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RETURNS FROM WOOL PROMOTION IN THE UNITED STATES: AN AWC-BAE ANALYSIS
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A REPORT PREPARED JOINTLY BY THE AUSTRALIAN WOOL CORPORATION AND THE BUREAU OF AGRICULTURAL ECONOMICS

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Decisions to promote wool consumption overseas have, in the past, been guided by largely circumstantial evidence about payoffs. This report contains the results of the most extensive analysis to date of the effectiveness of Australian wool promotion. Wool producers and the Government have made substantial investments in the marketing of Australian wool through their contributions to wool promotion. The results presented in this report provide evidence that the investment in extra promotion in the United States, which began in 1983-84, is profitable.

The study was initiated at the request of the Economic Research Advisory Committee of the Wool Research and Development Corporation and was conducted by staff of the Australian Wool Corporation and the Bureau of Agricultural Economics.

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May 1987
Acknowledgments

Organisations
The analysis of the economic effects of additional wool promotion in the United States was conceived and conducted as a joint research project of the Australian Wool Corporation and the Bureau of Agricultural Economics. The success of the research is a direct consequence of the co-operation between these two organisations. The quality and relevance of this final report justifies the necessarily higher cost of joint research projects between organisations separated both geographically and by corporate purpose.

The study could not have occurred without the participation of the International Wool Secretariat, particularly its US branch—the Wool Bureau. Besides providing the data on wool promotion expenditure, this organisation co-ordinated a review of market research data and eventually procured such data.

Individuals
Joe Dewbre of the Bureau of Agricultural Economics and Bob Richardson of the Australian Wool Corporation supervised the research and final drafting of this report. Stephen Beare (BAE) was directly responsible for the household demand analysis reported in chapter 2 and provided valuable consultation on the overall analysis. Margaret Thomson (BAE) developed the database and conducted much of the household demand analysis. Robyn Coote (BAE) and Hunter Ridley (BAE) assisted in modelling the raw wool market and provided valuable support for other parts of the analysis. Carmen Racioppi (BAE) wrote most of the computer programs and co-ordinated computer systems support. The raw data for the household demand analysis was acquired, tabulated and provided by Margeurite Gadel and Elliot Lewis of the Wool Bureau.

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SUMMARY

The United States is a substantial market for Australian wool, both in raw form and in imported products. The International Wool Secretariat doubled its spending on apparel wool promotion in the United States in 1983 and has maintained, with adjustments for inflation, this higher level of expenditure since then. The cost of the extra promotion, amounting to US$8.5m a year in 1982 dollar values, has been paid almost entirely by the Australian wool industry.

This report contains results of an analysis of the effects of that extra promotion on the demand for apparel wool in the United States and on returns to Australian wool producers. It was found that increased wool promotion has significantly increased the demand for wool apparel in the United States. An annual increase of 8 million kg (clean equivalent) in total apparel wool consumption in the United States was attributed to the increase in promotion.

A mathematical simulation model of the world market for apparel wool was used to trace the impacts of promotion on raw wool market prices and on Australian wool production. The major finding was that returns to Australian wool growers from the extra expenditure on promotion in the United States may have exceeded costs by as much as two to one. Moreover, there appear to be further opportunities for profitably expanding wool promotion in the United States.

Background
The results reported in this paper stem from research initiated following a decision by the International Wool Secretariat to expand the promotion of wool apparel in the United States. The expanded program, with a total projected cost of US$42.5m (in 1982 dollars), involved increasing total expenditure in each of the five financial (July–June) years 1983-84 to 1987-88. As a result, annual apparel wool promotion is now more than double the 1982-83 level.

Having details of the expanded program, as well as extensive data on past promotion, wool consumption and other variables in the United States, provided a unique opportunity to conduct research on the effectiveness of wool promotion in the United States.

Detailed research began in 1984 and an initial report, based on an analysis of data including the first two years of the expanded promotional effort, was completed late in 1985. That report presented results of the first stage of the research plan—estimating the impact of promotion on US household demand for wool in apparel and using those estimates to determine the impact of the additional promotion expenditure on aggregate US demand for apparel wool. In this final report on the project, the first stage of the research has been refined and extended with a further year of data.

The second major phase of the research involved developing a world supply and demand model for wool, which was used to translate demand shifts in response to promotion in the United States into net returns to Australian wool growers.

Effects on US wool demand
Estimating the impact of extra promotion on US household demand for wool in apparel
involved analysis of data from two main sources:
- records of wool apparel purchases by surveyed households in the United States;
- records of promotion expenditure by the International Wool Secretariat in various regions and end use markets in the United States.

Two US market research firms provided the data on annual wool apparel purchases by surveyed households during the period 1975-85. The number of households for which purchase records were available varied each year—from a low of around 7500 in 1975 to an average of around 20 000 in the last three years of the analysis, when the extra promotion occurred. Corresponding data on wool promotion expenditure within the United States by the International Wool Secretariat were obtained from detailed records held by the Secretariat.

The household sample data were weighted to be representative, with respect to region and income, of the US population. Annual consumption of apparel wool by this balanced sample of households over the period 1975-85 was found to be consistent with independent estimates of total US consumption of apparel wool during that period.

For the purpose of this analysis, wool in apparel was considered to be a product characteristic which consumers demand. Garment purchase prices were broken down into wool and non-wool components according to the relationship between wool apparel prices and wool content. This produced statistically significant price relationships for use in subsequent stages of the analysis.

Retail prices, household income and promotion expenditure by the International Wool Secretariat were all found to be statistically important factors affecting the demand for wool in apparel. The short run price elasticity of demand—that is, the percentage change in the quantity demanded caused by a 1 per cent change in the retail price—was estimated to be -1.10. Similarly, the income elasticity and the promotion elasticity were estimated to be 0.43 and 0.07, respectively. These measures refer to the demand response which could be expected in the first year of change in either price, income or promotion. But it was assumed that consumers only partly adjust their purchases in periods immediately following a change in any of the demand factors. That is, a permanent change in a demand factor such as promotion produces a relatively greater change in the quantity demanded in the second year than in the first, a still greater change in the third year and so on up to some upper limit—the long run elasticity. The estimated long run elasticities of price, income and promotion (achieved in roughly the fourth year of a permanent change in any one of these variables) were -1.35, 0.53 and 0.09, respectively.

These elasticities were used to estimate the impact of extra wool promotion in the United States over the period 1983-84 to 1985-86. It was estimated that the additional promotion generated additional wool sales in the United States totalling 21.8 million kg (clean equivalent) over the three-year period. This represents nearly an extra kilogram of apparel wool sold for each extra US dollar (real terms) of promotion expenditure during this period. The final or permanent effect of permanently increasing wool promotion in the United States was projected to be an increase in wool sales roughly 8 million kg a year.

Returns to wool producers from extra promotion depend on more than just these impacts. The wool market price and the effects of increased demand for wool in apparel were evaluated in the second phase of the analysis.

Benefits for Australian wool growers
Benefits for Australian wool growers from demand shifts due to additional wool promotion in the United States depend on supply and demand parameters in the raw apparel wool market. These parameters influence both the magnitude of the benefits and their allocation between consumers and producers and among producing countries. The research reported here involved developing and estimating equations for wool demand in major wool buying countries. Partial adjustment supply equations were specified and results of published research were used as a guide to elasticities of wool supply from various producing countries.
These demand and supply equations were linked with market clearing equations to complete a model representing price determination in the world apparel wool market. This model was then used to estimate the market outcomes of extra promotion in the United States.

The procedure involved comparing model solutions obtained under different assumptions about wool promotion in the United States from 1983-84 onward. Two alternative policies were compared with the base-year (1982-83) level of promotion expenditure:

- a one-off five-year increase in annual expenditure on apparel wool promotion in the United States of US$8.5m (in real terms); and
- a permanent increase in annual funding of the same magnitude.

Evaluating the impacts of extra promotion involved projecting year by year changes in net returns due to extra promotion. Simulated net returns were measured as the difference between the simulated increase in annual gross returns to the Australian wool industry caused by extra promotion and the sum of annual increases in wool promotion costs and the costs of any increased wool production.

These year by year changes in net returns were then added together, using a present value formula, to calculate the total net present value of extra wool promotion. The projected total net present value of a five-year program of extra promotion in the United States was estimated to be $A33.2m. The corresponding estimate for a permanent increase in funding was $A85.0m. The benefit–cost ratio associated with these returns was estimated to be 1.94—that is, a return of nearly $A2 for each dollar invested in extra promotion.

It is concluded that the program of extra apparel wool promotion in the United States is profitable. Although numerical estimates of returns vary with assumptions, this basic conclusion holds under a wide range of alternatives. Also, it seems that there are further opportunities for profitably expanding wool promotion in the United States. The present program of extra promotion is confined to only a small number of major regional markets in the United States. There are other, apparently similar, markets which are presently subjected to a relatively low level of wool promotion. Extra promotion in these markets could reasonably be expected to cause increases in wool demand similar to those estimated in this study.
1. Introduction

Beginning in the 1983-84 season the International Wool Secretariat increased its annual expenditure on apparel wool promotion in the United States. The increase was US$8.5m in the first year of the expanded campaign. The higher level of expenditure, with adjustments for inflation, was sustained in both the 1984-85 and 1985-86 seasons and the original commitment to this higher level extends to the 1987-88 season.

With the commencement of the augmented promotion program a research project was initiated to determine the net returns to Australian wool growers of the promotion. This project, funded by the Wool Research Trust Fund, was conducted jointly by staff of the Australian Wool Corporation and the Bureau of Agricultural Economics.

There were two major phases to the research program, with the objectives of:
- quantifying the influence of apparel wool promotion on the household demand for wool in apparel in the United States, and
- deriving the effects of expanded demand for apparel wool in the United States on raw wool prices and net grower revenue in Australia.

The first phase of the study was based on an econometric analysis of household purchases of wool apparel. The principal end use products involved were menswear, womenswear and knitwear. This is the outerwear apparel to which the promotion of the International Wool Secretariat is directed. Data on wool apparel consumption were compiled from purchase diaries maintained by households in two consumer surveys in the United States. Data on wool promotion expenditure were obtained from the Wool Bureau, the US branch of the International Wool Secretariat.

The second phase of the research program was based on models of the world apparel and total wool markets. These models contain simplified representations of the final demand for and the supply of raw wool and represent the market determination of wool auction prices. These models of the wool market were used to simulate the effect of extra promotion in the United States on raw wool market prices and production in Australia.
2. The response to wool promotion in the United States

The purpose of the analysis reported in this chapter was to estimate the impact of increased promotion of wool in the United States on US demand for apparel wool. This was accomplished in two stages. In the first stage an equation for household demand for wool in apparel was specified and elasticities of demand with respect to price, income and promotion were estimated. In the second stage these elasticities were used to compute estimates of the impact on total US demand for apparel wool of approximately doubling wool promotion expenditure beginning in 1983-84.

