Welfare Effects of and Supply Responses to Recent Australian Agricultural Policy Changes

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This paper examines the joint impact of wheat market deregulation and removal of the wool Reserve Price Scheme on Australian wheatbelt farmers using a simple model of land allocation between the two products and empirical details of the impact of the two policy changes on farmers' uncertain economic environment. It is shown that key parameters are wool micronage, wheat yield variability and the presence or not of a wool price ceiling due to stockpile disposal. Consequently, important regional differences in welfare impacts and supply responses may exist and these may be of significance to the mechanics of stockpile disposal.

1. Introduction

In the last few years Australian farmers have experienced two major policy changes: first, the deregulation of the Australian wheat market; and most recently, the removal of the wool Reserve Price Scheme (RPS). Although when considered separately each of these changes can be expected to have increased the riskiness of farming income and therefore to have had a negative impact on the well-being of wheat farmers and wool growers, the focus of this paper is on the joint impact of these changes on wheatbelt farmers whose land is typically allocated in part to both these products. In particular, the aim of the paper is to make use of a simple two-product model of land allocation to predict whether wheatbelt farmers will shift toward wheat or wool production as a consequence of the overall impact of the two policy changes.

It is recognised that there are considerably more complex models of wheatbelt farming available for policy analysis. For example, the ORANI model's characterisation of the Wheat-Sheep Zone allows for nine separate outputs as well as input substitution in response to relative price changes (see Adams 1987). In addition, the MIDAS model of the Western Australian wheatbelt has substantial flexibility in the combination of outputs and inputs, including both a range of soil types and a representation of the complementarity aspects of wheat and sheep enterprises (see Kingwell and Pannell 1987). However, it is felt here that the essence of the above-mentioned policy changes is their impact on the riskiness of wheatbelt farming, and neither of these models is appropriate for analysing the impact of uncertainty on farming decisions. Moreover, although recent developments with the MUDAS model hold promise for future research (MUDAS is a version of MIDAS which attempts to incorporate seasonal and price variability into its structure - see Kingwell *et al.* 1992), the simple methodology proposed here is at present arguably the best-suited to policy analysis where the particular focus is on the role of uncertainty in decision-making. Nevertheless, the simplicity of this approach to modelling the land allocation decision does suggest that any results should be viewed only as a basis for further empirical research.

The structure of the paper is as follows. The first section sets out the model of optimal land allocation which is based on that of Fraser (1991). In addition, it assembles the empirical details relevant to determining the impact of the policy changes on a farmer's uncertain economic environment. These details suggest that within the context of the Australian wheatbelt, there are potentially large regional differences in the overall impact of the policy changes, depending in particular on wool micronage and wheat yield variability. This suggestion is in large part confirmed by the simulation results presented in the next section, although of these two, wool micronage is shown to be of greater significance in determining regional differences in supply response to the policy changes. Moreover, these regional differences are shown to be large enough to include wheatbelt farmers shifting their land allocation between wheat and wool in opposite directions in response to the policy changes. The paper concludes with a brief summary.

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2. Model and Empirical Details

The model in Fraser (1991) assumes that although the producer has two alternatives for generating income from arable land, one of these alternatives is known premiums from "setting-aside" some of this land. By contrast, in the context of the Australian wheatbelt, the two alternatives are income from wheat and wool, where both of these incomes are subject to uncertainty. In what follows it is assumed that wheat income is uncertain due to both price and yield variability, but that wool income is subject only to price uncertainty.[1] In addition, it is assumed that costs of production per hectare are known and are equal for wheat and wool so that these values are irrelevant to the land allocation decision. These assumptions mean that the key parameters in the model of land allocation are those characterising the distributions of the two uncertain income sources. Moreover, although these uncertain income sources may be correlated, there is assumed to be no deterministic relationship between them as would be the case, for example, if the complementarity feature that exists between wheat and sheep enterprises was represented (see Fraser 1990).

On this basis the farmer's income (π) can be represented by:

$$\pi = w \alpha \theta L + s(1-\alpha)L \qquad (1)$$

where:
- w = uncertain price per unit of wheat output,
- θ = uncertain wheat yield per hectare,
- L = area of land (hectares),
- α = share of land allocated to wheat ($0 \leq \alpha \leq 1$),
- s = uncertain wool revenue per hectare.

