PRICE FORMATION IN THE RAW WOOL MARKET

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1. Introduction

Econometric analysis of the demand for raw wool at auction published by other authors has been mainly confined to an analysis of the determinants of the consumption of raw wool.[1] However the purchaser of raw wool at auction must hold his purchases either in transit or in store for some months before either reselling or consuming wool in his own mills. Thus the conventional analysis of the determinants of the demand for wool for consumption is not directly relevant when considering the short run demand for wool at auction. As a result, models based on the conventional analysis do not adequately explain fluctuations[2] in prices paid at auction in primary markets.

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1 See Horner F.B. (1952) "The Pre War Demand for Wool" Economic Record Vol.28 No.54; Philpott B.P. (1957) "Wool in the New Zealand Economy, Ibid Vol.33, No.65; Philpott B.P. (1965) "Fluctuations in Wool Prices 1870-1963" Agricultural Economics Research Unit Publication No.13; C.E. Ferguson & M. Polasek (1962) "The Elasticity of Import Demand for Raw Apparel Wool in the U.S., Econometrica Vol. 30, pp.670-690.

2 In this context, fluctuation is thought of as movement about the long run trend determined by consumer demand and the production of raw wool.

* The results given in this paper stem from a research programme financed by the Wool Research Organisation of N.Z.(Inc.).

An earlier attempt by Philpott[3] to explain such fluctuations used annual data. Based on this earlier work we develop in this paper two models of quarterly demand for raw wool at auction and we test these models against quarterly data for the period 1952 to the first quarter of 1967.

2. Notation

The notation used in this paper is as follows:-

P_t = The price of raw wool in period t

Q_t = The flow of new wool (supply) on to the market in period t

C_t = The mill consumption of raw wool in period t

S_t = The stock of wool held by purchasers of raw wool at the end of period t

D_i = A quarterly seasonal shift factor (i = 1,2,3)

Δ = Change between period t and period t-1.

Superscripts

x indicates unobservable expectation formulated in the previous period regarding the level of a variable in the period indicated by the subscript.

' indicates desired level of a variable.

** indicates statistical significance at the 1% level.

* " " " " " 5% "

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[3] B.P. Philpott (1955) "Fluctuations in Wool Prices", Yorkshire Bulletin of Economic and Social Research, Vol. 7, No.1, pp.1-28.

3. The Models

The models developed in this paper assume that in a period as short as three months both supplies and mill consumption of raw wool are pre-determined.

It can be argued that wool production is a stochastic function of sheep numbers only. As the important decisions regarding sheep numbers are made at the end of the previous season, any production response to price changes will be a lagged response. Supplies of wool offered for sale by growers can also be treated as being independent of current price if growers seldom exercise reservation demands. The floor price operations of the Wool Commission introduce a significant supply response to current prices but this was only important as from the first quarter of 1967 at which point our analysis terminates.[4]

The argument to support the contention that quarterly mill usage of raw wool (consumption) is also independent of current price is as follows. The price of raw wool is only one of the many costs that will influence manufacturers' wool textile production decisions. It can be argued that even if the price of wool rises markedly in relation to other costs and to the market value of the output, manufacturers would incur greater losses by failing to keep machinery active than in consuming a raw material even if it is thought that the price is too high in relation to product values. It is argued that mill production is

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[4] McKenzie C.J. (1966) Quarterly Models of Price Formation in the Raw Wool Market. Unpub. M.Ag.Sc.Thesis, Lincoln College.

determined by current demand for wool textiles. Given the production lags, it would therefore seem reasonable to assume that the level of mill production is responsive to lagged prices only, and is independent of current price.[5] However, it could be argued that the mix of fibres used in textile production is responsive to movements in the current price of raw wool. This is not supported by the results of the survey of mill owners conducted by the New Zealand Wool Marketing Study Group, which indicated that mill owners are reluctant to change their fibre mix and would only do so in response to price movements of more than 10%.[6] Admittedly this does not dispel all doubts about the exogenous nature of mill consumption of raw wool. The preferable alternative would be to test a simultaneous model. This poses considerable problems, not the least of which is the difficulty of adequately allowing for penetration of the market by new fibres.

