains from different countries by Grennes and Johnson and by Fontes. Even this degree of input substitution is large enough to offset the scale effects of input price changes. While the opportunities for substitution between wool top and other fibres are more limited they still may well be large enough to offset scale effects. Mullen, Alston and Wohlgenant used an elasticity of substitution between wool top and other fibres of 3.0.

Wool top is used in the production of textiles and hence its demand depends on the prices of other inputs such as competing fibres and labour and capital. Since its demand is derived from final consumer demand for clothing, it also depends on the growth in income and population and the prices of other consumer goods. Marshall identified four factors influencing the elasticity of derived demand. An appreciation of the role played by three of these factors can be gained from Allen's (p. 508) equation for the elasticity of derived demand for an input when other input prices are held constant:

$$\epsilon_{ii} = \kappa_i \eta - \Sigma \kappa_j \sigma_{ij}$$

for i not equal to j and where ϵ_{ii} is the elasticity of demand for the input, wool top for example, κ_i is the cost share of the input, η is the elasiticity of demand for the product, clothing and σ_{ij} is the elasticity of substitution between inputs.

If initially substitution effects are ignored, the derived demand for wool top depends on the share of wool top in the final cost of producing clothing and on the elasticity of demand for clothing. The short and long run elasticities of demand for wool in apparel in the US market were estimated by the BAE to be -1.1 and -1.3 respectively. The demand for clothing is expected to be less elastic than this. Cline (p.298) suggests that it is probably about -0.9. The cost share of wool top is uncertain but is unlikely to exceed ten percent. On this basis the scale effects are unlikely to exceed -0.1.

The demand for wool top becomes more elastic as input substitution possibilities increase. The share of processing inputs in the manufacture of clothing is likely to be about 0.75, leaving the share of other fibres as 0.15. If the elasticity of substitution between wool top and other fibres is as high as 3.0 and that between wool top and processing inputs is as high as 0.1 then the substitution term in the equation above is about 0.5 and the elasticity of derived demand for wool top would be about -0.6. Mullen, Alston and Wohlgenant used a value of -1.0.

Marshall's fourth principle was that derived demand became more inelastic as the supply of other inputs became more inelastic. The supply of other wool is expected to respond in a similar fashion as Australian wool to price changes. Estimated supply elasticites for agricultural commodities are generally less than one. Processing inputs are generally assumed to be highly elastic in supply and given their large share would be a force for a more elastic demand for wool top.

The wool top industry

Data limitations have influenced the way in which the wool top industry and the price and quantity variables used in an econometric analysis of this industry have been defined. Wool top production data (published in Wool Statistics) are only available from non-centrally planned economies and the industry has been restricted to this group. The price quote for 64's A wool top (equivalent to 21 micron wool) from the Bradford top market (published in Wool Record) was used as the price variable.

Data on the consumption of wool by this industry from exporting countries are unavailable. Further wool production data are only disaggregated into apparel and non-apparel uses and apparel use includes both the worsted (or wool top) and woollen industries. The implications this has for estimation are discussed further below. The production of raw wool by Australia was adjusted by deducting the exports of raw and semi-processed wool to the centrally planned economies, and by changes in stocks held by the Australian Wool Corporation. Ninety seven percent of Australian wool is suitable for apparel uses and over eighty percent is suitable for wool top production. The production of wool from the rest of the world that is suitable for apparel uses was derived by deducting from total world apparel wool production, wool production in CPE's and in Australia and exports of wool and semi-processed wool to CPE's by New Zealand, Argentina and Uruguay and making appropriate adjustments for the proportions of wool clips that are suitable for apparel use.

While it may be possible to estimate the amount of wool produced that is potentially suitable for wool top, some of the coarser wools are likely to be diverted to the woollen sector of the industry. The proportion of wool that is diverted in this fashion is not fixed but varies with the relative price of wool top to woollen goods. This deficiency of the data has made it difficult to estimate the demand for Australian and other wool by the wool top industry and hence to estimate the extent of substitution between wool from different sources and between wool and processing inputs in the production of wool top.

The price of 21 micron wool was used as the price variable for Australian wool. Wool prices in New Zealand, South Africa, Argentina and Uruguay were weighted by their estimated production of wool of merino and crossbred origin, that is wool suitable for apparel uses, to give a price series for wool from the rest of the world.

Textile and wool top processing costs were expected to be important in explaining the demand for wool top and for wool. Wage rates in textile manufacturing (as reported in the Year Book of Labour Statistics) in major OECD countries weighted by their total consumption of wool and fine hair was used as a proxy for these costs. A price series for other fibres was constructed by weighting the prices for cotton, polyester and rayon by their respective levels of production.