2.1 Effects of promotion on demand

The term 'promotion' as used in this study refers to a set of marketing activities undertaken by the International Wool Secretariat aimed ultimately at increasing final consumer demand for wool products. The most important of these activities has been media advertising of wool apparel. The cost of such advertising and its essential staff support functions usually accounts for around two-thirds of the total cost. The remainder is spent on various merchandising and technical support functions. The empirical analysis reported subsequently is of the impact on consumer demand for wool apparel of the total expenditure by the International Wool Secretariat on marketing activities directed at increasing such demand.

There are many ways to measure the effectiveness of advertising. An article by J. Little (1979) and a report by A.D. Little Inc. (1985) of an analysis of dairy promotion contain reviews of many previous attempts to model the response to advertising. Advertising recall rates and changes in indexes of attitude or brand recognition are frequently used measures of consumer response. However, the ultimate test of effectiveness must be based on additional purchases of the advertised product. Most commonly, such measurement is conducted within the framework of an appropriate model of consumer behaviour in which prices, consumer incomes and various taste and preference measures each contribute to the determination of consumption. In past studies there have been two general approaches to specifying consumer response to advertising within the utility maximisation framework of consumer theory. In one, advertising is assumed to influence consumer tastes and preferences directly. That is, exposure to advertising increases the utility associated with the consumption of a product. In the other, advertising is viewed as information, used by consumers to produce utility more efficiently through their consumption decisions. These theories yield identical implications for the general form of ordinary consumer demand equations which include advertising as an explanator along with the usual price and income arguments:

\[ Q = f(P_1, ..., P_n, Y, A) \]

where \( Q \) is the quantity demanded of some good; \( P_1, ..., P_n \) are the prices of the good and its close substitutes or complements; \( Y \) is the consumer's income; and \( A \) is the advertising exposure of the consumer.

It is widely accepted that advertising has carryover effects. Notions that advertising is an 'investment' and that the effect of advertising decays are based on the existence of lagged or carryover effects. In the simplest case, carryover effects are seen to be the residual impact of past advertising. However, advertising retention is not the only source of carryover effects on consumer demand. Wool apparel is a durable good. Advertising, as well as changes in incomes and prices, may alter the content of a consumer's desired wardrobe. However, consumers are not likely to completely depreciate their existing apparel in the short run. Consequently, they may only partly adjust their wardrobe toward a desired composition in any given
period. The adjustment process is then carried over into subsequent periods. Models of consumer purchase behaviour based on partial adjustment have been used in analyses of demand for a number of different commodities, particularly durables (see Philips 1974, pp.154-5).

The simplest and most common method of capturing carryover effects is to include past levels of consumption as an additional explanator of current consumption in a demand equation. This specification is consistent with both the partial adjustment and advertising retention hypotheses concerning the dynamics of advertising response. However, there are other reasons why such lagged dependent specifications 'work' empirically. For example, in a time series cross-section analysis, lagged consumption may serve as a proxy for existing tastes and preferences.

In the present analysis the lagged dependent variable model was chosen. Limitations on the length of the time series of household wool consumption (eleven years) prevented consideration of more general issues about the dynamics of advertising response.

The response of consumer demand to changes in advertising may depend on the existing level of advertising or other demand variables. There may be a decreasing or increasing marginal response to different levels of advertising; furthermore the response to advertising may change as price, income and other variables change. These are hypotheses which refer to the shape of the sales-to-advertising response curve. The existence of interaction effects and a diminishing or increasing marginal response to advertising means that the sales-to-advertising relationship is non-linear.

It is possible, however, that over some ranges of advertising rates the sales response curve is approximately linear. This appears to be the case in this study.

Preliminary regression analyses were performed using a quadratic approximation to the general form of demand in equation (1) and the data on consumption of wool in apparel, prices, incomes and promotion expenditure by the International Wool Secretariat. First, a general quadratic response surface model was estimated to decompose the explained variation in wool consumption into linear, interactive and squared effects. Virtually no explanation was attributed to interactive effects, indicating that the historical impact of promotion on the price and income response was negligible. Approximately 5 per cent of the explained variation was attributed to squared effects. The significance of the squared terms was sufficient to warrant additional investigation into possible decreasing or increasing returns to promotion spending. A model with linear and quadratic terms involving promotion was estimated. The squared promotion term was not statistically significant, indicating that the question of increasing or decreasing returns to promotion spending could not be accurately determined from the existing data.

Although total expenditure by the International Wool Secretariat on advertising of apparel wool in the United States has varied significantly in the past, this has occurred mainly as a consequence of changes in the number of markets (regional and end use) in which promotion is undertaken rather than as a consequence of changes in the rates of advertising expenditure per person within particular markets. For example, the very substantial increase in expenditure on apparel wool promotion in 1983-84 was largely in markets where there had been little or no prior wool promotion.

2.2 Conceptual and measurement issues

The presence of wool in a garment may be regarded by consumers as an indicator of desirable characteristics such as being of good quality, comfortable and fashionable, which together augment the utility associated with wool apparel. Houthakker (1952) extended the utility maximisation framework of consumer theory to include choices of both quantity and quality characteristics and demonstrated that consumer choice under utility maximisation yielded ordinary demand curves for product characteristics.

The quantity of apparel wool finally consumed is determined by consumer choice from a wide and continuous range of wool and non-wool types of apparel. These choices are conditioned by the usual demand variables—prices, incomes and factors which
affect consumer taste and preference (which in the present case include promotion).

The data used to measure the quantity and price of wool in apparel was derived from apparel purchase records of a sample of households in the United States. These data are described in appendix A. The information contained in these purchase records included garment type, fibre content and garment price as well as socioeconomic information on the household, in particular its location and income. The wool content of individual garment purchases was calculated by multiplying the reported percentage of wool content by the International Wool Secretariat estimates of average garment weights. The total of these calculations provided an estimate of the consumption of wool (clean equivalent) for each household for every year of the sample. The procedures used are detailed in appendix B.

To estimate prices of wool in apparel it was necessary to decompose the prices of individual wool garments into wool and non-wool components. This was accomplished by estimating implicit or hedonic price functions. (For a more detailed discussion of hedonic price functions, see Griliches 1971.) A simple linear form of an implicit price function was chosen:

\[ P_{ij} = a_j + b_j x_{ij} \]

where \( P_{ij} \) is the price of garment \( i \) in apparel category \( j \); \( a_j \) is the price of non-wool attributes in apparel category \( j \); \( b_j \) is the implicit price per 1 per cent of wool in apparel category \( j \); and \( x_{ij} \) is the wool content (in percentage terms) of garment \( i \) in apparel category \( j \).

Because there are other indicators of the quality of apparel besides wool content it is possible that implicit prices estimated in this way are biased. Variables such as brand (or manufacturer or designer label), quality of construction and quality of the wool itself have all been suggested as additional explanators of garment price which are excluded from the equation. The immediate objective was to isolate the relationship between garment price and wool content.

The exclusion of other explanatory variables presents a problem only if they are correlated with wool content, in which case the regression estimates of \( b_j \) will be biased in the same direction as the correlation (that is, the variable \( x_{ij} \), wool content, picks up the effects of the excluded variables). It is plausible that the wool content of apparel could indeed be correlated with excluded quality variables. Neither the degree nor the direction of any resultant bias is known at this stage.

The seriousness of this problem in terms of the main objective—identifying the relationship between household demand for wool apparel and promotion expenditure—depends on the degree and direction of the bias and how these implicit price estimates are used in the subsequent analysis. Under the assumption that such bias is constant over time for the aggregates directly used in the analysis, its existence poses no problems in inferring the response to wool promotion.

The \( a_j \) and \( b_j \) coefficients in equation (2) were estimated by ordinary least squares regression. Estimated implicit prices per 1 per cent of wool content are not directly comparable across apparel types, as such prices will vary with garment weights. That is, the price per 1 per cent of wool content in suits may exceed the corresponding price of wool in skirts because, in part, there is more fabric in a suit. To calculate an average implicit price across apparel types it was necessary to convert from a percentage of wool content basis to a weight of wool content basis.

The implicit expenditure on wool in each garment purchase was calculated by multiplying the percentage of wool content in each garment by the corresponding estimate of the implicit price per 1 per cent of wool content. The expenditure per garment was then aggregated for each household in each year to produce an estimate of the total implicit expenditure on wool in apparel. This expenditure and the total weight of wool in the garments purchased by the sample households were calculated for each year from 1974 to 1985. The ratios of total implicit expenditure to total weight in each year were used as estimates of the annual average implicit price of wool per unit of weight.

Further details on the implicit price estimation procedure and the results are presented in appendix B.
2.3 Household demand model

The ultimate objective of this part of the analysis was to estimate the parameters of an average household demand equation for wool in apparel. Estimating such parameters from household data which measure purchases presents a problem in that many households may not make a purchase in a given period. Some households do not purchase wool apparel, and even for purchasing households, most wool garments, like other semi-durable products, are infrequently purchased.

A reduction in apparel wool prices, an increase in income, or greater exposure to promotion may increase the desirability of a wool purchase during the relevant period. This might be viewed as a notional increase in demand. However, an individual may still not make a purchase and their effective demand remains unchanged.

This distinction between notional demand, defined as an index of consumer preferences for a good, and effective demand was first considered by Tobin (1958). Tobin proposed a model in which notional demand was defined as a function of prices, consumer income and other variables. A consumer’s notional demand becomes effective when it exceeds a purchase threshold, which with little loss of generality can be taken to be zero. Thus, notional demand is a latent variable which is observed only when a purchase is made, and all that is known when a purchase is not made is that notional demand is less than the purchase threshold.

A household’s notional demand for wool in apparel may be represented by a linear function of price, income, promotion, consumption in the previous period and other demographic variables:

\[
q^*_i = B_0 + B_1 P_{jt} + B_2 Y_{it} + B_3 A_{jt} + B_4 q_{i,t-1} + C' Z_{it} + u_{it}
\]

where \(q^*_i\) is a notional demand index for household \(i\) in year \(t\); \(q_{i,t-1}\) is the quantity of wool in apparel purchased by household \(i\) in period \(t-1\); \(B\) and \(C\) are model coefficients to be estimated; \(P_{jt}\) is the real price of wool in region \(j\) in year \(t\); \(Y_{it}\) is real income for household \(i\) in year \(t\); \(A_{jt}\) is real promotion in region \(j\) in year \(t\); \(Z_{it}\) is a vector of demographic variables for household \(i\) in year \(t\) (including household size, presence of children and region); and \(u_{it}\) is a disturbance term for household \(i\) in year \(t\).