If supplies and mill consumption of raw wool are exogenously determined in the short run, equilibrium in the market, unless it is fortuitous, can only be achieved by changes in stocks of wool held by traders. In the short run prices will settle at the level at which traders are

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[5] Philpott, B.P. (1955) "Fluctuations in Wool Prices - 1953". Yorkshire Bulletin of Economic and Social Research, Vol. 7, No.1, pp.1-28.

[6] The Final Report of the Wool Marketing Study Group (1967) para.71 pp.16 and 17.

prepared to absorb or disgorge from stock the imbalance between consumption and supply. We therefore need to specify a stock demand function.

People, other than suppliers of raw wool to primary markets, probably have either one or both of two motives for holding stocks of raw wool. This would depend on their status as:-

Either (a) manufacturers wanting to be able to meet the future requirements of their mills;
or (b) traders anticipating a profit on the transaction.

Two determinants of the desired stocks of raw wool are therefore expectations regarding mill consumption and expectations regarding future prices, i.e.

$$(3.1) \qquad S'_t = f_1(C^x_{t+1}, \Delta^x P_{t-1})$$

As neither of the two determinants of S'_t are observable, we must go further and attempt to explain them by means of other variables which are observable. In this paper expectations regarding price movements are treated in two ways. In the first instance a simple expectation hypothesis is adopted.

A Simple Model

This hypothesis assumes that the market's collective view of expected price changes is a negative function of the current price level, i.e. the higher prices rise the more they are expected to fall in the near future and vice versa. This may be expressed as:

$$(3.2) \qquad \Delta {}^{x}P_{t+1} = a_o + a_1 P_t \qquad a_1 < 0$$

In this rather simple model, static expectations are assumed for mill consumption, i.e.

$$(3.3) \qquad C^{x}_{t+1} = C_t$$

The model is completed by the equilibrium identity

$$(3.4) \qquad S_t = S_t \equiv S_{t-1} + Q_t - C_t$$

Substitution for the non-observable variables in equation (3.1) and solving for P_t leaves

$$(3.5) \qquad P_t = \phi_1(C_t, S_t)$$

A Distributed Lag Model

More sophisticated models can be developed by improving the specification of the expectation determinants in equation (3.2). Only the most successful example is developed and tested here.[7] This second model postulates (3.6).

$$(3.6) \qquad P^{x}_{t+1} = \beta \sum_{i=0}^{\infty} (1-\beta)^{i} P_{t-i} \qquad 0 \leq \beta \leq 1$$

This leads to

$$(3.7) \qquad P^{x}_{t+1} = \beta P_t + (1-\beta) P^{x}_{t}$$

This allows past price movements to complement the simple price level used as the determinant of price expectations in (3.3). The geometric pattern of decay

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[7] Variants are developed and tested in McKenzie op. cit.

of lagged influences assumed by this model is only adopted because of statistical convenience. From an economic viewpoint this sytem of lagged prices is no better and no worse than any alternative assumption that could be made regarding the shape of the lag.

The expected rate of mill consumption is handled by the adoption of a hypothesis formulated by Lovell.[8] He assumes that manufacturers' expectations regarding flows of production should fall between the two extremes of static and perfect forecasting. This can be expressed by

$$(3.8) \qquad C^{x}_{t+1} = \alpha C_{t+1} + (1-\alpha) C_t$$

The model is again completed by the equilibrium condition expressed in equation (3.4) above. Adoption of the linear form of equation (3.1) gives

$$(3.9) \qquad S'_t = b_o + b_1 C^{x}_{t+1} + b_2 \Delta^{x} P_t$$

Substitution of equations (3.7) and (3.8) for the non observable variables in equation (3.9) leads to:

$$(3.10) \qquad \Delta P_t = B_o + B_1 C_{t+1} + B_2 C_t + B_3 C_{t-1} + B_4 S_t + B_5 S_{t-1}$$

where:-

$$B_o = \frac{b_o \beta}{b_2 (1-\beta)}$$

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[8] Lovell M. (1961), "Manufacturers Inventories, Sales Expectations, and the Acceleration Principle". Econometrica Vol. 29, No.3, pp.293-314.

$$B_1 = \frac{b_1 \alpha}{b_2(1-\beta)}$$

$$B_2 = \frac{b_1(1-\alpha) - b_1\alpha(1-\beta)}{b_2(1-\beta)}$$

$$B_3 = -\frac{b_1(1-\alpha)(1-\beta)}{b_2(1-\beta)}$$

$$B_4 = -\frac{1}{b_2(1-\beta)}$$

$$B_5 = \frac{1}{b_2}$$

It can be seen that the model is over-identified in the sense that unique estimates of the five structural parameters b_o, b_1, b_2, α and β cannot be obtained from the six coefficients of equation (3.10).