Private consumption expenditure as reported in International Financial Statistics was used as an explanatory variable in the derived demand for wool top and population for the eight major OECD countries was used to express many variables on a per capita basis. All price series were expressed in Australian dollars and deflated by the Australian Gross Domestic Product deflator.

<u>The demand for wool top</u>

A simple specification of the derived demand for wool top, Y, is as a function of the relative price of wool top, P, to the price of other fibres, POF, the price of other inputs, W, and income, I. The attraction of using a relative price term is that the two price variables are expected to be highly correlated and hence the likelihood of one or both of the coefficients associated with these variables being imprecisely estimated individually is high. The model was estimated in double log form and the results are reported in Table 1. Generally variables have their anticipated sign but only the coefficient for the price of processing inputs is precisely estimated. The relationship between wool top and processing inputs in textile production that is suggested by this model is a complementary one. The hypothesis that the coefficients on own and other fibre prices are equal but of opposite sign could not be maintained (t = 2.2). (Including a dummy variable for 1973, a year when the price of wool top was much higher than other years, improved this model.)

This specification says that the demand for wool top responds within the current year to changes in prices but it seems likely that there are long lead times between the production of yarns and clothing for the final consumer and all explanatory variables have been lagged one period in model 2. When lagged relative price was introduced, the coefficient on current price was no longer significant (even when an instrumental variables approach was used in estimation to allow for the possibility that price is endogenous) and the coefficient on lagged relative price was highly significant. For this lagged price model (2), the elasticity of demand for wool top was -0.40 and the hypothesis that the coefficients for own and other fibre prices were equal but opposite in sign could still be maintained (t = 0.36) but there is a serial correlation problem.

One approach to the serial correlation problem is to difference the log variables (model 3). Plosser, Schwert and White have suggested that differencing also provides a non-specific specification test. If the specification being used is correct the parameter values are not altered after differencing. The hypothesis that the fibre price coefficients were equal but opposite in sign could still be maintained (t = -1.1) although the coefficient on the price of other fibres was not significantly different from zero. Differencing has removed the serial correlation problem (this model being very similar to one estimated as a first order autoregressive process), the coefficient on own price only falls by a small amount and the coefficient on the price of other inputs is positive indicating substitution between wool top and processing inputs. Note that in Table 1 all models in which the variables have been differenced are denoted by an asterisk.

In model , a t and term has been introduced to account for exogenous factors having a gradual influence such as technical change. The time trend suggests that the demand for wool top from factors other than the price variables included, has fallen by nearly four percent each year which is opposite to the direction expected for technical change of benefit to wool top and wool producers. Perhaps technical change has occurred at a faster rate for competing fibres than for wool. The demand for wool top is more elastic but the coefficients on other prices are not different from zero. The income term however is highly significant now suggesting that while technical change has been a negative influence on the demand for wool, demand factors such as income have offset this to some extent. The test for serial correlation is inconclusive. The hypothesis that the coefficients on the two fibre prices were equal but opposite in sign could not be maintained. Upon differencing, model 5, there is little change in most parameters except for the income parameter which is not significantly different from zero.

Model 4 is the most plausible model to date. It has a reasonable economic interpretation although because the coefficients on the other price terms are not significantly different from zero, the possibility of inputs being used in fixed proportions cannot be rejected. It is generally expected however that substitution occurs between wool top and other fibres.

It could be argued that not only does current consumption of wool top depend on lagged prices but that adjustment by the industry to changes in prices takes longer than one year. This type of behaviour is often modelled as a partial adjustment process by introducing lagged consumption of wool top as an explanatory variable as in model 6. The time trend has not been included in this model and the coefficient on income is not significantly different from zero suggesting that income is again picking up the opposing influence of the omitted variable. The coefficients for both fibre prices are significantly different from zero (and from each other in absolute terms). The lagged dependent variable is also different from zero. The short run elasticity of demand for wool top is -0.43 and the long run elasticity is -1.08. Other fibres are substitutes for wool top but processing inputs are complements for wool top in textile manufacturing (although the coefficient on this price is not different from zero).

When model 6 is estimated in first differences, model 7, there are quite large changes in all parameters apart from own price which again raises concern about the specification of the model. In particular the partial adjustment coefficient is not significantly different from zero.

