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RATIONAL EXPECTATIONS IN THE AUSTRALIAN WOOL INDUSTRY*

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The process by which producers form expectations has implications for model building and policy analysis. An econometric model of the Australian wool market is estimated. It is shown that the rational expectations hypothesis is not inconsistent with the data for both the period before the floor price scheme was implemented and since that date. This finding has important implications, since it has been shown that the welfare gains from stabilisation are small if producers form rational expectations.

It is now well accepted that expectations play an important role in determining economic behaviour. Although agricultural economists have incorporated 'expectations' variables in their models for a considerable period of time, there have been relatively few attemps made to test the validity of the assumptions underlying these models. Direct tests of models in which the formation of expectations are described are rare because of the cost of data collection (for some exceptions see Heady and Kaldor 1954; Fisher and Tanner 1978; Munro and Fisher 1982). Recently there has been some interest shown in testing the rational expectations hypothesis within the framework provided by models of agricultural supply and demand (Goodwin and Sheffrin 1982 and Shonkwiler and Emerson 1982). The aim in this paper is to present the results of an indirect test of the rational expectations hypothesis in the context of a quarterly econometric model of the Australian wool industry and to discuss the policy implications of the findings.

The implications of the rational expectations hypothesis for model building and policy analysis have been pointed out elsewhere (for an overview see Lucas and Sargent 1981; Sargent 1981; Fisher 1982). A knowledge of the mechanism underlying the formation of expectations is important in designing effective stabilisation policies. Scandizzo, Hazell and Anderson (1983) contend that the expected gains from stabilisation are large if producers are naive in their expectations, while the gains are rather small if producers are rational. If producers form their expectations adaptively, then the potential gains lie somewhere between the above extremes. The Australian Wool Corporation (AWC) is involved in a stabilisation scheme which potentially involves large and, therefore, costly stock holdings. Given this fact, it is particularly relevant to attempt to determine whether the rational expectations hypothesis is consistent with behaviour in the wool market and whether the introduction of the marketing authority had any effect on the behaviour of woolgrowers.

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The Australian Wool Market

Approximately 80 per cent of the Australian wool clip is sold at public auction, the remainder being sold by private treaty. Apart from a period during the second world war, the wool market was free from intervention until 1970. In November 1970 the Australian Wool Commission instituted a flexible reserve price scheme with the aim of reducing the fluctuations in daily market prices by buying wool in the auction market if individual lots did not reach the Commission's reserve price. Prices fell sharply toward the end of 1970 and, early in 1971, the Commission effectively established a floor price of 63.9c/kg for the remainder of that season. After the recovery of the market late in 1972 the Commission abandoned the floor price concept until the beginning of the 1974-75 season. At that time the Australian Wool Corporation (formed by the amalgamation of the Australian Wool Commission and the Australian Wool Board on 1 January 1973) established a floor price scheme which currently operates in conjunction with the flexible reserve price scheme. The minimum reserve price (floor price) is announced at the beginning of each season. The flexible reserve price operates above the minimum reserve price and is established for each wool type. The flexible reserve price scheme is designed to ensure that individual sellers are not disadvantaged by very short-term aberrations in the market while the minimum reserve price scheme is an underwriting scheme which is financed by woolgrowers through a tax on wool deliveries.

In addition to its underwriting role, the AWC attempts to stabilise wool prices. The AWC operates a traditional buffer stock scheme by buying when prices are low and selling, either at auction or by private treaty, when prices are buoyant. As well as stabilising prices, the buffer-stock operation is aimed at increasing both grower and buyer confidence in the market. The overall impact of stabilisation will depend not only on changes in market characteristics between the buying and the selling periods (Powell and Campbell 1962) but also on how producers form expectations (Scandizzo, Hazell and Anderson 1983 and Turnovsky 1978).