Price Response to Changes in Supply

Although supply is not included in either (3.5) or (3.10), inferences may be drawn regarding price responses to changes in supply. Given exogenously determined consumption, an increase in supply ceteris paribus must drive down prices to a new equilibrium level such that traders are prepared to absorb the new wool in speculative stocks. Thus the coefficient of end of period stocks S_t measures the responsiveness of price to changes in supply under these assumptions.

4. Estimation of the Models Using Quarterly Data

The period of estimation is the first quarter of 1952 to the fourth quarter of 1966. The market considered is the ten major non Communist consuming countries supplied

by the non Communist world.

Quarterly data against which the models can be tested, is given in the appendix together with a description of the methods of estimation of quarterly supplies and stocks of raw wool held by traders which alone are not obtained from published sources.

The stock estimates are derived from an estimate of stocks held by the Group on 30 June 1957 together with estimates of excess supplies in each succeeding and preceding quarter. The stock estimates are therefore likely to reflect errors made in estimating quarterly supplies and in the stock estimates these errors will be cumulative. Difficulties were also encountered in obtaining estimates of supplies to the Group from all sources at a uniform point in the marketing chain. The data used range from sales at auction in Australia, New Zealand, South Africa and the United Kingdom, through export data for South America and other smaller suppliers such as India and Pakistan, to imports by the Group from minor sources supplying between 15 and 30 mn lb. annually.

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[9] The Group referred to in the appendix is:- The U.K.; The U.S.A.; France; Western Fermany; Belgium; Italy; Japan; The Netherlands; and Sweden. This group consumed 78% of the wool produced in the non-Communist world (for consumption in the non-Communist world) in the period 1957 to 1963 and, in the same period, 60% of total wool production.

Linear forms of the models are assumed for the sake of convenience in the absence of any a priori knowledge. The results obtained using ordinary least squares are as follows:-

The Simple Model

$$(4.1) \quad P_t = 97.40 + \underset{(.04)\ **}{0.196C_t} - \underset{(.02)\ **}{0.127S_t} - \underset{(3.34)\ **}{11.17D_1} - \underset{(3.16)\ **}{10.31D_2} - \underset{(3.03)}{1.32D_3}$$

$$R^2 = 0.54$$

$$d = 0.5696$$

(Durbin-Watson Statistic) (significant autocorrelation)

The Distributed Lag Model - Estimation of (3.8) by ordinary least squares yields

$$(4.2) \quad P_t = -39.55 + \underset{(.04)\ **}{0.118C_{t+1}} + \underset{(.05)\ **}{0.152C_t} - \underset{(.03)\ **}{0.104C_{t-1}} - \underset{(.02)}{0.008S_t} - \underset{(.02)}{0.031S_{t-1}} - \underset{(4.74)}{4.54D_1} - \underset{(2.89)\ **}{17.48D_2} - \underset{(2.51)\ **}{8.95D_3}$$

$$R^2 = 0.6100$$

$$d = 2.20$$

$$(R'^2) = .881$$

Where R' = coefficient of correlation between actual P_t and P_t estimated from equation (4.2) to facilitate comparison with (4.1).

By comparison with equation (4.1), equation (4.2) (the distributed lag model), shows no evidence of auto-correlation so that reliable estimates of the standard

errors of the coefficients can be obtained. It also gives a much better explanation of price movements. This is perhaps to be expected given a serial correlation coefficient of 0.81 between P_t and P_{t-1}.

Figure I gives a comparison of actual prices and those predicted from this equation for the period of the analysis, i.e. up to fourth quarter 1966 and also for the succeeding five quarters to March 1968.