Allowing for a possible covariance between wheat price and yield ($cov(w,\theta)$) and assuming expected yield per hectare is equal to unity ($E(\theta)=1$) means expected income ($E(\pi)$) is given by:

$$E(\pi) = w_e \alpha L + cov(w,\theta)\alpha L + s_e(1-\alpha)L \qquad (2)$$

where:
- w_e = expected price per unit of wheat output, and
- s_e = expected wool revenue per hectare.

In addition the variance of income ($Var(\pi)$) is given by (see Mood *et al.* 1974, p.179):

$$Var(\pi) = Var(w\alpha\theta L) + Var(s(1-\alpha)L) + 2\,cov(w\alpha\theta L, s(1-\alpha)L) \qquad (3)$$

where:
$cov(w\alpha\theta L, s(1-\alpha)L)$ = covariance between wheat and wool income.

Moreover, the variance of wheat income ($Var(w\alpha\theta L)$) can be approximated by (see Mood *et al.* 1974, p.181):

$$Var(w\alpha\theta L) = \alpha^2L^2\sigma_w^2 + w_e^2\alpha^2L^2\sigma_\theta^2 + 2w_e\alpha L cov(w,\theta) \qquad (4)$$

where:
- σ_w^2 = variance of wheat price, and
- σ_θ^2 = variance of yield,

while the variance of wool income ($Var(s(1-\alpha)L)$) is given more simply by:

$$Var(s(1-\alpha)L) = (1-\alpha)^2L^2\sigma_s^2 \qquad (5)$$

where:
σ_s^2 = variance of wool revenue per hectare.

In what follows the output of wool per hectare will be defined to equal unity so that the variance of wool revenue per hectare is identically equal to the variance of wool price. Note that in all cases these parameters of the distributions of the two uncertain income sources are taken to be subjectively formulated by farmers and may be based on a range of information, both historical and forecast.

It is further assumed that farmers seek to maximise the expected utility of income ($E(U(\pi))$) and that the expected utility of income can be approximated by a mean-variance formulation:

$$E(U(\pi)) = U(E(\pi)) + {}^1/_2U''(E(\pi)).Var(\pi)\,. \qquad (6)$$

[1] This simplification is supported by empirical evidence on the variability of wool production. Harris *et al.* (1974) estimate that less than 6 per cent of wool income variation is attributable to output variability. Piggott (1987) estimates the coefficient of variation of fine combing wool (20-24 microns) to be only 3.7 per cent. The bulk of wool produced in the wheatbelt falls into this category.

See Meyer (1987) and Hanson and Ladd (1991) for arguments supporting the use of the mean-variance framework in empirical applications. Note that this framework is not an approximation if all uncertain parameters are normally distributed.

The optimal land allocation is then given by differentiating (6) with respect to α and equating to zero:

$$U'(E(\pi)).(\partial E(\pi)/\partial\alpha) + {}^1/_2U'''(E(\pi)).Var(\pi).(\partial E(\pi)/\partial\alpha) + {}^1/_2U''(E(\pi)).(\partial Var(\pi)/\partial\alpha) = 0\,. \quad (7)$$

Using the substitutions:

$$cov(w,\theta) = \rho_{w\theta}\sigma_w\sigma_\theta \quad (8)$$

$$\text{and } cov(w\alpha\theta L, s(1-\alpha)L) = \rho_{AB}\sigma_A\sigma_B \quad (9)$$

where:

$\rho_{w\theta}$ = correlation coefficient between wheat price and yield,
σ_w = standard deviation of price,
σ_θ = standard deviation of yield,
ρ_{AB} = correlation coefficient between wheat income (A) and wool income (B),
σ_A = standard deviation of wheat income, and
σ_B = standard deviation of wool income,

the derivatives in (7) may be evaluated from (2), (3), (4) and (5) as:

$$\partial E(\pi)/\partial\alpha = L(w_e - s_e) + L\rho_{w\theta}\sigma_w\sigma_\theta \quad (10)$$

$$\partial Var(\pi)/\partial\alpha = \partial Var(w\alpha\theta L)/\partial\alpha + \partial Var(s(1-\alpha)L)/\partial\alpha + 2\rho_{AB}((\partial\sigma_A/\partial\alpha)\,.\,\sigma_B + (\partial\sigma_B/\partial\alpha)\,.\,\sigma_A) \quad (11)$$

where:

$$\partial Var(w\alpha\theta L)/\partial\alpha = 2\alpha L^2\sigma_w^2 + 2w_e^2\alpha L^2\sigma_\theta^2 + 2w_eL\rho_{w\theta}\sigma_w\sigma_\theta, \quad (12)$$

$$\partial Var(s(1-\alpha)L)/\partial\alpha = -2(1-\alpha)L^2\sigma_s^2, \quad (13)$$

$$\partial\sigma_A/\partial\alpha = {}^1/_2(Var(w\alpha\theta L))^{-1/2}.(\partial Var(w\alpha\theta L)/\partial\alpha), \quad (14)$$

$$\partial\sigma_B/\partial\alpha = {}^1/_2(Var(s(1-\alpha)L))^{-1/2}.(\partial Var(s(1-\alpha)L)/\partial\alpha)\,. \quad (15)$$