A Model of the Australian Wool Market

The model presented below is a short-term model of the market during the period in which the AWC has been a participant. The main aim in constructing the model was to attempt to capture the effects of short-run (quarterly) changes in supply, prices, stocks and the buying activities of the AWC. The model contains four equations: an equation describing receivals of wool into store (supply); a price equation; an equation describing stockholding by manufacturers; and an equation describing the purchasing behaviour of the AWC. The model is as follows:

$$\text{(1)} \qquad \mathrm{QWS} = \mathrm{f}_1[PWO^*,\ C,\ SN_{-1},\ D_1,\ D_2,\ D_3],$$

$$\text{(2)} \qquad PWO = f_2[(QWS - NP),\ PSW,\ SFP,\ ER,\ WY,\ D_1,\ D_2,\ D_3],$$

$$\text{(3)} \qquad PSW = f_3[PWO,\ NP,\ PSW_{-1},\ DR,\ D_1,\ D_2,\ D_3],$$

$$\text{(4)} \qquad NP = f_4[(P\tilde{W}O - FPWO)],$$

where QWS = receivals of taxable wool into store (m kg greasy);
PWO = price of wool (c/kg clean);
PSW = stocks of raw wool held in Belgium, France, Italy, Japan, the Netherlands, and the U.K. (m kg);
NP = net purchases of wool by the AWC (m kg greasy);
PWO^* = expected price of wool given the information set up to and including period $(t-1)$;
C = proxy for the cost of withholding wool from the market;
SN = sheep numbers on farms;
SFP = price of synthetic fibres represented by the US price of polyester (c/lb);
ER = trade-weighted index of the value of the $A;
WY = index of industrial production in the OECD—Europe, USA and Japan ('Citibase' data base, Citibank Economics Department, New York) weighted by regional consumption of wool;
DR = interest rates on call money in major wool consuming countries weighted by stockholdings in those countries;
$FPWO$ = minimum reserve price for wool established by the AWC (c/kg clean);
$P\tilde{W}O$ = unobservable free market price for wool (that is, price without AWC intervention); and
D_1, D_2, D_3 = seasonal dummy variables.

For the purpose of exposition, the model can be written in the general form:

$$\beta_o y + \beta_1 y_{-1} + A y^* + \Gamma_1 x_1 + \Gamma_2 x_2 = u, \tag{5}$$

where y = a vector of endogenous variables;
y^* = a vector of expectations variables;
x_1 and x_2 = vectors of exogenous variables, x_1 containing variables whose future values are not known with certainty and x_2 containing variables whose future values are known with certainty;
u = a vector of disturbances; and
β_o, β_1, A, Γ_1 and Γ_2 = matrices of parameters.

All of the equations in the model were assumed to be linear.

The supply variable was specified as receivals of taxable wool into store. This was considered to be a more appropriate supply variable than offerings at auction because of the importance of private sales in some years. The major variable determining the quantity of wool supplied was assumed to be sheep numbers. Given some base level of production determined by the number of sheep shorn, graziers have the option of selling their wool or storing it. Although the amount that can be stored on farms is limited by the availability of appropriate storage facilities, a recent survey of woolgrowers has indicated that many growers actually use this strategy in their marketing (Munro and Fisher 1982). It was hypothesised that graziers would adjust supply according to their price expectations and the cost of withholding wool from sale. Graziers com-

monly take out short-term loans to pay shearing costs and, therefore, a major cost of withholding wool from market is the cost of the borrowed funds. In an attempt to capture this effect, the cost of shearing was used as a proxy for the cost of withholding wool from sale. It was anticipated that the coefficient on this variable would possess a positive sign.

It was assumed that price expectations were formed rationally according to Muth (1961). Because the expected price was unobserved, the approach suggested by Wallis (1980) and outlined by Fisher (1982) was used in obtaining a form of the model suitable for estimation. This approach gives rise to a model which contains expected values of the exogenous variables as well as the original exogenous variables themselves. In addition, the structural model contains non linear cross-equation restrictions on some of the coefficients. Testing the validity of these restrictions provides one way of testing the validity of the rational expectations hypothesis.