Effective consumer demand is defined by the conditional relationship:

\[
q_{it} = \begin{cases} 
q^*_i & \text{if } q^*_i > 0 \\
0 & \text{if } q^*_i < 0.
\end{cases}
\]

Together, equations (3.1) and (3.2) define the complete demand model for an individual household. (It is commonly referred to as a censored regression model; the procedures for estimating this model are presented in appendix C.) When considering the total market, the sample of households will be distributed between purchasers and non-purchasers. Furthermore, for those households actually purchasing wool apparel there will be variation in the quantity purchased.

The expected average quantity of wool in apparel purchased is given by:

\[
E(q) = q = \frac{1}{N_t} \sum_{i=1}^{N_t} q_{it}
\]

where \(N_t\) is the total number of sample households in year \(t\).

The average quantity purchased can be re-expressed as the average quantity purchased by purchasing households multiplied by the proportion of households in the sample that make a purchase:

\[
q = \frac{1}{n_p} \sum_{i=1}^{n_p} \frac{n_i}{N_t} q_{it}
\]

where \(n_p\) is the number of purchasing households in the sample in year \(t\).

An equivalent expression for the expected quantity purchased may be derived for the household demand model:

\[
E(q_i) = E(q_i q_i > 0) Pr(q_i > 0) = E(q^*_i q^*_i > 0) Pr(q^*_i > 0)
\]

where \(Pr\) denotes probability.

Thus, for the average household, the expected quantity purchased is equal to the average quantity purchased by purchasing households multiplied by the probability of purchase, which is equal to the proportion of purchasing households.
The impact of a change in an explanatory variable, such as an increase in promotion, is twofold. First, there may be an increase in the quantity purchased given a purchase is made. Second, there may be an increase in the probability that a purchase is made. In terms of a market level impact this is equivalent to an increase in the average quantity purchased by consumers who make a purchase and an increase in the proportion of all consumers who make purchases.

For notational convenience the demand model may be written without subscripts and in matrix notation as:

\[ q^* = B' x + u \]

\[ q = q^* \text{ if } q^* > 0 \]
\[ = 0 \text{ if } q^* \leq 0 \]

where \( x \) is a vector of explanatory variables corresponding to equation 3.1. It may be estimated in two stages.

In the first stage, the purchase decision is modelled to obtain estimates of the household purchase probability and scaled estimates of the notional demand parameters. The household purchase probability may be expressed as:

\[ \Pr(q > 0) = \Pr(B' x + u > 0) = \Pr(u > -B' x) \]

To estimate the model it is necessary to make an assumption regarding the distribution of the demand equation error terms. Assuming the distribution of the error term is logistic, the purchase probability may be written as:

\[ \Pr(q > 0) = \frac{1}{1 + \exp \left( \frac{-B' x}{\sigma} \right)} \]

where \( \sigma \) is a scale parameter measuring the dispersion of the logistic error distribution.

This expression is the underlying probability equation for the logit model for discrete choice (MacFadden 1974). The dependent variable represents the purchase decision, taking a value of 1 for households that purchase and 0 for households which do not purchase. Estimates of the scaled parameters are obtained using a maximum likelihood procedure.

The first stage yields estimates of scaled model parameters. The scale parameter is estimated in a second stage regression using observations of the household quantities purchased and estimates of the household purchase probabilities from the first stage. Under the assumption of a logistic error distribution, the expected quantity purchased (equation 4) may be expressed as:

(5) \[ E(q) = -\sigma \ln[1 - \Pr(q > 0)] \]

The scale parameter can be estimated from this equation using ordinary least squares. Quantity purchased is the dependent variable and the estimated purchase probabilities may be used to compute the independent variable, given by the term expressed as a natural logarithm in equation (5). The estimate of the scale parameter can be used in turn to calculate the coefficients for the complete demand model.

Equation (5), when evaluated at the mean level for the explanatory variables, is an expression for average household level demand. The average impact on household demand of a change in one of the explanatory variables can be calculated from the derivative of equation (5) with respect to \( x \):

(6) \[ \epsilon_k = \frac{B_k x_k}{1 + \exp \left( \frac{-B' x}{\sigma} \right)} \cdot q \]

The initial latent demand specification, equation (3), includes a lagged dependent variable. To compute a long run elasticity, the expected and lagged quantity purchased in equation (5) may be equated with an equilibrium quantity \( q^* \). This revised expression may then be differentiated implicitly with respect to \( x \) to yield:

(7) \[ \epsilon^L_k = \frac{B_k x_k}{\left[ 1 - B_k + \exp \left( \frac{-B' x}{\sigma} \right) \right] q} \]
2.4 Sample balancing procedures

The equations described in the previous section were estimated using data from a sample of US households. The sample consisted of over 90,000 observations of annual wool-in-apparel purchases from 1975 to 1985 inclusive. These observations were constructed from the purchase record data discussed in appendix A. The distribution of sample households by region and income class did not match the corresponding distribution of households in the US population in any year of the sample. In addition, the sample size grew more quickly than the population over the estimation period. In proposing to draw inferences concerning the average impact of promotion on US demand for wool in apparel, it was necessary to balance the sample to be more representative of the population.

This was achieved by assigning a sample balance factor to each household in the sample. This factor was based on a comparison of the proportion of sample households in various income and region classes with the corresponding proportion of population households in the same income and region classes. The sample weights were then readjusted to maintain an equivalent sample size over the estimation period.

Geographic and income cell proportions in the US population were computed using US Bureau of the Census data on the distribution of household money incomes by census region (US Department of Commerce, Bureau of the Census 1986). There were nine census regions. There were seven income categories for the years 1975 to 1978, but the categories were increased to nine in 1979 when additional data became available.

This reduced the problem of bracket drift due to inflation. The US Bureau of the Census does not publish data on the distribution of households by real income. For example, households that earned more than US$50,000 in 1974 were classified as the high income group. By 1979, due to inflation, this category included a large number of households whose real income classification would be in a lower group. By adding additional higher income cells, the distinction between income groups was maintained and the sample appropriately balanced.

2.5 Coefficient estimates

Tables 1 and 2 contain first and second stage coefficient estimates and associated standard errors of estimated coefficients for principal explanatory variables in the wool-in-apparel demand equation. Corresponding results for the demographic variables are presented in appendix C. Table 3 contains elasticity estimates for the combined first and second stage results.

The logistic model coefficients are estimates of the scaled demand model parameters. The impact of changes in the explanatory variables on the purchase probability is difficult to interpret directly from the coefficients. The last column of table 1 contains estimates of impact multipliers which were calculated to aid interpretation. These impact multipliers measure the expected change in average probability of purchase caused by a 10 per cent increase in a demand variable. For example, a 10 per cent increase in real promotion expenditure could be expected to produce a 0.0018 increase in the average probability of purchase or, equivalently, in the proportion of households which buy some wool apparel.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Scaled coefficient</th>
<th>Standard error</th>
<th>Significance level</th>
<th>Impact multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real income</td>
<td>0.0039</td>
<td>0.0001</td>
<td>0.999</td>
<td>0.011</td>
</tr>
<tr>
<td>Real promotion</td>
<td>2.632</td>
<td>0.202</td>
<td>0.999</td>
<td>0.0018</td>
</tr>
<tr>
<td>Real wool price</td>
<td>-4.849</td>
<td>0.355</td>
<td>0.999</td>
<td>-0.026</td>
</tr>
<tr>
<td>Lagged wool demand</td>
<td>0.823</td>
<td>0.016</td>
<td>0.999</td>
<td>0.0044</td>
</tr>
</tbody>
</table>

Pseudo R = 0.300
Second stage regression estimate of the scale parameter $\sigma$

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Sample standard error</th>
<th>Significance level</th>
</tr>
</thead>
<tbody>
<tr>
<td>$-\ln[1 - Pr(q &gt; 0)]$</td>
<td>0.627</td>
<td>0.003</td>
<td>0.999</td>
</tr>
</tbody>
</table>

The estimated short run retail price elasticity of demand for apparel wool of $-1.104$ compares with a price elasticity of demand for raw wool at the farm level of $-0.31$ reported by Martin and Shaw (1986). Retail level price elasticities which are higher than the corresponding farm level elasticities characterise most agricultural commodities. This result is consistent with the hypothesis of constant markup marketing costs.

The estimated short run elasticity of demand with respect to income of 0.43 is identical to that reported for raw wool by Dewbre, Vlastuin and Ridley (1986).

The short run elasticity of demand with respect to real promotion expenditure by the International Wool Secretariat is a central result of this study. For the overall sample period, a 1 per cent increase in real promotion expenditure is projected to result in a 0.07 per cent increase in average household wool consumption. Allowing for full adjustment to changes in price, income or promotion yields longer run elasticities which are somewhat higher than the corresponding short run elasticities.

### 3 Estimates of short run elasticities of demand for wool in apparel

<table>
<thead>
<tr>
<th>Variable</th>
<th>Short run mean elasticity</th>
<th>Long run mean elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income</td>
<td>0.431</td>
<td>0.527</td>
</tr>
<tr>
<td>Promotion</td>
<td>0.070</td>
<td>0.086</td>
</tr>
<tr>
<td>Wool-in-apparel price</td>
<td>$-1.104$</td>
<td>$-1.349$</td>
</tr>
</tbody>
</table>

### 2.6 Total market impacts

The wool-in-apparel demand equation coefficients and the income, price and promotion elasticities reported in the previous section are average relationships specific to the households in the sample and for the time period of the data. In order to estimate total quantity effects of promotion induced shifts in wool-in-apparel demand it is necessary to calculate and project estimates of promotion impacts on sample household purchases to US averages and totals.

In this study the effects of generic promotion of wool in apparel were investigated. Thus, total market projections must be limited to apparel wool. In this regard, the sample based estimates of average
household wool consumption, when applied to the total population, substantially understate apparel wool consumption in the United States. Over the period of the data used, sample projections of total apparel wool consumption are slightly less than one-third of the International Wool Secretariat estimates of total US consumption of wool in apparel. This bias is reasonably constant, however, as the pattern of changes in International Wool Secretariat estimates of total US consumption of wool in apparel over the period of analysis is matched very closely by the pattern of changes in average sample household consumption of wool in apparel. This was confirmed by results of a least squares regression using total market estimates as the dependent variable and sample based estimates as the independent variable. The intercept and slope coefficients estimated from this regression were both statistically significant. The estimated slope coefficient was not significantly different from unity, there was no evidence of serial correlation, and the equation 'explained' approximately 85 per cent of the variation in the International Wool Secretariat estimates of total US apparel wool consumption over the period 1975-85.

There are several factors contributing to the sample understatement of apparent total US consumption of wool in apparel. The most important of these appears to be under-reporting of apparel purchases by the households in the sample. Both of the market research firms which provided individual household data on which this analysis was based also provided projections of regional and US totals of purchases for many major garment types and apparel categories. Comparison of these projections with raw transactions data indicates a degree of under-reporting of all apparel purchases similar to that discovered for wool-in-apparel purchases.