Hence the full version of the first order condition is given by substituting the right-hand-side of equations (10)-(15) for the appropriate derivatives in equation (7).

The impact of the two policy changes on the farmer's welfare can be found by evaluating (6) before and after the change using the appropriate parameter values, while the supply response to the changes can be found by comparing the values of α which solve (7) before and after the changes.

Consider next the empirical details relevant to these evaluations. In relation to the wheat industry, Fraser (1992) has estimated the impact of deregulation to be an increase in the coefficient of variation of producer prices from 8.2 per cent to 17.4 per cent. Moreover, this increase has two components: a decrease of 0.74 per cent in the expected price due primarily to the reduction in price support from the Guaranteed Minimum Price Scheme; and an increase of 110.5 per cent in the standard deviation of prices due both to reduced price support and removal of the Australian Wheat Board's domestic monopoly. Although these changes can be expected to apply across-the-board to wheat farmers, an aspect of significant regional differential among wheat farmers has been identified by Anderson, Dillon, Hazell, Cowie and Wan (1988) in relation to yield variability. In particular, they estimate that whereas the coefficient of variation of wheat yield in Western Australia for the period 1975-85 was 20 per cent, in Victoria, South Australia, New South Wales and Queensland, it was approximately double this level (37 per cent, 37 per cent, 36 per cent and 40 per cent respectively). To allow for the possibility that this divergence may cause a significant regional differential in the impact of wheat deregulation on wheatbelt farmers, in what follows simulation results are presented for two alternative levels of yield variability (20 per cent and 37 per cent). An obvious connection between price and yield variability is through the correlation coefficient ($\rho_{w\theta}$) and Fraser (1992) specifies this value to be -0.25 based on the results of Harris, Crawford, Gruen and Honan (1974). Although a negative correlation coefficient seems appropriate to the Australian wheat industry, because of doubt about its magnitude, in the simulation results to follow a sensitivity analysis is included.

Turning to the wool industry, Murrell (1992) estimated the impact of the RPS to be a general reduction in the coefficient of variation of wool prices. However, it is also shown that the magnitude of this reduction varied substantially across wool micronages. Connelly *et al.* (1987) also found substantial variation across wool types, although the results differ considerably from those of Murrell (1992). In particular, Murrell's (1992) estimates for 21 micron wool show the coefficient of variation of prices was reduced from 23.34 per cent to 10.28 per cent, while for 23 micron wool the reduction was from 12.38 per cent to 8.72 per cent. Because both of these wool types are produced on wheatbelt farms, this divergence is a further potential source of regional variation of policy impact among wheatbelt farmers, this time arising from the removal of the RPS. Consequently, in what follows simulation results are presented for both wool types. Moreover, in simulating the impact of the removal of the RPS, doubt exists about how to specify precisely this removal, mainly because of uncertainty over the effect of the wool stockpile on the operation of the "free" market. The approach taken here in presenting the simulation results is to consider two extreme scenarios. The first characterises the removal of the RPS simply as an increase in the variability of wool prices to a level given by the estimates of Murrell of wool price variability in the absence of the RPS. In other words, the potential price-depressing effect of the presence of the stockpile is ignored by this scenario.[2] However, the second scenario allows for the presence of the stockpile by assuming the Wool Realisation Commission adopts a price-based stock release strategy as recommended by Vines, Davis and Millar (1991). In particular, their recommendation of a 500c/kg (clean) trigger price based on an expected market price of 435c/kg is characterised in the simulations as a price ceiling set 15 per cent above the expected price. Consequently, in this case producer prices are not only more variable but also lower in expectation following the removal of the RPS, where the precise impacts of the price ceiling on expected producer prices (E(s(c))) and the variance of producer prices (Var(s(c))) are calculated from the formulae derived in Fraser (1988):