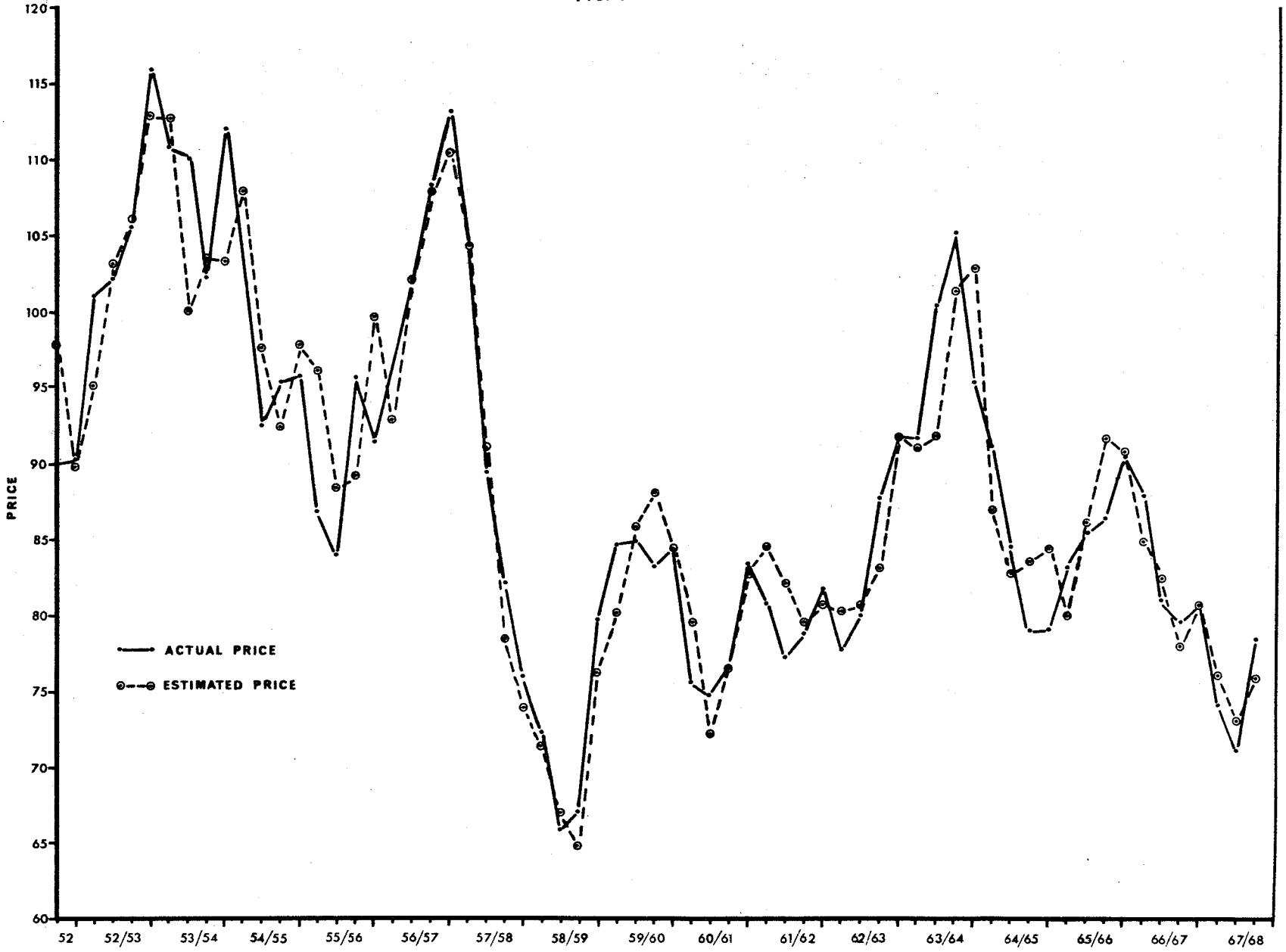
As the diagram shows, the model explains quite well the historical price changes in the wool market and it provides a reasonably good prediction of price developments beyond the period of analysis.[10] The actual and estimated changes in price for the period second quarter 1967 to first quarter 1968, together with the standard error of the forecasts are given below in Table 1.