The major variable determining wool price was assumed to be the amount of wool moving through the market, that is, the amount of wool supplied plus or minus sales or purchases by the AWC. The coefficients on the supply and net purchases variables were constrained to be equal but opposite in sign. The effect on the demand for wool of substitute fibres was represented by the synthetic fibre price variable. A representative synthetic fibre price variable is difficult to obtain, the best proxy available being the US price of polyester.

An exchange rate variable was included directly in the price equation. The demand for wool at auction could be expected to respond to changes in the value of the Australian dollar. The exchange rate variable was included separately because price and exchange rate movements may have different impacts as a result of the general equilibrium effects of exchange rate changes (Chambers and Just 1979, p. 253). The demand for wool is influenced strongly by the level of economic activity in the major wool processing countries. In an attempt to model this effect, an index of industrial output in OECD countries was included in the price equation.

Reliable data on stocks of wool held by processors were available for several major wool consuming countries. Unfortunately no such quarterly data were available for West Germany over the entire sample period. The stock of wool held in major consuming countries was specified as a function of the price of wool, net purchases by the AWC, interest rates, and stocks in the previous period. The net purchases variable was included on the presumption that if the AWC was buying heavily and, therefore, accumulating stocks it was reducing the need for processors to carry large stocks. The interest rate variable was included to represent the opportunity cost of stockholding.

The AWC's net purchases were specified as a function of the difference between the floor price and the unobservable price that would have existed had there been no intervention in the market. An assumption was made that all wool in the carryover at the end of each quarter arose as a result of the minimum reserve price scheme. It was not possible to account for the effects of the day-to-day changes in stocks due to the operation of the flexible reserve price scheme. An analogue of the model presented above, excluding the effects of the AWC, was used to generate an unrestricted reduced form price equation. The reduced form was derived from the following structural model:

$$QWS = f_5(PWO^*, C, SN_{-1}, D_1, D_2, D_3), \tag{6}$$

$$PWO = f_6(QWS, PSW, SFP, ER, WY, D_1, D_2, D_3), \tag{7}$$

$$PSW = f_7(PWO, PSW_{-1}, DR, D_1, D_2, D_3). \tag{8}$$

The reduced form price equation was substituted for the variable, $P\tilde{W}O$, in equation (4). It was assumed that the disturbances in the unestimated reduced form equation and structural equation (4) were independent. The procedure followed allowed for the possibility that some or all of the market parameters had changed after intervention by the AWC.

Initially, quarterly data were collected for the period 1971(1) through 1980(4). However, data on sheep numbers were available only on an annual basis. Quarterly values for this variable were obtained using quadratic interpolation (Wymer 1977b). Data for the floor price were also obtained by interpolation for the period 1971(3) through 1973(3) during which there was no official floor price.

Parameter Estimation and Results

As already mentioned, the unobserved expectations variable in the structural model was replaced using the procedure outlined in Wallis (1980). The procedure generated a structural model of the following form:

$$\beta_o y + C_1 y_{-1} + \Gamma_1 x_1 + C_2 \hat{x}_1 + C_3 x_2 = u, \tag{9}$$

where C_1, C_2, C_3 = matrices of coefficients embodying non linear restrictions; and

$\hat{x}_1$ = a vector of anticipations on the exogenous variables whose future values are not known with certainty.

The necessary and sufficient conditions for the identification of the structural parameters in such models are set out by Wegge and Feldman (1983).

The coefficients in the system were estimated using a two-stage procedure. In the first stage, univariate time series models were specified and estimated to provide anticipated values of the exogenous variables. The forecast values of these variables were included as data in the second stage and the coefficients of the full system (9) were estimated using the full information maximum likelihood estimator. The estimates were obtained using Wymer's (1977a) RESIMUL package. Some gain in efficiency might be expected if the system were to be estimated in one stage. However, the inclusion of a moving-average process among the models describing the generation of the exogenous variables meant that estimation of the complete model in one step was computationally burdensome.