A specification in which a time trend is included is reported as model 8. Both the time trend and the income term coefficients are significantly different from zero but neither the price of other fibres nor the lagged dependent variable are different from zero. When estimated in first differences, model 9, the income term is no longer different from zero.

The better models have high R^2's but quite a few insignificant coefficients. Such situations often arise when explanatory variables are highly correlated. Income is likely to be highly correlated with the price of other inputs because a wage rate has been used as a proxy for this variable. Omitting income as an explanatory variable, model 10, has important consequences. The coefficients on both the price of other fibres and the lagged dependent variable are significantly different from zero. However when the model was re-estimated (as model 11) using the Hildreth-Liu procedure to correct for suspected serial correlation (Durbin t-statistic for first order serial correlation being 1.97), the other fibre price variable was not different from zero. When the model was estimated in first differences, model 12, the lagged dependent variable also became insignificant. This suggests that it is important to retain income as an explanatory variable. If it is omitted its influence appears to be taken up by the price of other fibres and lagged demand for wool top and hence estimates of fibre substitution and partial adjustment are likely to be biased.

Discussion

Across the range of models estimated the coefficients for the time trend and own price were precisely estimated with little variation between models. The short run elasticity of demand for wool top, where the response occurs with a lag of twelve months, is about -0.45. The demand for wool top has been decreasing at a rate of about 3.5 percent per year suggesting that technical change has been wool saving or perhaps more likely, that the rate of technical progress has been more rapid for wool's competitors.

Income appears to be an important explanatory variable although it is not different from zero in differenced models. While income effects serve to offset the fall in demand from technical change perhaps an income elasticity of less than one is smaller than we would expect.

Little can be deduced from these models about either the extent of input substitution or the rate of adjustment by the industry to change. Coefficients for these parameters that are significantly different from zero can only be obtained by omitting one or more explanatory variables and the consequence of this is that the estimates of the remaining coefficients are biased. Multicollinearity is clearly a problem. Even when all variables were included, model 8, there was a large change in the income variable when the model was estimated in first differences. This suggests that the specification of the model remains a problem.

The own and cross price elasticities from these models can be used derive implications for input substitution using the Allen formula above. For the input shares above, an elasticity of demand for clothing of -0.9 and an elasticity of substitution between wool tops and processing inputs of 0.1, an elasticity of derived demand for wool tops of -0.45 implies an elasticity of substitution between wool tops and other fibres of 1.9. The elasticity of substitution between wool tops and other fibres falls as the demand for clothing becomes more elastic and as the substitution between wool tops and processing inputs increases but increases as the demand for wool tops becomes more elastic.

An estimate of the elasticity of demand for raw Australian wool can be derived by redesignating the original Allen formula as the elasticity of demand for Australian wool where η is now the elasticity of demand for wool tops, -0.45, κ_1=0.5 is the share of Australian wool in the wool tops industry, κ_2=0.3 is the share of wool from other countries, κ_3=0.2 is the share of processing inputs, σ_{12}= 5.0 is the elasticity of substitution between wool from different sources, and $\sigma_{13} = \sigma_{23} = 0.1$ are the elasticities of substitution between the two wool types and processing inputs. These parameters imply an elasticity of demand for raw Australian wool of -1.75.

The demand for Australian wool

As mentioned above, in estimating the demand for Australian wool we are most interested in the degree of substitution between wool from Australia and from other countries and between Australian wool and inputs used in producing wool top. A convenient functional form to estimate these parameters is the Generalised Leontief (GL) cost function used by Lopez (adapted by him from Parks and Diewert(1971)) which has the form:

(1) $C = Y\Sigma\Sigma b_{ij}(W_iW_j)^{0.5} + Y^2\Sigma\alpha_i W_i + Yt\Sigma\gamma_i W_i$

where W is the price of input i (i = Australian wool, ROW wool, and processing inputs, 1,2 and 3 respectively in Table 2), Y is the production of wool top and t stands for time. This cost function is linearly homogeneous in prices. If $b_{ij} = b_{ji}$ and $\alpha_i = 0$ it is also symmetric and linearly homogeneous in output. Using Shephard's Lemma the cost minimising input demand functions are:

(2) $X_i = Y\Sigma b_{ij}(W_j/W_i)^{0.5} + Y^2\alpha_i + Yt\gamma_i + e_i$

where X is the quantity of input i and e_i is the error term. If $b_{ij} = 0$ then substitution between inputs i and j is not possible. If γ_i is not equal to zero then technical change is factor biased. It is unlikely that the error term associated with equation 2 is homoscedastic. Following Lopez and Parks, if the variance of the error term for each input is assumed to be proportional to the squared output, that is $e_i = Y\mu_i$, then after dividing through by output the input demand equations take the following form:

(3) $X_i/Y = \Sigma b_{ij}(W_j/W_i)^{0.5} + Y\alpha_i + t\gamma_i + \mu_i$

where the variance of the error term is now homoscedastic.