TABLE 1

Period	Actual Price Changes	Price Changes estimated from equation (4.2)	The standard error of the forecast of Change in Price
		pence/lb clean c.i.f. Bradford	
Apr.-June 1967	1.3	1.29	4.67
July-Sept 1967	-6.6	-4.67	4.71
Oct.-Decr 1967	-2.9	-0.95	4.68
Jan.-Mar. 1968	7.2	4.70	4.86

[10] Strictly speaking the model should not be used to predict prices in the 1967/68 period since the substantial reserve price operations of the N.Z. Wool Commission in this period invalidate the assumption that supply of wool is exogenous.

FIG. 1


PRICE
120
115
110
105
100
95
90
85
80
75
70
65
60
ACTUAL PRICE
ESTIMATED PRICE
52
52/53
53/54
54/55
55/56
56/57
57/58
58/59
59/60
60/61
61/62
62/63
63/64
64/65
65/66
66/67
67/68

5. The Stock Elasticity

The coefficient reflecting the effect on wool prices of changes in stocks (and therefore of supplies of wool), is of major importance in any speculative model and of special interest in relation to the question of schemes for supply management in wool marketing.

The non significance of the stock variables in equation (4.2) is therefore disturbing. However there is a sufficiently strong relationship between S_t, S_{t-1} and the seasonal shift factors to produce multicollinearity, and when this is removed by suppressing S_{t-1} we secure the following result in which S_t is now significant at the 1% level.

$$(4.3)\quad \Delta P_t = -38.34 + \underset{(.04)\ **}{.130C_{t+1}} + \underset{(.05)\ *}{.138C_t} - \underset{(.03)\ **}{.111C_{t-1}}$$

$$\underset{(.01)\ **}{-.035S_t} - \underset{(3.94)\ *}{8.35D_1} - \underset{(2.40)\ **}{15.16D_2} - \underset{(2.10)\ **}{6.95D_3}$$

$$R^2 = .59$$

$$d = 2.24$$

$$(R'^2) = .874$$

The model, estimated by (4.1) indicates that an increase in quarterly supply of only 7.4 million lb. clean is required to induce a penny fall in the clean c.i.f. Bradford equivalent of auction price in primary markets. By contrast, the distributed lag model estimated by (4.3) indicates that 28.7 million lb. clean would be

required.[11]

It must be remembered however that through suppression of the variable S_{t-1}, equation (4.3) is purely heuristic and no longer reflects the basic structural system set out in equations (3.6) - (3.9).

Further work in this field, on which we are now engaged, involves reformulation of the structural model so that we secure an estimating equation which does not suffer from multicollinearity and allows us to secure more reliable estimates of the important stock elasticity.

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[11] These figures are equivalent to conventional elasticities of demand in the short run for stocks of wool purchased from primary suppliers of 1.4 and 5.8 respectively. These compare with Horner's & Philpott's estimates of approximately -0.4 for the elasticity of consumption demand for raw wool.

APPENDIX I

QUARTERLY DATA

	Price Wool Average 64's & 50's d lb.clean	Mill Consumption in Group mn lb.clean	Net Supplies of Wool to Group mn lb.clean	Est.Stocks at end Period in Group mn lb.clean
1951/52				
July-Sept.	109.2	306.6	208.6	452.1
Oct.-Dec.	109.7	324.5	391.9	532.8
Jan.-March	90.0	335.4	415.1	625.8
April-June	90.2	343.6	301.0	596.6
1952/53				
July-Sept.	101.0	371.2	214.9	453.6
Oct.-Dec.	102.2	425.1	538.3	580.1
Jan.-March	105.9	436.6	504.4	661.3
April-June	115.8	448.7	456.1	682.1
1953/54				
July-Sept.	110.7	416.5	223.6	502.5
Oct.-Dec.	110.2	414.8	449.8	550.8
Jan.-March	102.2	393.1	410.9	582.0
April-June	111.9	394.7	367.8	568.4
1954/55				
July-Sept.	104.3	371.0	243.8	444.5
Oct.-Dec.	92.5	387.4	435.4	505.9
Jan.-March	95.5	403.3	466.8	582.7
April-June	95.9	402.8	376.5	569.7
1955/56				
July-Sept.	87.0	380.0	246.9	450.0
Oct.-Dec.	84.4	419.7	513.3	556.9
Jan.-March	95.9	443.1	514.8	641.9
April-June	91.5	436.2	451.2	670.3
1956/57				
July-Sept.	97.0	405.8	252.7	530.5
Oct.-Dec.	102.0	456.0	538.8	626.6
Jan.-March	108.7	475.3	547.4	712.1
April-June	113.5	461.5	481.1	745.0
1957/58				
July-Sept.	104.5	408.4	249.3	599.2
Oct.-Dec.	89.5	409.4	461.6	664.7
Jan.-March	82.2	401.3	484.7	761.4
April-June	76.0	383.8	331.1	722.1