Time series models were specified for the variables representing synthetic fibre prices, exchange rates, industrial activity, interest rates, shearing costs and the floor price. For all variables except industrial production, interest rates and synthetic fibre prices, the first differences of the series were white noise processes. In the case of the industrial production and interest rate variables the second difference series were white noise processes. The following moving-average model was fitted for synthetic fibre prices:

$$(10) \qquad (1-L)SFP = \underset{(0.47)}{0.97} + \underset{(0.15)}{(1+0.51L)}a,$$

where L = the backward shift operator (Box and Jenkins 1970, p. 8); and
a = a white noise process.

The numbers in parentheses below the coefficients are standard errors. The χ^2 test of model adequacy (Box and Jenkins 1970, p. 291) indicated that the model fitted the data well.

The full information maximum likelihood estimates of the parameters in equation (5) are given in Table 1. In most cases the estimated coefficients exhibited the expected signs. A number of the coefficients were not statistically different from zero at the usually accepted levels of significance. The main problem appeared in the price equation where the coefficients on both the exchange rate and the synthetic fibre price variables were statistically insignificant. The individual equations have relatively high explanatory power. The R^2 values reported in Table 1 for individual equations are the asymptotic R^2 values calculated using the procedure set out by Carter and Nagar (1977). The equation describing the net purchasing behaviour of the AWC explained 61 per cent of the variation in the changes in AWC stocks. This compares well with the results obtained by Carland (1981) in a study where AWC purchases and sales were treated separately. The overall system fitted the data well. The Carter-Nagar systems R^2 was 0.95.

A likelihood ratio test was performed to determine whether the rational expectations restrictions were consistent with the data set. The comparison of the maximum likelihood values for the model containing the restrictions and its unconstrained counterpart provides a weak test of the rational expectations hypothesis. This test is weak in the sense that its validity is conditional on the model specification being appropriate. The likelihood ratio test is based on the statistic, $2(Lu - Lc)$, where Lu is the log-likelihood value of the unconstrained model (containing p_1 parameters) and Lc is the log-likelihood value of the constrained model which contains a subset of p_2 parameters from the unconstrained model. The statistic is distributed asymptotically as a chi-squared distribution with $(p_1 - p_2)$ degrees of freedom.

The rational expectations hypothesis provided six restrictions on the parameters in the estimated model. The value of the test statistic was 16.0. Since this value is less than the value of $\chi^2_{0.01,6} = 16.8$ it can be concluded that the rational expectations hypothesis provides an acceptable way of modelling producer expectations in the wool industry if a significance level of one per cent is chosen. This finding in itself does not provide enough evidence to conclude that there is no useful role to be played by the AWC's stabilisation scheme. One of the AWC's aims has been to ensure that the market functions efficiently. The presence of the AWC may have contributed to the formation of rational expectations by wool growers through, for example, the provision of more and better market information. To test this proposition the model represented by equations (6) through (8) was estimated for the period 1963(2) through 1970(4), a period which pre-dated the AWC's direct involvement in the wool market.

The results for the three-equation model representing the pre-

TABLE 1

Parameter Estimates for a Wool Commodity Model Incorporating Rational Expectations and the Activities of the AWC[a]