There are two other less important sources of under-reporting contributing to the understatement. First, there are several apparel categories which include wool items which were excluded from this analysis but which are included in International Wool Secretariat calculations of net domestic consumption of wool in apparel (for example, childrenswear and uniforms). Second, there is probably wool consumed in small proportions in some items of apparel which is unreported. For example, survey households are requested to report fibre proportions only for the three major fibre types contained in any particular garment.

The sample understatement of the total US wool-in-apparel market means that it is not possible to use the estimated wool-in-apparel demand equation directly for calculating total market impacts of extra promotion in the United States. To do so would imply that unreported wool-in-apparel purchases were not affected by promotion. Under certain assumptions the calculated promotion elasticity is, however, representative of average US household response and thus may be used in producing total market inferences. In particular, use of the average sample household promotion elasticity to represent average US household promotion response is valid if the rate of under-reporting is not affected by promotion. This assumption is consistent with the evidence that the degree of under-reporting appears to be relatively constant over time.

The procedure used to calculate the total market impact of extra US promotion thus consisted of solving the wool-in-apparel demand equation to estimate the percentage impact of extra promotion on average sample household purchases, and then applying this percentage change to the International Wool Secretariat estimates of total market size. Specifically, a simulation baseline was calculated by solving the wool-in-apparel demand equation to obtain expected average household purchases, given actual levels of promotion spending for the three financial years 1983-84 to 1985-86. An alternative simulation was calculated with promotion spending held constant at the real 1982-83

<table>
<thead>
<tr>
<th>Year</th>
<th>Change</th>
<th>Total increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>1983-84</td>
<td>+7.6</td>
<td>6.5 million kg</td>
</tr>
<tr>
<td>1984-85</td>
<td>+8.9</td>
<td>7.6 million kg</td>
</tr>
<tr>
<td>1985-86</td>
<td>+9.1</td>
<td>7.8 million kg</td>
</tr>
</tbody>
</table>

Simulated impacts on apparel wool demand of increased promotion expenditure
level in subsequent years. These results were used to calculate percentage increases attributable to the increase in promotion spending between 1983-84 and 1985-86. The International Wool Secretariat estimate of net domestic consumption of apparel wool in calendar year 1983 (84.8 kt) was used to impute total demand impacts (table 4).

The percentage impacts for 1983-84 are derived directly from the short run elasticity estimates. The growth in the impact of promotion is relatively rapid. By 1985-86 the percentage impacts had reached their approximate long run elasticity levels. This suggests that carryover effects of promotion beyond the third or fourth year are small.

2.7 Conclusions
Wool promotion has significantly increased demand for apparel wool in the United States. Wool promotion as well as prices and household income were all found to be statistically significant variables in a household level wool-in-apparel demand equation. An average short run elasticity of promotion response of 0.07 was estimated in the analysis reported in this chapter. The corresponding long run elasticity, which is achieved within a relatively short four to five year response period, was estimated to be 0.09.

The statistical analysis was based on data from a representative sample of US households. Sample based estimates of wool-in-apparel consumption were found to be consistent with independent estimates of total US consumption of apparel wool and thus provided a sound basis for extrapolating promotion impacts.

Simulation experiments performed using average elasticities yielded estimates of impacts of extra promotion on total US apparel wool demand for the first, second and third years of 6.5, 7.6 and 7.8 million kg, respectively. The permanent effect of the increased wool promotion expenditure was estimated to be additional sales of wool in apparel of approximately 8 million kg, or just less than a kilogram for each extra US dollar of promotion. The returns from extra US promotion depend critically on the magnitude of those demand effects but depend more directly on the induced wool market price and quantity outcomes. These effects are examined in the next chapter.

A number of secondary issues regarding the impact of apparel wool promotion were also examined. Perhaps the most important issue is whether there is increasing or decreasing marginal response to further promotion expenditure. At this time, this question remains unanswered. However, it is reasonable to expect that the rate of response to promotion does change as promotion is increased and at some point this rate will begin to diminish. Extrapolating current results beyond historically observed levels of promotion may be misleading.

There are, however, a large number of regional markets in the United States which are exposed to a relatively low level of wool promotion expenditure. Only a selected number of markets were targeted for extra promotion under the present program. There are many other regional markets, apparently similar to the targeted markets, for which rates of wool promotion spending have remained virtually unchanged at comparatively low levels during the period of this analysis. It is reasonable to expect that increases in promotion expenditure in these markets would produce consumption responses similar to those observed in this analysis.
3. Net benefits

The analysis reported in the previous chapter culminated in an estimate of the demand shifting impact of extra wool promotion in the United States. It was estimated that the approximate doubling of apparel wool promotion expenditure which occurred in the United States in 1983-84 resulted in an increase of about 6.5 million kg in the total annual US demand for apparel wool in the first year of the campaign. It was estimated that a permanent doubling of such expenditure in the United States would produce a permanent increase in annual demand for apparel wool in the United States of approximately 7.8 million kg. These are not predictions of the change in actual consumption attributable to the increased promotion; such changes depend also on the price impact of the demand shift.

The purpose of the analysis reported in this chapter was to quantify these price and quantity impacts in order to calculate net returns to Australian wool growers from extra wool promotion in the United States. This analysis involved developing simplified models of the world apparel wool market and of the world total wool market and using them in simulation experiments to evaluate the global impact of the additional wool promotion in the United States.

3.1 Scope of analysis

World wool supply is usually divided into apparel and non-apparel wool categories. Finer wool types, typically those with fibre diameters of less than 32.5 micron, are labelled apparel wool, and wool types with fibre diameters greater than 32.5 micron are typically labelled non-apparel or carpet wool. There are, however, significant overlaps, with some finer wool being used in carpets and broader wool being used in knitwear, jackets and coats.

Virtually all of Australia’s production is, by the usual classification, apparel wool. The extra demand attributed to expanded promotion in the United States was for wool apparel, and in marketing terms was focused on wool finer than about 27 microns. In the absence of any price induced substitution in the production of wool apparel between wool types labelled apparel wool and those labelled non-apparel wool, the impacts on raw wool prices are properly evaluated in a model restricted to the apparel wool market. Alternatively, a high degree of price induced substitution between apparel and non-apparel wool types would require evaluation with a model of the total wool market. Because of the smaller size of the apparel wool market, the estimated impacts of extra US demand on Australian raw wool prices are greater if the analysis is restricted to the world apparel wool market.

The actual degree of price induced substitution between apparel wool and non-apparel wool is unknown. Implicit in much of the previous research is the assumption that such substitution is very limited. Freebairn (1978) estimated the export demand elasticity for Australian wool on the basis of a model restricted to apparel wools. Previous analyses of the impacts of wool promotion on the Australian raw wool price have been based on models restricted to the world apparel wool market (Industries Assistance Commission 1976). Moreover, divergences in price trends between fine and coarse wool types (International Wool Secretariat 1986, table 11) deny a high degree of substitution, at least in the short run. In the present analysis raw wool market impacts are evaluated both with a model of the world apparel wool market, assuming no price induced substitution between apparel and non-apparel wool types, and with a model of the world total wool market, assuming perfect substitution between apparel and non-apparel wool. With respect to uncertainty over substitution between apparel and non-apparel wool, results from these two alternatives represent, respectively, upper and lower bounds to the actual raw...
wool market impacts of extra promotion in the United States. However, the results from the apparel wool model are regarded as more representative of actual outcomes.

The distribution of promotion impacts between price changes and quantity changes, and the overall magnitude of the promotion impacts also depend on the elasticities of wool supply and demand in the major wool producing and consuming countries. A comparative static illustration of this is presented in the figure. Aggregate wool demand and a simplified representation of its components are combined in the upper portion of this figure and wool supply in the lower portion. Part (a) shows wool demand schedules for the US market with and without the increased promotion by the International Wool Secretariat, part (b) contains a wool demand schedule for the rest of the world (except the United States) and part (c) shows world wool demand schedules with and without the increased promotion in the United States. Both the base level US demand ($D_{US}$) and demand in the rest of the world ($D_R$) are assumed to include the existing level of global wool promotion. Parts (d), (e) and (f) contain supply functions for Australia, the rest of the world (except Australia) and the total world.

The essence of this overall study is the translation of the promotion induced shift in wool demand in the United States, represented as the shift of the US demand schedule in part (a) of the figure from $D_{U1}$ to $D_{U2}$, into wool price and quantity effects.

**Effects of a promotion induced increase in US wool demand on the world wool market**

<table>
<thead>
<tr>
<th>(a) US demand for wool</th>
<th>(b) Rest of world demand for wool</th>
<th>(c) Total demand for wool</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D_{U1}$</td>
<td>$D_R$</td>
<td>$D_{T1}$, $D_{T2}$</td>
</tr>
<tr>
<td>$D_{U2}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$P_2$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$P_1$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$Q_{U1}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$Q_{U2}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d) Australian supply of wool</td>
<td>(e) Rest of world supply of wool</td>
<td>(f) Total supply and demand of wool</td>
</tr>
<tr>
<td>$S_A$</td>
<td>$S_R$</td>
<td>$D_{T1}$, $D_{T2}$</td>
</tr>
<tr>
<td>$P_2$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$P_1$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$Q_{A1}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$Q_{A2}$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Wool promotion
in the Australian market, represented as the changes $P_1$ to $P_2$ and $Q_{A1}$ to $Q_{A2}$ in part (d). It is clear that the relative sizes of these changes depend on the magnitude of the shift in US demand and the price elasticities (slopes) of the demand and supply schedules for the rest of the world in parts (b) and (e).

In general, the price and net benefit impacts of wool promotion are inversely related to the price elasticities of both wool supply and demand. That is, the price impacts of a promotion induced demand shift in a particular country are greater the more inelastic is wool demand in all other consuming countries and the more inelastic is wool supply from all supplying countries.

The wool demand modelling effort reported here included the specification and estimation of wool consumption demand equations for eight major wool consuming countries—Belgium, France, the Federal Republic of Germany, Italy, the Netherlands, the United Kingdom, the United States and Japan. In this part of the analysis the International Wool Secretariat estimates of net domestic consumption of wool in apparel and non-apparel in these countries were used. Demand equations were specified and estimated for both total apparel wool demand and for the total of apparel and non-apparel wool demand in each of the major wool consuming countries. The specification of these aggregate demand equations was based on an analytical framework similar to that used for the study of US wool demand. The modelling and results of estimation of the world wool demand equations are reported in the next section of this chapter.

The wool supply modelling effort reported here involved specification of partial adjustment equations for raw wool production in each of five major wool supplying countries—Australia, New Zealand, Argentina, Uruguay and South Africa—and a rest-of-world region. Short and long run elasticities of wool supply, based on a review of prior research on wool supply response, were imposed directly on these wool production equations. Wool supply equations were developed both for apparel and for the total of apparel and non-apparel categories of wool production under fixed proportions assumptions. Wool production equations and elasticity choices are discussed in the third section of this chapter.