QUARTERLY DATA (cont'd)

	Price Wool Average 64's & 50's d lb.clean	Mill Consumption in Group mn lb.clean	Net Supplies of Wool to Group mn.lb.clean	Est.Stocks at end Period in Group mn lb.clean
1958/59				
July-Sept.	72.3	369.4	244.6	610.6
Oct.-Dec.	65.9	424.4	539.5	739.0
Jan.-March	67.2	423.7	532.1	860.8
April-June	79.7	477.8	443.2	839.5
1959/60				
July-Sept.	84.7	447.1	315.9	721.6
Oct.-Dec.	84.9	486.4	548.5	797.0
Jan.-March	83.3	499.9	515.0	825.5
April-Sept.	84.5	483.7	436.5	791.6
1960/61				
July-Sept.	75.5	427.8	298.6	675.7
Oct.-Dec.	74.7	457.6	540.8	772.3
Jan.-March	76.7	468.6	543.8	860.8
April-Sept.	83.4	484.2	502.4	892.3
1961/62				
July-Sept.	80.7	457.8	308.2	756.1
Oct.-Dec.	77.2	501.3	551.8	819.9
Jan.-March	78.7	503.1	538.4	868.5
April-Sept.	81.8	494.5	431.2	818.6
1962/63				
July-Sept.	77.7	436.2	336.8	732.7
Oct.-Dec.	80.0	493.8	547.8	799.8
Jan.-March	88.0	498.6	558.5	873.1
April-Sept.	91.9	495.4	402.2	793.2
1963/64				
July-Sept.	91.8	447.8	300.7	659.4
Oct.-Dec.	100.0	475.7	566.9	764.0
Jan.-March	105.2	486.3	501.6	792.6
April-Sept.	95.4	461.3	415.5	760.1
1964/65				
July-Sept.	91.2	405.2	279.2	647.5
Oct.-Dec.	84.5	426.1	496.0	730.7
Jan.-March	78.9	435.8	493.0	801.2
April-Sept.	79.0	461.2	458.5	811.9

QUARTERLY DATA (cont'd)

	Price Wool Average 64's & 50's d lb.clean	Mill Consumption in Group mn lb.clean	Net Supplies of Wool to Group mn lb.clean	Est.Stocks at end Period in Group mn lb.clean
1965/66				
July-Sept.	82.8	432.1	330.7	723.8
Oct.-Dec.	85.4	489.4	511.8	759.5
Jan.-March	86.4	499.7	566.8	840.0
April-June	90.5	503.7	451.7	801.3
1966/67				
July-Sept.	87.9	434.4	308.6	679.8
Oct.-Dec.	81.0	461.8	462.6	694.0
Jan.-March	76.5	446.0	422.6	683.9
April-June	80.8	441.7	396.1	651.6
1967/68				
July-Sept.	74.2	389.5	284.5	560.0
Oct.-Dec.	71.25	426.6	500.0	646.7
Jan.-March	78.5	455.7	579.3	783.6
April-June	80.2	458.0	427.1	766.1

APPENDIX II

THE METHOD USED TO ESTIMATE STOCKS HELD BY THE GROUP AND QUARTERLY SUPPLIES TO THE GROUP

Since September 1955, estimates of stocks, held largely by manufacturers in the United Kingdom, West Germany, Belgium, Sweden, Japan and The Netherlands at the end of each quarter, have been published in Wool Intelligence. We shall refer to these estimates as "Reported Commercial Stocks", to distinguish them from our own estimates. Since 1957 Italy has been included in the survey, but the United States was not included until June 1962.