The problem we confront in estimating equations such as 3 for the demand for wool by the worsted industry from Australia and other countries has already been referred to. While estimates could be made of the quantity of wool from Australia and other countries that is potentially suitable for the worsted industry, these estimates appeared to be poor proxies for the amount of wool actually consumed by the industry because the coarser wools switch between the woollen and worsted industries in reponse to relative price chang: Attempts to estimate the demand for wool using these proxy variables and a range of model specifications were unsuccessful. A relationship between the quantity of wool and own price could not be established. Nor could cross price effects be estimated.

Whilst it is doubtful if this lack of adequate data can be overcome we tried another approach to estimating the amount of wool used in the worsted industry. In the equations above X_1 is unobserved and could be denoted as $X1^*$. The allocation of total Australian wool to the worsted or wool top industry can be characterised as:

4. $X1^*/X1 = c_{11} + c_{15}(W1/W5)^{0.5}$

where X1 is total Australian wool supply and W5 is the New Zealand Market Indicator for wool which is used as a proxy for the price of wool used in the woollen industry. Using (4) to estimate $X1^*$ in (3) yields:

5. $X1/Y = (b_{11}+b_{12}(W2/W1)^{0.5}+b_{13}(W3/W1)^{0.5}+\alpha_1 Y+\gamma_1 t)/(c_{11}+c_{15}(W1/W5)^{0.5})$,

and similarly

6. $X2/Y = (b_{22}+b_{12}(W1/W2)^{0.5}+b_{23}(W3/W2)^{0.5}+\alpha_2 Y+\gamma_2 t)/(c_{22}+c_{25}(W2/W5)^{0.5})$.

These equations are non-linear in parameters and were estimated using the LSQ option of TSP.

The demand for Australian and other wool were first estimated as single equations which are reported as model 1 in Table 2. Looking first at the demand for Australian wool, only the technical change and output variables are not significantly different from zero suggesting that technical change has not been biased and that the cost function may be linearly homogenous in output. The main concern with this equation is the negative sign associated with the price of processing inputs variable, B13, which raises doubts as to whether the underlying cost function is concave in prices, an issue which will be discussed in greater detail below. The elasticity of substitution between the two sources of wool for this model is 8.6 and the own price elasticity of demand holding output constant is -3.7 which is much larger than previously published estimates.

The demand for wool from other countries was less successfully estimated. Of greatest concern is the positive own term, B22. Technical change appears to be biased against the use of wool from other countries and there is a negative output effect.

Because the error terms of these two equations are likely to be contemporaneously correlated, parameters may be more precisely estimated by using a seemingly unrelated regression technique and estimating the equations as a system. Equality of the wool cross price effects, B12 = B21, can also be imposed, a restriction consistent with symmetry of the cost function. Beggs (p.16) however cautions against systems estimation when one equation has few good econometric or economic properties as is the case here with the demand for wool from other countries.

Estimating the equations as a system has not resulted in much change in either equation with the exception that technical change now appears to be biased in favour of Australian wool. The elasticity of substitution between wool is now 6.6.

In models 3 and 4 linear homogeneity of the cost function has been imposed. If this restriction is binding, twice the difference in the log of the likelihood function (LLF in Table 2), will exceed a critical value of the chi-squared variable with degrees of freedom equal to the number of restraints. The critical chi-squared values at a one percent significance level are 6.6 and 9.2 for one and two restraints. The test statistic when the equations were estimated as a system was almost 23 and hence the null hypothesis of constant returns to scale could not be maintained. However, when the equations were estimated singly, model 3, constant returns to scale was not rejected in the demand for Australian wool. This equation is very similar to that in model 1, although technical change is biased in favour of Australian wool and the elasticity of substitution between wools has fallen to 5.9.

When estimated as a system, model 4, both B13 and B23, are negative implying a positive own price elasticity for processing inputs as well as for wool from other countries and a cost function that is not concave in prices. The elasticity of substitution between wools is 6.2.

One approach to this problem is to impose fixed proportions in the use of wool and processing inputs (B13=B23=0) and the single equation and system approach are reported as models 5 and 6. The null hypothesis of fixed proportions cannot be maintained in either model and there are large changes in some parameters. The elasticity of substitution between wools is 6.8 and 6.4 in models 5 and 6 respectively.