The apparel and total wool market models are closed with identities equating total world wool supplies and demands. These equations serve to determine equilibrium world market prices for wool, and thus permit modelling of both price and quantity impacts of promotion. The fourth section of this chapter contains a discussion of results of simulations conducted and calculation of net benefit impacts of extra promotion in the United States. Conclusions and proposed directions for future research are contained in the final section.

### 3.2 World demand for wool

This part of the analysis involved the specification and estimation of parameters of aggregate apparel and total wool demand equations for the major wool consuming countries. In the analysis reported in the previous chapter a household level demand equation for wool in apparel was developed. In the specification of that equation, wool was treated as a product characteristic. This logic can be extended to the development of aggregate wool demand equations. Thus the general form chosen for individual country demand equations is similar to that chosen for the household level wool-in-apparel demand equation for the United States.

One difference between the household wool-in-apparel demand equation and the world wool demand equations should be noted. Raw wool price data were used in the estimation of the aggregate raw wool demand equations, whereas retail level wool-in-apparel prices were used in the household analysis. This choice was based on the requirement for the analysis to derive raw wool price impacts of promotion induced demand shifts and the fact that retail level wool-in-apparel price data were not available for countries other than the United States. In principle, the elasticity of final product demand with respect to raw wool prices can be estimated directly if a stable relationship exists between prices of wool at various levels of the wool marketing chain. Most models of the linkage between final product prices and farm or market level prices for commodities imply the existence of stable price
transmission processes. For example, both the constant markup margin and the constant proportional markup margin hypotheses commonly used in agricultural market analysis (Tomek and Robinson 1972) assume a well-behaved relationship between prices at different market levels.

The apparel and total wool demand equations finally chosen were:

\[ q^{w}_{it} = b^{w}_{0i} + b^{w}_{1} P^{w}_{it} + b^{w}_{2} Y^{a}_{it} + b^{w}_{3} A^{w}_{it} + b^{w}_{4} q^{w}_{i,t-1} \]

\[ q^{a}_{it} = b^{a}_{0i} + b^{a}_{1} P^{a}_{it} + b^{a}_{2} Y^{a}_{it} + b^{a}_{3} A^{a}_{it} + b^{a}_{4} q^{a}_{i,t-1} \]

where \( q^{w}_{it} \) is the annual net domestic consumption of total apparel and non-apparel wool in country \( i \) in year \( t \); \( q^{a}_{it} \) is the annual net domestic consumption of apparel wool in country \( i \) in year \( t \); \( b_{0,...,4} \) are regression coefficients to be estimated; \( P^{w}_{it} \) is a measure of the annual average real price of all wool in country \( i \) in year \( t \); \( P^{a}_{it} \) is a measure of the annual average real prices of apparel wool in country \( i \) in year \( t \); \( Y^{a}_{it} \) is the total consumer expenditure per person in country \( i \) in year \( t \); and \( A^{w}_{it} \) is the per person International Wool Secretariat expenditure on wool promotion in country \( i \) in year \( t \).

Estimates of annual net domestic consumption of apparel and non-apparel wool in each of the major consuming countries addressed in this study are prepared annually by the International Wool Secretariat (1986). These estimates are based on publicly available data measuring domestic production, imports and exports of wool final products and on market research data measuring such things as fabric weights, wool market shares, production losses and processing yields.

The raw wool price measures were defined as the ratios of world prices of total and apparel wool to a world price of other fibres. The world price of all wool was measured by a production share weighted average of raw wool prices in the five major producing and exporting countries. The world price of apparel wool was measured by a production share weighted average of raw wool prices in Australia and South Africa. These prices were all financial year (July–June) averages, expressed in US dollars. The specific series used and their sources were:

- Australia: price of greasy wool at auction (National Council of Wool Selling Brokers of Australia, Wool Review);
- New Zealand: price of greasy wool at auction (New Zealand Wool Board, Statistical Handbook);
- Argentina: price of greasy wool at auction, calculated as the average unit fob export value (Federacion Lanera Argentina, Informe Mensual Estadistico);
- Uruguay: price of greasy wool at auction, calculated as the average unit fob export value (Secretariado Uruguayo de la Lana, Informacion Basica Retrospectiva); and

The world price of other fibres was measured by a weighted average of cotton and synthetics prices. The weights used in calculating this average were the respective consumption levels in each of the eight countries. The actual raw price series used and their sources were:

- cotton: world cotton price (International Cotton Advisory Committee, Quarterly Bulletin of ICAC); and
- synthetics: world synthetic price, Group B price for polyester in USc/kg (US Department of Agriculture, Cotton and Wool Outlook Situation).

The measure of real per person consumer expenditure used was annual total private consumption expenditure per person in each country deflated by the relevant consumer price index. These data were obtained from International Financial Statistics published by the International Monetary Fund.

Real promotion expenditure was measured as the per person average of annual expenditure by the International Wool Secretariat branches in each country, measured in domestic currencies, divided by country-specific consumer price indexes. It was not possible to allocate historical promotion expenditure between apparel and non-apparel categories and thus the total...
expenditure was used in both versions of the demand equations.

The coefficients were estimated using the 'seemingly unrelated regressions' technique. Coefficients of price, consumer expenditure, promotion and lagged adjustment were restricted to be the same for each country and time period. Intercept terms were allowed to vary between countries to reflect constant differences in the underlying level of per person wool demand. The 'seemingly unrelated regressions' procedure exploits contemporaneous correlations arising between individual equation error terms. Such correlations were anticipated because some excluded demand factors, such as fashion trends, are common to all countries.

Coefficient estimates for price, consumer expenditure and promotion for both the apparel and the total wool demand equation are presented in table 5. In order to minimise scaling problems, data on all variables were converted to 1980 base period indexes prior to estimation. This also produces coefficient estimates which can be interpreted directly as short run elasticities for 1980 levels of the variables. Corresponding long run elasticities can be calculated according to the formula for solution of a first difference equation:

\[ e_i^l = \frac{b_i}{(1 - b_4)} \]  

where \( e_i^l \) is the long run elasticity of demand for wool with respect to either price, income or promotion; \( b_i \) is the estimated coefficient of either price, income or promotion in equations (8) and (9); and \( b_4 \) is the estimated coefficient of lagged adjustment in equations (8) and (9).

The procedures used for estimating the equations complicates the interpretation of the usual summary statistics such as the R^2. To overcome this problem the estimated country equations were used to simulate historical wool consumption data for each of the country markets for each of the years 1971 to 1985. These data were used to calculate, separately for each country, a measure of fit—the square root of the average squared difference (expressed as a percentage) between simulated and actual consumption levels. These error measures, called 'root mean square percentage error', were then weighted by consumption in each country to yield single overall indicators of equation performance. These are reported in the last row of table 5. An approximate R^2 can be calculated as the difference between 100 per cent and the root mean square percentage error.

Asymptotic t values are presented beneath short run coefficient estimates in table 5. Strictly speaking, these measures of statistical precision are only accurate given a sufficiently large sample. In table 5 they can be regarded as providing an indication of a high degree of statistical reliability of the estimated coefficients. All of the elasticities have the hypothesised signs and their magnitudes accord well with prior estimates and with estimates from other sources.

## 5 Short and long run elasticity estimates and measures of coefficient and equation reliability for the wool market demand equation

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total wool</th>
<th>Apparel wool</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Short run</td>
<td>Long run</td>
</tr>
<tr>
<td>Price</td>
<td>-0.234(-14.30)</td>
<td>-0.788(7.92)</td>
</tr>
<tr>
<td>Consumer expenditure</td>
<td>-0.267(7.60)</td>
<td>0.899(5.51)</td>
</tr>
<tr>
<td>Promotion</td>
<td>0.105(8.00)</td>
<td>0.354(3.51)</td>
</tr>
<tr>
<td>Lag</td>
<td>0.703(35.93)</td>
<td>0.729(25.14)</td>
</tr>
<tr>
<td>Root mean square percentage error</td>
<td>11.127</td>
<td>16.122</td>
</tr>
</tbody>
</table>

**Note:** Elasticity estimates based on 1980 average values. Figures in parentheses are t statistics.
The estimated short run price elasticities of total and apparel wool demand of -0.23 and -0.16, respectively, are consistent with most previously published estimates for this market level of wool demand. For example, Emmery (1967) reported a range of estimates for this parameter for the United Kingdom of -0.23 to -0.30. Other short run price elasticity estimates on a clean wool basis were -0.28 for the wool sweater market from an analysis by the Industries Assistance Commission (1976) and -0.23 to -0.33 reported by Veldhuijzen and Richardson (1984).

The magnitude and significance of the income elasticity estimates reported in table 5 confirm the critical importance of world economic activity as a factor affecting the demand for wool. The estimates obtained in this analysis are consistent with results obtained in other recent analyses (see Dewbre, Vlastuin and Ridley 1986).

Estimated short run elasticities of aggregate wool consumption response to promotion are statistically significant in both the total and apparel wool versions of the demand equation. The magnitudes of these coefficients are in the neighbourhood of the estimate of short run apparel wool promotion response of 0.07 reported for the US market in the previous chapter. However, because of differences in the estimated value of the lagged adjustment coefficient the corresponding long run elasticities are different. The short and long run elasticities of aggregate wool demand response to promotion reported in table 5 are also generally consistent with reported findings of the Industries Assistance Commission (1976) inquiry into rural promotion.

In order to have a complete model of world wool demand it is necessary to adopt some assumptions about wool demand in the rest of the world. Data availability and problems of aggregation precluded independent estimation of demand parameters for other countries. Because of the nature of the experiments performed with this model the critical parameter of interest is the price elasticity of rest-of-world demand. The price elasticities of apparel and total wool demand assumed for the rest of world were the averages estimated for the major consuming markets. This assumes virtually free market transmission of wool price signals into all consuming countries within the rest of the world. There are, of course, government interferences to the transmission of world market price signals, at least in the short run, in some important wool consuming countries (the USSR and China, for example). Incorporating these considerations would result in a lower aggregate elasticity of demand for the rest of the world.

### 3.3 World supply of wool

Total world wool supply can be divided into two segments: the five major wool exporting countries—Australia, New Zealand, Argentina, South Africa and Uruguay—and other producers (but not significant exporters), of which the major ones are the USSR and China.

Wool supply decisions are influenced by many factors, including prices of competing and complementary outputs, prices of production inputs, and various government incentive or disincentive arrangements. Because of different resource endowments and government policies, these factors are of varying degrees of importance in different countries. However, in evaluating the returns to wool promotion from an Australian perspective it is the responsiveness of wool supply to wool price that is the critical parameter of interest.