Variable	Supply *QWS*	Price *PWO*	Private stocks *PSW*	AWC stocks *NP*
QWS		−4.22		
		(2.51)		
PWO			−0.04	
			(0.02)	
PSW		6.94		
		(4.88)		
NP		4.22	−0.22	
		(2.51)	(0.09)	
*PWO**	0.13			
	(0.07)			
C	1.05			
	(0.37)			
SFP		5.00		
		(4.58)		
ER		1.84		
		(2.31)		
WY		6.90		
		(2.07)		
DR			−1.05	
			(0.60)	
$SN_{.2}$	2.38			
	(0.56)			
PSW_{-1}			0.63	
			(0.08)	
PWO-FPWO				−0.13
				(0.11)
D_1	−136.04	−546.75	6.72	
	(5.43)	(335.69)	(3.40)	
D_2	−157.82	−645.87	7.13	
	(5.49)	(390.85)	(3.84)	
D_3	−42.52	−220.88	4.44	
	(5.49)	(141.95)	(3.30)	
Intercept	−147.06	−935.66	57.21	739.26
	(105.03)	(653.90)	(12.73)	(382.79)
R^2	0.97	0.93	0.90	0.61

[a] Numbers in parentheses are asymptotic standard errors. The Carter-Nargar systems R^2 was 0.95.

intervention period in Australian wool marketing are presented in Table 2. There is evidence that some change occurred in the market parameters between the two periods. The first period was characterised by a steady downward trend in nominal wool prices while during the second period nominal wool prices trended upwards and other major changes such as the oil price shocks occurred. Despite such changes the rational expectations hypothesis was consistent with the data for the early period at the one per cent level of significance. The value of the test statistic was 8.06. This value can be compared with a $\chi^2_{0.01,5}$ value of 15.9. It would appear, therefore, that the AWC has had little impact on the way in which woolgrowers form their price expectations.

TABLE 2

Parameter Estimates for a Wool Commodity Model Prior to the Establishment of the AWC[a]

Variable	Supply *QWS*	Price *PWO*	Private stocks *PSW*
QWS		−0.95	
		(0.26)	
PWO			0.16
			(0.06)
PSW		2.30	
		(0.52)	
*PWO**	1.59		
	(0.53)		
C	15.06		
	(5.24)		
SFP		−0.01	
		(0.28)	
ER		−3.92	
		(6.48)	
WY		−1.29	
		(0.41)	
DR			4.33
			(1.22)
SN_{-1}	3.78		
	(1.09)		
PSW_{-1}			0.52
			(0.10)
D_1	−4.35	−37.99	−0.41
	(12.91)	(10.64)	(2.84)
D_2	154.64	127.89	−11.35
	(13.74)	(35.97)	(3.14)
D_3	190.97	180.77	−15.86
	(15.11)	(47.23)	(2.64)
Intercept	−1092.19	469.77	26.75
	(349.37)	(666.56)	(19.52)
R^2	0.99	0.87	0.81

[a] Numbers in parentheses are asymptotic standard errors. The Carter-Nagar systems R^2 was 0.98.

Concluding Remarks

The rational expectations hypothesis was tested against a general unrestricted model which contained a class of variables not usually found in commodity models, that is, variables representing the anticipated values of the original exogenous variables. Because of this, the models presented here are not readily comparable with traditional commodity models. In addition the tests performed do not allow a comparison of rational expectations with alternative hypotheses such as adaptive or extrapolative expectations. While the possibility that other hypotheses are also consistent with the data cannot be ruled out, the likelihood ratio tests performed show that the rational expectations hypothesis provides a valid way of modelling short-term aggregate producer expectations in the wool industry if one is prepared to accept the chosen levels of statistical significance.

The implications of the above findings for the welfare effects of

stabilisation are clear. Scandizzo, Hazell and Anderson (1983) have shown that if producers' expectations are rational, then the welfare gains from stabilisation are small. The rational expectations hypothesis appeared to provide an adequate representation of producer behaviour before the establishment of the buffer stock scheme. Any attempt to justify the stabilisation scheme must, therefore, be based on arguments that the AWC has been able to maintain or increase the demand for wool by increasing the confidence of buyers. It is likely that the AWC has increased or, at least maintained, buyer confidence with respect to the continuity of supply by holding strategic stocks in major wool consuming countries. However, such attempts to improve buyer confidence could be undertaken quite effectively without the need for a buffer stock scheme aimed at price stabilisation.

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