Discussion

Estimating the demand for wool, particularly wool from other countries, has proved difficult. Our view is that data problems are far more significant than concerns about model specification and functional form. Consequently the returns to further refinements in the latter areas are likely to be small. The elasticity of substitution between Australian and other wool was estimated to be about 6.5, which was consistent with our expectations but we found little evidence of substitution between wool and processing inputs.

Concluding Comments

These attempts to estimate demand parameters in wool processing have not been wholly successful. While concerns about model specification remain, inadequate data most constrain more precise estimation. The elasticity of demand for wool top was estimated to be -0.45. Technical change appeared to be biased against the use of wool top but was offset by other demand factors taken up by an income term. There was little evidence of input substitution either between wool top and other fibres, which is not a credible result, or between wool top and processing inputs. Explanatory variables were lagged one period and strong evidence of an even longer period of adjustment was not found. In general, equations for the demand for Australian wool and wool from other countries were poorly estimated. The elasticity of substitution between wool from different sources appeared to be about 6.5 which is consistent with our expectations.

The demand parameters that we were able to estimate in this study are not so different from those used in our previous study of the returns to Australian woolgrowers from R&D at different stages of the wool chain, that the main conclusions of that study need to be revised. The returns to Australian woolgrowers and other market participants from one percent cost reductions in textile manufacturing, wool top processing and Australian wool production if an elasticity of demand for wool top, η, of -0.45 is used instead of -1.0 and an elasticity of substitution between wool from different countries, σ_{12}, of 6.5 is used rather than 5.0, are detailed in Table 3. The cost shares, κ_i's, the elasticities of substitution between the two wool types and processing inputs, σ_{13} and σ_{23}, and the input supply elasticities were all left at their original values (see table).

As expected the effect of making the demand for wool top less elastic is to alter the distribution of gains from new technology at any stage of the wool chain towards the consumers of wool top and away from inputs suppliers such as Australian woolgrowers. However in the case of new Australian farm technology this is offset to some extent by greater opportunities for processors to substitute towards Australian wool. Hence the productivity gains in textile manufacturing and wool top processing that are required to return the same amount to Australian woolgrowers as a reduction of one percent in the cost of growing wool are 1.6 and 9.7 percent, quite an increase from the scenario in which the elasticity of demand for wool top and the elasticity of substitution between wool types were -1.0 and 5.0.

TABLE 1
THE DEMAND FOR WOOL TOP

MODEL	C	TREND	P/POF	W	I	P	POF	P/POF(-1	P(-1)	POF(-1)	W(-1)	I(-1)	Y(-1)	R²/
1.	2.20 (1.5)		-0.18 (-1.5)	-0.86 (-2.3)	0.35 (1.0)									0.5 1.2
2.	2.31 (1.9)							-0.40 (-4.6)			-0.70 (-2.4)	0.36 (1.2)		0.7 0.8
3.*								-0.37 (-6.1)			0.14 (0.4)	0.26 (0.7)		0.6 1.7
4.	3.72 (5.8)	-0.037 (-7.7)							-0.45 (-6.6)	0.08 (1.3)	-0.26 (-1.6)	0.71 (4.3)		0.9 1.3
5.*		-0.038 (-2.7)							-0.44 (-7.1)	0.02 (0.2)	-0.03 (-0.1)	0.55 (1.6)		0.7 2.0
6.	0.88 (1.0)								-0.43 (-4.7)	0.24 (3.4)	-0.27 (-1.2)	-0.02 (-0.1)	0.60 (4.9)	0.9
7.*									-0.44 (-6.2)	0.19 (1.3)	0.13 (0.4)	0.11 (0.3)	0.20 (1.5)	0.7
8.	3.28 (3.7)	-0.033 (-4.0)							-0.45 (-6.6)	0.1 (1.4)	-0.23 (-1.1)	0.60 (2.8)	0.11 (0.7)	0.9
9.*		-0.034 (-2.3)							-0.45 (-7.0)	0.03 (0.2)	-0.01 (-0.03)	0.44 (1.2)	0.10 (0.8)	0.7
10.	1.03 (4.5)	-0.02 (-2.7)							-0.47 (-6.1)	0.13 (1.8)	0.003 (0.02)		0.39 (3.05)	0.9

Continued over

TABLE 1
THE DEMAND FOR WOOL TOP

MODEL	C	TREND	P/POF	W	I	P	POF	P/POF(-1)	P(-1)	POF(-1)	W(-1)	I(-1)	Y(-1)	R^2
11.	0.97 (3.3)	-0.029 (-2.5)							-0.47 (-6.4)	0.12 (1.0)	0.15 (0.9)		0.24 (1.8)	0.
12.*		-0,027 (-2.0)							-0.45 (-7.0)	0.06 (0.4)	0.28 (1.7)		0.16 1,3	0.