$$E(s(c)) = (1-F(s_c))s_c + F(s_c)\,(s_e-\sigma_s Z(s_c)/F(s_c)) \quad (16)$$

$$\begin{aligned} Var(s(c)) = {} & F(s(c))\sigma_s^2\,(1-((s_c-s_e)/\sigma_s)).(Z(s_c)/F(s_c)) \\ & -(-Z(s_c)/F(s_c))^2)+ \\ & (1-F(s_c))(s_c-E(s(c)))^2+ \\ & F(s_c)(s_e-\sigma_s Z(s_c)/F(s_c) - E(s(c)))^2 \end{aligned} \quad (17)$$

where:

s_c = price ceiling = 1.15 s_e,

$F(s_c)$ = cumulative probability of the price being less than the price ceiling, and

$Z(s_c)$ = the ordinate of the standard normal density at s_c.

Given that a wheatbelt farmer's total income is a joint function of uncertain levels of wheat and wool income, (3) allows for a non-zero correlation between these levels in determining the overall variability of income. There is a range of factors which will determine the nature of this correlation, including Australia's market power in relation to wheat and wool, geographical correlations of wheat yields and exchange rates. Given their export-orientation, the approach taken here is to focus on the $A value dependence of income in the wheat and wool industries and in what follows the correlation coefficient between wheat and wool income (ρ_{AB}: see (9)) is set equal to 0.5. However, doubt about its precise value due to the role of other factors makes this coefficient a further subject of sensitivity analysis in the simulation results to follow.

Finally, consider the specification of the farmer's utility function of income as required for the evaluation of (6) and (7). In calculating the simulation results use is made of the constant relative risk aversion function:

$$U(\pi) = \pi^{1-R}/1-R \quad (18)$$

where:

$R = -U''(\pi)\pi/U'(\pi)$.

As shown in Fraser (1991), results generated using the model of this section are relatively insensitive to this specification compared with both the constant absolute risk aversion and quadratic forms.

[2] As is the issue of whether the RPS had any sustained role in maintaining wool prices at artificially high levels rather than just stabilising prices. However it would be relatively straightforward to allow for such a feature in the simulation results once an estimate of its magnitude was available.

Moreover, its use allows a direct substitution of the risk aversion coefficient estimated by Bardsley and Harris (1987) for farmers in the Australian wheatbelt (R = 0.7).

This completes the specification of the model and empirical details required for simulating the joint impact of wheat deregulation and the removal of the RPS on wheatbelt farmers' welfare and supply decisions.

3. Simulation Results

Details of the simulation results classified according to wool micronage, yield variability and wool price scenario are reported in Table 1. Welfare impacts of the two policy changes are presented as the change in the certainty equivalent of income as a percentage of expected income (with the proportion attributable to wheat deregulation in brackets), while results on land allocation are to be contrasted with an optimal allocation prior to the policy changes of 50 per cent of land to each product. Note that this optimal prior allocation is solely for expositional purposes and is arbitrarily achieved by varying the ratio of the expected price of wheat to the expected price of wool. In a more realistic context, the optimal prior allocation could be any level depending not just on the two income sources but also on a whole range of other technological and economic factors.

Consider initially the welfare impacts. It is suggested in Table 1 that the total welfare impact of the policy changes is likely to be relatively small - being in all cases less than the proportion of income contributed by wool growers to the market support fund (at least 4 per cent). Nevertheless, it is also suggested there is likely to be considerable variation in the size of this welfare impact between farmers with 21 and 23 micron wool and between farmers with more and less variable wheat yield. For example, in the absence of a wool price ceiling the welfare impact for a farmer with CV_θ = 20 per cent and 23 micron wool is only -1.0 per cent compared with nearly double this impact for a farmer with CV_θ = 37 per cent and 21 micron wool (-1.9 per cent). Moreover, of these two variables, wool micronage can be seen to be the more significant in determining the size of the welfare impact. Specifically, welfare impacts for 21 micron wool are 50 per cent or more larger than those for 23 micron wool, whereas this differential is 25 per cent or less for yield variability.[3]

Table 1:Simulation Results for the Two Policy Changes

Wool Micron	CV_θ[a] (%)	Wool Price Scenario[b]	Welfare Impact[c] (%)	α[d] (%)
21	20	No ceiling	-1.5 (55.6)	38.8
		Ceiling	-3.1 (27.6)	100.0
	37	No ceiling	-1.9 (55.9)	39.3
		Ceiling	-3.4 (31.2)	69.8
23	20	No Ceiling	-1.0 (84.8)	3.1
		Ceiling	-1.3 (65.7)	18.6
	37	No Ceiling	-1.2 (84.3)	27.4
		Ceiling	-1.5 (69.1)	33.2

Notes:

a CV_θ = coefficient of variation of wheat yield.
b Wool Price Ceiling = 115 per cent of expected price.
c Change in the certainty equivalent of income as a percentage of expected income. Figures in brackets represent the proportion of the impact attributable to wheat deregulation.
d α = proportion of land allocated to wheat after the policy changes.