No attempt was made in this analysis to estimate price elasticities of wool supply. Instead a model of wool producer price response was selected and parameters of price adjustment chosen on the basis of a review of prior wool supply research. The model of producer response to price chosen for this analysis was based on the partial adjustment model introduced by Nerlove (1958). Implicit in this model is the hypothesis that price changes cause producers to partially adjust single period (usually annual) production levels toward desired or target production levels. Target production levels are changed in each period in consequence of changes in expected prices and other factors affecting production planning. However, production adjustments are partial because of biological constraints to rapid expansion in flock size, adjustment costs associated with altering levels of fixed capital and delays in adjusting price expectations to changes in actual prices.
The reduced form of the production adjustment model used for both the apparel and total wool models was:

\[ q_{jt}^* = \gamma_1 P_t + \gamma_2 q_{j,t-1} \]

where \( q_{jt}^* \) is the logarithmic first difference of the annual level of either total or apparel wool production in country \( j \) in year \( t \); \( P_t \) is the logarithmic first difference of the annual world average price of either apparel or all wool—these were the same prices as were used in the estimation of the demand equations; and \( \gamma_1 \) and \( \gamma_2 \) are, respectively, the elasticities of price and lagged adjustment for country \( j \).

Variables were measured in logarithmic first differences to facilitate imposition of wool supply elasticities. The price coefficients \( (\gamma_{1j}) \) in equation (11) are short run (one year) price elasticities of wool supply. The values chosen for them in the present analysis were based on estimates of short run price elasticities of wool supply discussed below.

The long run elasticity of supply associated with the partial adjustment model is defined as:

\[ \varepsilon_{1j}^l = \gamma_{1j} (1 - \gamma_{2j}) \]

where \( \varepsilon_{1j}^l \) is the long run elasticity of wool supply in country \( j \).

Values assigned to the \( \gamma_{2j} \) coefficients in equation (11) were calculated, using equation (12), from assumed short and long run elasticities of wool supply. Assumptions about long run elasticities of wool supply were based on published estimates.

There have been several attempts to estimate wool supply elasticities in Australia and New Zealand, but very little is known about wool supply response in other wool producing and exporting countries. Witherell (1969) estimated partial adjustment wool production equations for the five major wool exporters (table 6). This is the only study available that contains estimates for Argentina, Uruguay and South Africa.

Numerous attempts have been made to estimate wool supply elasticities for Australia. Results of some of these studies are summarised in table 7. There is a high degree of consistency between the various estimates of the medium term elasticity of wool supply.

The most current econometric estimates of the elasticity of Australian wool supply with respect to wool price are probably those from the Bureau of Agricultural Economics’ econometric model of Australian broadacre agriculture, known as EMABA (Dewbre, Shaw, Corra and Harris 1985). For the current version of that model these are:

<table>
<thead>
<tr>
<th>Response period</th>
<th>Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>After 1 year</td>
<td>0.04</td>
</tr>
<tr>
<td>After 2 years</td>
<td>0.12</td>
</tr>
<tr>
<td>After 5 years</td>
<td>0.35</td>
</tr>
<tr>
<td>After 10 years</td>
<td>0.59</td>
</tr>
<tr>
<td>Long run</td>
<td>0.86</td>
</tr>
</tbody>
</table>

Tweedie and Spencer (1980), Laing and Zwart (1983) and Shaw (1986) all report elasticities of wool supply in New Zealand. Short run elasticities of 0.05 reported by Laing and Zwart and 0.08 by Shaw are similar to Witherell’s estimate of 0.03. Estimates of medium term wool supply elasticity for New Zealand range from 0.33 (Tweedie and Spencer) and 0.43 (Shaw) to 0.72 (Witherell) and 1.38 (Laing and Zwart).

The most recent estimates of elasticities of New Zealand wool supply with respect to

<table>
<thead>
<tr>
<th>Estimated wool supply elasticities: by country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>Australia</td>
</tr>
<tr>
<td>New Zealand</td>
</tr>
<tr>
<td>South Africa</td>
</tr>
<tr>
<td>Argentina</td>
</tr>
<tr>
<td>Uruguay</td>
</tr>
</tbody>
</table>

wool prices are those contained in a revised version of Shaw's model of New Zealand wool supply, and recently incorporated in EMABA. The values of the short and long run elasticities of New Zealand wool supply estimated from this revised version are:

<table>
<thead>
<tr>
<th>Response period</th>
<th>Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>After 1 year</td>
<td>0.02</td>
</tr>
<tr>
<td>After 2 years</td>
<td>0.04</td>
</tr>
<tr>
<td>After 5 years</td>
<td>0.08</td>
</tr>
<tr>
<td>After 10 years</td>
<td>0.14</td>
</tr>
<tr>
<td>Long run</td>
<td>0.30</td>
</tr>
</tbody>
</table>

There was no information available on wool supply response in any of the other major wool producing countries. The elasticity of wool supply with respect to an average world market price is likely to be small in many of these other countries. In many European wool supplying countries wool is essentially a by-product of sheep meat production, and in other countries producers are insulated by government policy, at least in the short term, from variations in world wool prices. In the analyses of returns to wool promotion reported by the Industries Assistance Commission (1976), wool production in the USSR and in China was assumed to be unresponsive to the free world price of wool (that is, a zero price elasticity of wool supply). A long run price elasticity of supply of 0.2 was assumed for all other apparel wool producing countries which are not members of the International Wool Secretariat. A short run elasticity of 0.05 was assumed to apply to the major dual purpose sheep meat and wool producing countries. A still lower estimate of 0.025 was applied to the suppliers in the rest of the world. These long run elasticities were imposed by assigning an adjustment coefficient of 0.9 to all suppliers and are roughly consistent with previously reported long run supply elasticities.

### 8 Importance of apparel wool production

<table>
<thead>
<tr>
<th>Country or region</th>
<th>Proportion of total wool production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>97</td>
</tr>
<tr>
<td>New Zealand</td>
<td>28</td>
</tr>
<tr>
<td>Argentina</td>
<td>82</td>
</tr>
<tr>
<td>Uruguay</td>
<td>98</td>
</tr>
<tr>
<td>South Africa</td>
<td>93</td>
</tr>
<tr>
<td>Rest of world</td>
<td>61</td>
</tr>
</tbody>
</table>

The elasticity of supply of apparel wool was defined as the product of the elasticity of supply of total wool and the apparel wool proportion of each country's total wool production. This implicitly assumes that there is no price induced substitution in supply between wool categories and that, apart from random effects (such as weather), apparel and non-apparel wool types are produced in fixed proportions in each of the producing countries (see table 8).

### 3.4 Model summary and simulation experiments

The wool demand and supply equations described in the previous sections, together with market clearing identities equating total world wool demand and supply, form closed models of the total and apparel raw wool markets. These models are summarised in equations (13) to (15) below.
Demand equations:

$$q_{it} = b_{0i} + b_{1i}p_{it} + b_{2i}Y_{it} + b_{3i}A_{it} + b_{4i}d_{it-1}$$

for $i = 1, 2, \ldots, 8$ major wool consuming countries and $k = 1$ and $2$, respectively, for apparel and for the total of apparel and non-apparel wool demanded, and

$$q_{it} = b_{0i} + b_{1i}P_{i}$$

for the rest of the world.

Supply equations:

$$q_{jt} = \gamma_{1j}p_{jt} + \gamma_{2j}q_{jt-1}$$

for $j = 1, 2, \ldots, 6$ wool suppliers and $k = 1$ and $2$, respectively, for apparel and for the total of apparel and non-apparel wool supply.

Market clearing:

$$\sum_{i=1}^{8} q_{it} + q_{jt} = \sum_{j=1}^{6} q_{jt}$$

Model solutions consist of annual total wool and apparel wool demand and supply quantities and average annual wool prices which jointly satisfy the equations. The models were solved for values of endogenous wool quantities and price by assigning values to the exogenous variables (incomes, promotion expenditure, exchange rates and so on) for those years for which solutions are required. The models were solved for various projection horizons, each involving a different assumption about wool promotion in the United States and each beginning in 1982-83.

The purpose of this part of the analysis was to estimate the 'extra' returns to the Australian wool industry attributable to the augmented US wool promotion program. It was assumed that the primary source of benefits to Australian wool growers from extra wool promotion is higher raw wool prices which result from promotion induced increases in the demand for wool.

Alternatively, it could be argued that the primary impact of extra promotion is to reduce Australian wool reserve stocks and thus that the benefits are revealed in savings of costs of stockholding. If, however, wool reserve prices are adjusted with movements in underlying market prices, such stock reductions will occur only in the short term.

It is on the basis of this rationale that stockholding is excluded from the present analysis. However, experimentation with a version of the model which included producer stocks suggested that net benefits to Australia are much the same regardless of whether they take the form of increased wool prices or a combination of increased wool prices and reductions in stockholding costs.

For any given year, the extra gross returns to Australian wool producers attributable to the expanded wool promotion program in the United States can be calculated according to the usual producer surplus calculation:

$$R^G_i = \Delta P_i (Q_i^t + \frac{1}{2} \Delta Q_i)$$

where $R^G_i$ is the promotion induced change in Australian wool industry gross returns in year $t$; $\Delta P_i$ is the promotion induced change in raw wool prices in year $t$; $Q_i^t$ is the base total quantity of wool produced in Australia in year $t$; and $\Delta Q_i$ is the change in quantity of wool produced in Australia in year $t$ caused by promotion induced price increases.

Net additional returns to Australian wool growers, attributable to the augmented US program in a particular year, $R^N_i$ are defined as the difference between the promotion induced extra gross returns to wool production in that year, $R^G_i$, and the cost of the extra promotion in that year, $C_i$:

$$R^N_i = R^G_i - C_i$$

The returns to the extra wool promotion are spread, and vary in magnitude over several years (though the costs are assumed to remain constant in real terms). The impacts of the extra promotion on demand for wool in apparel differ between years because of 'carryover' effects as explained in chapter 2. These yield a dynamic time path of changes in wool prices and quantities which, in turn, produce a pattern of gross and net additional returns which vary over time.

This time-varying or dynamic nature of returns complicates the analysis in two important ways. First, it is necessary to be specific about the duration of the program of extra promotion. Second, by the usual present-value arguments, it is necessary to discount promotion induced price changes.
which are projected to occur in the future relative to those which occur immediately.

For the present analysis, two alternatives concerning the duration of the expanded promotion program in the United States were evaluated:

- a one-off five-year increase of US$8.5m a year in real promotion expenditure beginning in 1983-84; and
- a permanent increase in annual funding of the same magnitude.

In both instances the evaluation was of the total or permanent effect of the change. The effects of a one-off five-year doubling of promotion spending persist beyond the first five years because of carryover effects. A real discount rate of 10 per cent was chosen to compute present values of the flow of benefits in both alternatives.