For our purposes, these estimates are inadequate. For the most part they include only stocks owned by manufacturers and merchants, other participants in the market having been ignored. Furthermore, with the exception of French stocks, they do not include stocks in transit, but are simply an estimate of stocks held in the reporting countries.

Even if these deficiencies could be overlooked, use of these estimates would severely limit the scope of this study. We would be forced to confine our attention to the period October 1955 - June 1964, and to further limit the scope of the market by excluding the United States and Italy.

In the face of these difficulties, an attempt was made to estimate stocks of wool held by the Group, both at home and abroad, for the period September 1951 to June 1964. The method employed was as follows. First, an estimate was made of stocks held at a particular point in time, namely June 30, 1957, on the basis of reported commercial stocks, an estimate of stocks held in the United States and Italy, and an estimate of stocks of wool in transit from the five major exporters, assuming an average transit time of two months. The net change in commercial stocks, over each quarter, was then estimated as a residual between supply to the Group and mill consumption by the Group, as estimated above. By cumulative addition of the changes in stocks before and since June 30, 1957, an estimate of the stocks held at the end of each quarter was obtained.

Quarterly supplies of raw wool to the Group presented the greatest problems of data estimation. No published estimates are available. However, an unpublished attempt to estimate quarterly supplies of raw wool to the Group has been made by Mr A. Zentler, of the International Wool Secretariat. He has kindly supplied notes of the method of estimation used. The method used in this study closely follows Zentler's methods. In several instances however, Zentler has been able to use unpublished data supplied directly to the International Wool Secretariat. It was therefore necessary to modify his method to allow for the use of published data throughout.

A careful examination of the method employed indicates that the estimates are deficient in several respects. Firstly, the intention has been to estimate sales of raw wool to Group countries in each quarter. In practice it was only possible to directly estimate sales from Australia, New Zealand, South Africa and the United Kingdom. For all other major suppliers, export data has been used in the absence of sales figures. Inevitably there will be a time lag between the sale of wool and its shipment, so that, while quarterly exports are a fair indication of quarterly sales, they are by no means a direct measure of sales. Suppliers from minor sources had to be estimated on the basis of imports from these sources by the Group. Here the time lag is even greater and, in consequence, greater inaccuracies can be expected. Fortunately supplies from this group of countries form only a very small proportion of the total.

Secondly, it was not possible to obtain quarterly data for all items. It was therefore necessary to make some rather dubious assumptions regarding the quarterly break-up of annual or seasonal estimates. This is particularly important in the case of supplies from the U.S.A., a large supplier, for which only annual figures of production are available.

Finally there was the problem of converting data published in terms of greasy weight to a clean basis. This was deemed necessary in order that quarterly supplies might be estimated on a comparable basis with quarterly mill consumption. Whenever possible, conversion was made on the

basis of the approximate yields of wool from various countries published in the April issue of Wool Intelligence. Even these estimates are probably only accurate to the order of $\pm$ 2% at best. In many instances, much less reliable estimates had to be used. Thus the conversion from a greasy to a clean basis is probably a considerable source of error.

When our estimates of stocks held by the Group at the end of each quarter are compared with reported commercial stocks, it is apparent that they contain a downward bias, due either to consistent under-estimation of supply, or to over-estimation of consumption. An independent estimate of stocks held on June 30, 1963, was compiled on a similar basis to the estimate for June 30, 1957. Comparison of the two estimates thus obtained for June 30, 1963, indicated a downward bias of approximately 13.3 m lb clean per quarter in the original series. It was therefore decided to correct this bias, in a purely arbitrary manner, by adding 13.3 m lb clean to the original estimate of stock change for each quarter.

The original estimates of changes in commercial stocks, together with the adjusted series and the final estimates of commercial stocks held at the end of each quarter, are shown in Appendix I.

Although these estimates of commercial stocks do represent an improvement on published information, the method of estimation is by no means perfect. As indicated above, the estimates of quarterly supplies of raw wool to Group countries contain many imperfections, all of which are reflected in the stock estimates. The most serious defect is the cumulative nature of errors introduced by the under-estimation of quarterly supplies. Although an attempt has been made to correct for this, it has been made on a purely arbitrary basis, so that it is doubtful whether it represents any real improvement.