Quantity of wool top produced per capita is dependent variable
P - price of wool top
POF - weighted price of cotton and man made fibres
W - wage rate in textile manufacturing
I - per capita income
t - statistics reported in parenthesis
* - models in which variables are expressed as first differences

TABLE 2
THE DEMAND FOR WOOL

MODEL	1	2	3	4	5	6
The Demand for Australian Wool:						
Y_1	-0.004	0.004	0.004	0.004	-0.001	-0.001
	(1.5)	(1.8)	(2.8)	(3.5)	(-1.7)	(-1.8)
B11	-0.69	-0.73	-0.86	-0.88	-0.82	-0.79
	(-3.9)	(-4.8)	(-5.8)	(-7.4)	(-6.6)	(-6.7)
B12	1.26	1.28	1.24	1.25	1.24	1.21
	(8.7)	(10.4)	(12.6)	(15.0)	(10.0)	(10.4)
B13	-0.25	-0.25	-0.24	-0.24		
	(-3.0)	(-3.7)	(-4.1)	(-4.9)		
α_1	0.02	0.02				
	(0.2)	(0.3)				
C15	-0.39	-0.40	-0.40	-0.39	-0.44	-0.43
	(-10.4)	(-16.3)	(-11.5)	(-14.5)	(-12.5)	(-13.1)
R^2	.81	.81	.81	0.81	0.56	0.56
DW	2.3	2.2	2.3	2.2	1.8	1.8
LLF	50.49		50.46		40.08	
The Demand for ROW Wool:						
Y_2	-0.014	-0.016	-0.014	0.024	0.003	0.007
	(-2.3)	(-2.3)	(1.3)	(3.2)	(1.0)	(1.7)
B21	0.71	1.28	0.49	1.25	-0.04	1.21
	(1.6)	(10.4)	(0.7)	(15.0)	(-0.1)	(10.4)
B22	0.65	0.49	0.52	0.19	0.65	-0.13
	(2.8)	(2.2)	(1.1)	(0.5)	(1.9)	(-0.4)
B23	0.12	0.08	-0.46	-0.77		
	(0.8)	(0.5)	(-1.3)	(-2.8)		
α_2	-0.74	-0.96				
	(-3.2)	(-5.3)				
C25	-0.13	0.1	0.10	0.54	-0.15	0.61
	(-0.7)	(1.0)	(0.2)	(1.8)	(-0.6)	(1.5)
R^2	0.64	0.63	0.29	0.27	0.11	0.04
DW	2.3	2.3	2.0	1.9	1.5	1.6
LLF	41.41	98.24	32.82	86.80	36.03	68.74

The numbers in parentheses are t - statistics
Models 1,3 and 5 were estimated as single equations using the LSQ option of TSP
Models 2,4 and 6 were estimated as a system using the LSQ option of TSP

Table 3: Impact of Research on Australian Woolgrowers

	Textile Research	Australian Farm Research	Top Processing Research
A. Returns to industry sectors (in $A million at 1985 prices) from one percent cost reductions at each stage in the wool chain when parameters are set at base levels[a].			
Australian woolgrowers	3.46	10.37	1.07
Other woolgrowers	2.08	-4.49	0.64
Top processors	0.08	0.05	0.07
Top consumers	15.66	15.37	6.73
Total industry	21.27	21.30	8.50
B. Productivity gains required from textile and topmaking research to provide the same returns to Australian woolgrowers as a one percent reduction in the cost of growing wool.			
Base run	1.50[b]	1.0	9.69

a. Base run parameter values :

$\eta = -0.45$

$k_1 = 0.5$	$s_1 = 1.0$	$\sigma_{12} = 6.5$
$k_2 = 0.3$	$s_2 = 1.0$	$\sigma_{13} = 0.1$
$k_3 = 0.2$	$s_3 = 0.05$	$\sigma_{23} = 0.1$

b. Recall that it has been assumed that a one percent reduction in textile processing costs cause an increase in demand for wool top of 0.5%. The figures in this column are also required shifts in the demand for wool top. Required reductions in textile processing costs will be larger.

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