Price and quantity impacts of extra US promotion were calculated by solving the wool market models under various assumptions about demand effects and duration of the wool promotion program in the United States. The estimates of the promotion impact on US demand reported in table 4 were used in the simulation analysis. The simulation analysis consisted of comparisons of model projections of yearly raw wool price and quantity outcomes under the assumption of extra US promotion with model projections with no extra promotion. This comparison was done for both the one-off five-year and a permanent expansion of wool promotion in the United States and with both the total wool market model and the apparel wool market model.

All of the various scenarios involved projections to future periods for which data on income, prices of competing fibres and other exogenous factors which determine future wool price and quantity outcomes are unknown. Projections of these exogenous variables were based on an assumption that their values would remain constant in real (1982) terms. For the purpose of determining the price and quantity impacts of extra US promotion the levels chosen for other exogenous variables (incomes, price of competing fibres, and so on) are relatively unimportant. That is to say, the primary interest is in calculating the change in wool prices and quantities uniquely attributable to increased wool promotion in the United States. For these purposes it is necessary to make the usual 'all other things being equal' assumptions. It matters very little where, within a plausible range of the data, 'all other things' are set, so long as they remain unchanged in consequence of a change in wool promotion.

3.5 Results

Table 9 contains projections of the impacts in the first, second, fifth and tenth years and in the long run (taken here to mean approximately 40 years) of extra wool promotion in the United States evaluated with the apparel wool model and corresponding lower bound estimates produced using the total wool market model. The wool price impacts, which are the major source of gain to Australian wool producers, are greatest in the initial periods and then diminish with increases in wool production in Australia and competing countries.

The simulated quantity impact of extra promotion on annual US apparel wool consumption is just over 6 million kg (clean equivalent) in the first year of extra promotion. This increase stabilises at about 7.5 million kg by the third or fourth year. This final equilibrium change in consumption is slightly less than the final 7.8 million kg increase in demand reported in chapter 2, the difference being due to induced price effects. According to results obtained with the apparel wool version of the model, only 2.1 million kg of the increased US consumption are supplied by increased Australian wool production. The remainder is supplied by a combination of price induced diversions from other consuming markets and extra wool production in other wool producing countries.

Two measures of the net benefit of the extra wool promotion are presented in table 9. The first measure, the net present value of projected benefits from extra promotion, is equal to the sum of discounted annual differences between gross additional returns and costs of the extra promotion. Gross additional returns were measured as the change in wool producer surplus. Costs to Australian wool growers of the extra US promotion were defined as 90 per cent of total additional costs—or approximately
$A8.5m a year (in real terms). The other 10 per cent of the additional cost of promotion has been borne by South Africa through its membership of the International Wool Secretariat. The estimates of net present value of projected benefits to Australian wool growers of a five-year program of extra US wool promotion are $A33.2m when evaluated with the apparel wool model and $A1.0m when evaluated with the total wool model. The corresponding estimates for a permanent increase in funding are $A85.0m and $A2.4m.

The second measure of the benefits of expanded US wool promotion was a benefit-cost ratio. This is defined as the ratio of the sum of discounted gross additional benefits to the sum of discounted additional costs. For both the five-year and the permanent version of extra promotion funding this ratio was estimated at 1.94 with the apparel wool model and 1.03 with the total wool model.

9 Projected impacts on wool price, quantity and net returns from five-year and permanent increases in US wool promotion funding

<table>
<thead>
<tr>
<th>Impact</th>
<th>Clean wool basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
<td>Unit</td>
</tr>
<tr>
<td>Apparel wool model</td>
<td></td>
</tr>
<tr>
<td>Five-year increase</td>
<td></td>
</tr>
<tr>
<td>US net domestic consumption</td>
<td>kt</td>
</tr>
<tr>
<td>Australian production</td>
<td>kt</td>
</tr>
<tr>
<td>Australian price</td>
<td>$A/kg</td>
</tr>
<tr>
<td>Present value of net benefits</td>
<td>$Am</td>
</tr>
<tr>
<td>Benefit-cost ratio</td>
<td>1.94</td>
</tr>
<tr>
<td>Permanent increase</td>
<td></td>
</tr>
<tr>
<td>US net domestic consumption</td>
<td>kt</td>
</tr>
<tr>
<td>Australian production</td>
<td>kt</td>
</tr>
<tr>
<td>Australian price</td>
<td>$A/kg</td>
</tr>
<tr>
<td>Present value of net benefits</td>
<td>$Am</td>
</tr>
<tr>
<td>Benefit-cost ratio</td>
<td>1.94</td>
</tr>
<tr>
<td>Total wool model</td>
<td></td>
</tr>
<tr>
<td>Five-year increase</td>
<td></td>
</tr>
<tr>
<td>US net domestic consumption</td>
<td>kt</td>
</tr>
<tr>
<td>Australian production</td>
<td>kt</td>
</tr>
<tr>
<td>Australian price</td>
<td>$A/kg</td>
</tr>
<tr>
<td>Present value of net benefits</td>
<td>$Am</td>
</tr>
<tr>
<td>Benefit-cost ratio</td>
<td>1.03</td>
</tr>
<tr>
<td>Permanent increase</td>
<td></td>
</tr>
<tr>
<td>US net domestic consumption</td>
<td>kt</td>
</tr>
<tr>
<td>Australian production</td>
<td>kt</td>
</tr>
<tr>
<td>Australian price</td>
<td>$A/kg</td>
</tr>
<tr>
<td>Present value of net benefits</td>
<td>$Am</td>
</tr>
<tr>
<td>Benefit-cost ratio</td>
<td>1.03</td>
</tr>
</tbody>
</table>

Note: Figures in parentheses indicate percentages of 1982-83 base year levels.

Occasional paper 100
3.6 Conclusions

The single major conclusion of this report is that the increase in wool promotion expenditure in the United States from 1983-84 produced returns to Australian wool growers in excess of the associated costs. Using the preferred apparel wool version of the model and what are believed to be 'most likely' wool supply and demand elasticities, the benefit–cost ratio was estimated at just under 2.0. This represents a return to Australian wool growers of nearly $2 for each $1 invested in extra wool promotion in the United States. The net present value of a one-off five-year program of additional promotion was estimated to be $A33.2m. The net present value of a permanent increase was estimated to be $A85.0m.

Of course, actual numerical results depend on assumptions and it is not possible to be absolutely precise about the magnitudes of net benefits. Critical assumptions include those made about wool demand and supply elasticities (regardless of whether estimated or not), and the degree of price induced substitution between apparel and non-apparel wool types. However, the conclusion that returns exceed the costs of extra wool promotion holds up even under some extreme alternative assumptions about elasticities and size of market. For example, even under the assumption that apparel and non-apparel wool types are perfectly substitutable, estimated net returns to extra spending are still positive. There are some assumptions in the analysis, such as perfect world market price transmission, which if relaxed would yield even higher estimates of net benefits to Australian wool growers from extra wool promotion in the United States.

There are several issues highlighted in this report that require further analysis. In particular, present knowledge of wool supply response in countries other than Australia and New Zealand and of demand response in other than major markets is limited. Conclusions reported here are based on judgmental choices of a number of important elasticities and further research is necessary to quantify more precisely such important parameters.

Furthermore, it must be emphasised that the results reported here are specific to additional wool promotion in the United States. The evidence which was obtained on the response to global promotion is indicative, but further research is necessary to be able to draw confident conclusions about promotion effectiveness in other specific markets.
Appendix A Data used in household demand analysis

Household apparel purchase records were obtained from the Market Research Corporation of America and the National Purchase Diary Company. It was considered necessary to purchase data from both sources to ensure a sufficiently large sample from which to draw inferences. Because wool apparel items are not purchased frequently by households, the number of purchase records available from either source alone was too small. Both of these firms have panels of households which are selected as a stratified quota sample of all households in the United States. Table 10 contains information on the total number of sample households in these surveys for the years 1974-85. Participants are required to contribute detailed information each month on their purchases of a wide range of goods, including those items of apparel covered in this analysis.

Households were chosen for membership in the respective panels on the basis of statistical requirements for representativeness across a number of geographic and demographic dimensions. The purchase records contain details both on the transaction itself (for example, price, type of garment, sex of wearer, fibre composition) and on the household for which the purchase was made (for example, family income, size of family). The apparel records used for this analysis were purchases of menswear, womenswear, boyswear, and girlswear as listed in table 11.

The data provided by the International Wool Secretariat relate to its expenditure on a wide variety of promotional activities designed to shift the demand for apparel wool. These data are available in cross-section, time series dimensions similar to the data on apparel purchases. Advertising has been directed extensively toward consumers and, to a lesser extent, decision makers in the marketing system—retailers, manufacturers and distributors. The costs incurred by the Secretariat in promoting wool apparel can be divided into five major categories.

Retail co-operative advertising expenditure
This results from agreements between the International Wool Secretariat and various apparel retailers to share costs of newspaper advertisements, catalogues and related promotion. The Secretariat has a range of requirements for such advertisements—for example, the advertised item cannot be price discounted—in addition to the primary requirement that the ‘WOOLMARK’ or ‘WOOLBLENDMARK’ label be prominently featured.

Mill or manufacturer co-operative advertising expenditure
This results from agreements between the International Wool Secretariat and mills or manufacturers to share costs of (usually) magazine advertising.
### Methods used to allocate International Wool Secretariat promotion effort geographically

<table>
<thead>
<tr>
<th>Promotion expenditure category</th>
<th>Geographic allocation method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio</td>
<td>Specific to geographic market; no allocation necessary</td>
</tr>
<tr>
<td>Television</td>
<td>As above</td>
</tr>
<tr>
<td>Billboards</td>
<td>As above</td>
</tr>
<tr>
<td>Newspapers</td>
<td>Circulation rates</td>
</tr>
<tr>
<td>Magazines</td>
<td>Circulation rates</td>
</tr>
<tr>
<td>Retail co-operative (newspapers and magazines)</td>
<td>Specific to geographic market; no allocation necessary</td>
</tr>
<tr>
<td>Retail co-operative (catalogues)</td>
<td>Allocated firstly by major end use—menswear, womenswear and knitwear—and then by household populations within each geographic market</td>
</tr>
<tr>
<td>Marketing costs</td>
<td>Allocated proportionally on the basis of direct promotion expenditure occurring in each market for each end use—menswear, womenswear and knitwear</td>
</tr>
<tr>
<td>Trade</td>
<td>Allocated on the basis of household populations within each geographic market</td>
</tr>
</tbody>
</table>

**Wholly International Wool Secretariat advertising expenditure** This arises from advertising which covers the full range of media and target groups. For example, radio, television and billboard advertising is usually wholly funded by the Secretariat. From time to time the Secretariat has also wholly funded print media campaigns.

**Marketing support expenditure** This is a catch-all category for a number of International Wool Secretariat promotion costs related to marketing overheads, public relations, economics and market research and fashion services.