In addition, it is shown in Table 1 that the size of the welfare impacts is sensitive to the specification of the effect of removing the RPS on the wool market. Clearly, the presence of a price ceiling magnifies the welfare impact by depressing expected prices, and particularly so in the case of 21 micron wool where the size of the welfare impact is increased by 80 per cent or more depending on yield variability.

Turning next to land allocation, the presence or not of a price ceiling is shown in Table 1 to be important as well in determining supply response to the two policy changes. Although in the case of 23 micron wool the relative stability of prices even in the absence of the RPS means that in all cases producers are encouraged on balance to shift out of wheat and into wool (the welfare impacts on growers of 23 micron wool are predominantly due to wheat deregulation), in the case of 21 micron wool the presence or not of a price ceiling is crucial in determining whether on balance farmers shift into wheat or into wool. For example, if a price ceiling is in operation then even farmers with relatively variable wheat yields will shift their allocation of land so that the majority is in wheat production following the two policy changes.[4]

Before completing this section, it should be recalled that some doubt exists about the appropriate magnitude of the two correlation coefficients used in generating the simulation results and, as a consequence, a sensitivity analysis of their values has been conducted. Details of the results of this analysis are contained in Table 2. For simplicity, the analysis is only reported for the case of 21 micron wool, $CV_\theta = 0.37$ and a price ceiling as this is the case with perhaps the most surprising supply response result. However, the results in Table 2 are sufficient to show that the estimates of welfare impacts and supply response are relatively insensitive to proportionately large changes in the value of both correlation coefficients - with results varying by only about 10 per cent or less in all situations. Consequently it would seem reasonable to conclude that the results in Table 1 are robust with respect to uncertainty about the magnitude of the two correlation coefficients.

4. Conclusion

This paper has examined the joint impact of wheat market deregulation and removal of the wool RPS on wheatbelt farmers. Using a simple model of land allocation between the two products under conditions of income uncertainty combined with empirical details of the impact of the two policy changes on these uncertain conditions, both the welfare

[3] Note that in both cases the coefficient of variation of the more variable parameter is approximately double that of the less variable parameter (23.34/12.38 for wool price; 37/20 for wheat yield).

[4] Note that farmers with 23 micron wool and $CV_\theta = 20$ per cent are used to a relatively low risk environment and so respond to the risk-enhancing policy changes by moving almost completely into the relatively safe product (wool).

Table 2: Sensitivity Analysis of Correlation Coefficients (21 micron wool, $CV_\theta = 0.37$, price ceiling)

	Welfare Impacts (%)	α (%)
$\rho_{w\theta}$		
-0.1	-3.1	76.4
-0.25	-3.4	69.8
-0.4	-3.6	63.4
ρ_{AB}		
0.25	-3.2	65.3
0.5	-3.4	69.8
0.75	-3.5	78.1

effects of and supply responses to the policy changes were simulated.

It was shown that key parameters influencing the simulation results were the wool micronage, the variability of wheat yield and the presence or not of a wool price ceiling brought about by stockpile disposal. Although the welfare effects were generally relatively small, it was argued that the role of the first two parameters introduced an important regional dimension to the impact of the policy changes which, when coupled with the role of the price ceiling, may mean that farmers in one region of the wheatbelt respond to the policy changes by moving out of wheat production and into wool production, while the opposite response could occur in another region.

Moreover, this contrasting supply response may be of some significance to the mechanics of the disposal of the stockpile as, although production of the two micronages under consideration (21 and 23) prior to the removal of the RPS was approximately equal (about 170kt greasy), stocks of 23 micron wool are approximately double those of 21 micron wool (215kt greasy compared with 110kt greasy) - and yet the results of this study suggest that wheatbelt farmers producing 21 micron wool may be shifting out of wool into wheat while those producing 23 micron wool may be doing just the opposite! It would seem that empirical investigation of this possibility is a suitable topic for further research.

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