**Trade advertising expenditure** This advertising cost includes promotion expenditure by the International Wool Secretariat on advertisements directed at the ‘trade’—mills, manufacturers and buyers, for example.

Over half of promotion expenditure was specific to individual regional markets. Other promotion expenditure was allocated using additional data, such as subscription rates and media coverage for relevant national publications. The methods used in the study to allocate promotion expenditure so they are related directly to consumers in the various regional markets are listed in table 12.

Total promotion expenditure in each regional market was divided by the number of households (total population) within that market to produce promotion expenditure per household.

Other data required for the analysis included consumer price indexes specific to the selected regional markets. These data were used to convert prices, income and promotion expenditure used in the demand equation estimation to ‘real’ terms. The US Bureau of Labor Statistics (1986) publishes such indexes specific to 25 of the regional markets included in this analysis. They also publish regional consumer price indexes, cross-tabulated by population size, for four regions and four population size groups in the United States. The remaining markets were also classified by population size and region and consumer price index data were assigned accordingly.

The household population data used in calculating per household rates of promotion expenditure and ultimately the total market impacts of promotion were obtained from Arbitron Ratings Company (1984).

The International Wool Secretariat also provided data on garment weights, cross-classified by wool content and garment category. These data were used to estimate the total consumption of wool in apparel by each household in each year.
Appendix B Retail price and quantity formulas

Retail prices for wool in apparel were estimated using ordinary least squares regressions of the form:

\[ P_{ijt} = B_{0jt} + B_{1jt}C_{ijt} \]

where \( P_{ijt} \) is the total garment price for garment \( i \) in apparel category \( j \) in year \( t \); \( B_{0jt} \) is the price of non-wool factors in apparel category \( j \) in year \( t \); \( B_{1jt} \) is the implicit price per percentage of wool in apparel category \( j \) in year \( t \); and \( C_{ijt} \) is the percentage of wool fibre content of garment \( i \) in apparel category \( j \) in year \( t \).

The regressions were performed for a total of 22 apparel categories using purchase observations on apparel containing wool. The results are summarised in table 13.

The quantity of wool demanded, in kilograms, was computed using purchase record data on the number of apparel items purchased and the percentage of wool fibre content. In addition, the calculation required International Wool Secretariat estimates of average garment weights for various categories of apparel. The quantity of wool demanded by household \( k \) in year \( t \) is given by:

\[ Q_{kt} = \sum_j W_{jt} \sum_i (N_{ijkt}C_{ijkt}) \]

where \( W_{jt} \) is the average garment weight in apparel category \( j \) in year \( t \); \( N_{ijkt} \) is the number of raw units of garment \( i \) in apparel category \( j \) purchased by household \( k \) in year \( t \); and \( C_{ijkt} \) is the percentage of wool fibre content of garment \( i \) in apparel category \( j \) purchased by household \( k \) in year \( t \).

Average retail prices for wool in apparel, in dollars per kilogram, were computed using the implicit prices. The average retail price for wool in year \( t \) is given by:

\[ \bar{p}_t = \frac{\sum_i \sum_j B_{ijt} C_{ijt} / W_{ijt}}{\sum_i \sum_j \sum_k N_{ijkt}} \]

where \( W_{ijt} \) is the total wool weight for garment \( i \) in apparel category \( j \) in year \( t \).
### Implicit prices by garment category

Price per percentage point of wool content

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Knitwear</td>
<td>0.03</td>
<td>0.06</td>
<td>0.08</td>
<td>0.12</td>
<td>0.09</td>
<td>0.10</td>
</tr>
<tr>
<td>Coats</td>
<td>0.15</td>
<td>0.87</td>
<td>0.45</td>
<td>0.44</td>
<td>0.65</td>
<td>1.00</td>
</tr>
<tr>
<td>Dress trousers</td>
<td>0.08</td>
<td>0.16</td>
<td>0.08</td>
<td>0.20</td>
<td>0.22</td>
<td>0.25</td>
</tr>
<tr>
<td>Casual trousers</td>
<td>0.12</td>
<td>0.10</td>
<td>0.13</td>
<td>0.12</td>
<td>0.10</td>
<td>0.13</td>
</tr>
<tr>
<td>Other trousers</td>
<td>0.04</td>
<td>0.25</td>
<td>0.26</td>
<td>0.28</td>
<td>0.22</td>
<td>0.22</td>
</tr>
<tr>
<td>Outer jackets</td>
<td>0.22</td>
<td>0.26</td>
<td>0.18</td>
<td>0.06</td>
<td>0.09</td>
<td>0.09</td>
</tr>
<tr>
<td>Suits</td>
<td>0.22</td>
<td>0.42</td>
<td>0.43</td>
<td>0.31</td>
<td>0.45</td>
<td>0.28</td>
</tr>
<tr>
<td>Leisure suits</td>
<td>0.12</td>
<td>0.46</td>
<td>0.004</td>
<td>0.23</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td>Socks</td>
<td>0.01</td>
<td>0.01</td>
<td>0.00</td>
<td>0.02</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Accessories</td>
<td>0.03</td>
<td>-0.01</td>
<td>0.01</td>
<td>0.03</td>
<td>0.002</td>
<td>0.01</td>
</tr>
</tbody>
</table>

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</thead>
<tbody>
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<td>Knitwear</td>
<td>0.07</td>
<td>0.07</td>
<td>0.05</td>
<td>0.03</td>
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<td>Coats</td>
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<td>0.55</td>
<td>0.90</td>
<td>1.12</td>
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<td>Dress trousers</td>
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<td>0.65</td>
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<td>Casual trousers</td>
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<td>0.22</td>
<td>0.25</td>
<td>0.24</td>
<td>0.23</td>
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<tr>
<td>Other trousers</td>
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<td>0.20</td>
<td>0.24</td>
<td>0.25</td>
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<td>Suits</td>
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<td>0.75</td>
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<td>Outer jackets</td>
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<td>0.46</td>
<td>0.80</td>
<td>0.47</td>
<td>0.65</td>
<td>0.54</td>
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</tbody>
</table>

* Significant at the 5 per cent level.
Appendix C Estimation of the censored regression model

Only about 30 per cent of the sample of US households purchased wool items in the apparel categories included in the analysis in any given year. Thus, about 70 per cent of the sample consisted of zero observations on wool demand.

This presents a statistical problem in an ordinary least squares regression model. The assumption that the error terms are drawn from a population with a continuous density function is not maintained. Error terms are truncated, which results in biased coefficient estimates. For a more complete discussion of the problem, see Maddala (1983).

The estimation problem can be formulated as a censored regression. The censored regression model may be written as:

\[ q_{it}^* = B'x_{it} + u_{it} \]  

where \( q_{it}^* \) is a latent demand index for household \( i \) in period \( t \); \( B \) is a vector of coefficients; \( x_{it} \) is a vector of explanatory variable values; and \( u_{it} \) is a disturbance term. The relationship between the latest demand index and effective demand may be written, dropping subscripts, as

\[ q = q^* \quad \text{if} \quad q^* > 0 \]
\[ = 0 \quad \text{if} \quad q^* \leq 0 \]

where \( q \) is the quantity demanded.

Values of \( q^* \) are not observed (censored) for all \( q^* \) less than zero. The latent demand index \( q^* \) is observed, as the quantity demanded, for all \( q^* \) greater than zero. This may be expressed as a condition on the disturbance term:

\[ q^* = q \quad \text{if} \quad u > -B'x. \]

Thus, for all the positive observations on \( q \), the disturbance terms are drawn from a truncated distribution. The expected value of the truncated error term is given by:

\[ E(u|u > -B'x) = \frac{g(-B'x)}{1 - F(-B'x)} \]

where

\[ g(-B'x) = \int_{-\infty}^{-B'x} uf(u)du \]

and \( f(\cdot) \) is the density function of the untruncated error distribution, and \( F(\cdot) \) is the cumulative density function of the untruncated error distribution.

The most common approach to estimating the model is to assume that the underlying untruncated error distribution is normal. This yields the standard tobit model for which estimation procedures are given by Tobin (1958) and Heckman (1976). Here, it is assumed that the underlying untruncated error distribution is logistic:

\[ f(u) = \frac{\pi \exp\left(-\frac{\pi u}{\sigma \sqrt{3}}\right)}{\sigma \sqrt{3} \left[1 + \exp\left(-\frac{\pi u}{\sigma \sqrt{3}}\right)\right]^2} \]

\[ F(u < u) = \frac{1}{1 + \exp\left(-\frac{\pi u}{\sigma \sqrt{3}}\right)} \]

and \( E(u) = 0, \ E(u^2) = \sigma^2. \)

The logistic density (C3.1) may be substituted into equation (C2.2). Integration by parts yields:

\[ g(-B'x) = -B'x \left[1 - \frac{1}{1 + \exp\left(-\frac{\pi B'x}{\sigma \sqrt{3}}\right)}\right] + \frac{\sigma \sqrt{3}}{\pi} \ln \left[1 + \exp\left(\frac{\pi B'x}{\sigma \sqrt{3}}\right)\right]. \]

Substitution of this expression for the logistic cumulative into (C2.1) yields an expression for the expected value of the truncated error which may be rewritten in terms of the
First stage logit analysis and second stage results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Sample standard error</th>
<th>Significance level</th>
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<tbody>
<tr>
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<tr>
<td>Real income</td>
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<td>Census region 8</td>
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<td>0.042</td>
<td>0.975</td>
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<tr>
<td>Intercept</td>
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<td>0.999</td>
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</tbody>
</table>

Second stage

\[
\ln[1 - \Pr(q > 0)] = 0.627, \quad 0.003, \quad 0.999
\]

purchase probability as:

\[
(C5) \quad \operatorname{E}(u \mid u > -B'x) = -B'x + \frac{\sigma \sqrt{3}}{\pi \Pr(q > 0)} \ln \left[ \frac{1}{1 - \Pr(q > 0)} \right].
\]

An expression for the expected quantity purchased, given that a purchase is made, may be written as:

\[
\operatorname{E}(q \mid q > 0) = B'x + \operatorname{E}(u \mid u > -B'x).
\]

Substituting equation (C6) into this expression yields an expression for the conditional expectation on the quantity purchased, given that a purchase is made:

\[
(C6) \quad \operatorname{E}(q \mid q > 0) = \frac{\sigma \sqrt{3}}{\pi \Pr(q > 0)} \ln \left[ \frac{1}{1 - \Pr(q > 0)} \right].
\]

An unconditional expectation on the quantity purchased is given by:

\[
\operatorname{E}(q) = \Pr(q > 0) \cdot \operatorname{E}(q \mid q > 0).
\]
References


Heckman, J. (1976), ‘The common structure of statistical models of truncation, sample selection and limited dependent variables and a simple estimator for such models’, *Annals of Economic and Social Measurement* 5(4), 475–92.


