Grower perceptions of the impact of protein premiums

and discounts for wheat

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Abstract

This paper presents results of a survey of Western Australian wheat growers designed to elicit perceptions of the impact of protein premiums and discounts for wheat on income, utility and off-farm risk management. The results indicate that a grower's perception of the scheme's impact on expected income and utility depends on that grower's expected protein level. Additionally, growers do not perceive protein premiums and discounts to have affected the variance of income, or their willingness-to-pay for a forward contract. These latter findings are contrary to previous studies of actual rather than perceived effects. However, the perceptions of growers are understandable given that the scheme's effect on the variance of income is small relative to its effect on the level of expected income. A further result is that growers with low expected protein levels expect to be disadvantaged by the scheme, which is consistent with studies of actual effects.

Introduction

In 1989 the Australian Wheat Board (now the AWB Ltd) introduced a scheme by which growers are paid a price for their wheat which is dependent on protein content. Generally, growers are paid a premium for high protein wheat (above 10%) and are discounted for low protein wheat (below 10%) (AWB 1998). This paper presents an empirical analysis of the impact of this protein premium and discount scheme on a grower's income stream and willingness-to-pay (w-t-p) for a forward contract.

When considering a grower's income steam, Fraser (1997) found that, for a protein premium and discount scheme centred on a grower's existing expected protein level, the negative correlation between wheat yield and protein decreases a grower's expected income level, E(I), and variance of income, Var(I). Fraser (1997) also found that the greater a grower's seasonal variability, the stronger the scheme's effect to decrease E(I) and Var(I), which has ambiguous implications for a grower's expected utility, EU.

Petersen and Fraser (2000) extended these results to consider a protein premium and discount scheme not centred on a grower's existing protein level and found Fraser's (1997) findings to be true for growers with expected protein levels less than approximately 10.3%. Petersen and Fraser (2000) also considered the impact of the scheme on EU and found that, for expected protein less than approximately 10.2%, the E(I) effect dominates the Var(I) effect causing EU to decrease. For the small expected protein window, between approximately 10.2% and 10.3%, Petersen and Fraser (2000) found the Var(I) effect dominates the E(I) effect, and EU increases. For expected protein levels greater than 10.3%, Petersen and Fraser (2000) found that E(I)

increases and Var(I) decreases, both working to positively affect EU. Seasonal variability was found to have only a minor influence on the impact of the scheme.

When considering the effect of protein premiums and discounts on a grower's w-t-p for a forward contract, Fraser (1997) suggests that, for a protein premium and discount scheme centred on a grower's existing expected protein level, growers are willing-to-pay more for a forward contract in the presence of the scheme and that the less reliable the seasonal conditions, the greater this increase in w-t-p. Petersen and Fraser (2000) extended these results to consider the effect of differing expected protein levels and suggest that a grower with an expected protein level less than approximately 10% is willing to pay more for a forward contract in the presence of the scheme, and a grower with an expected protein level greater than this amount is willing to pay less. However, Petersen and Fraser (2000) found these differences in w-t-p to be small and to vary little with changes in seasonal variability.

A personal survey of Western Australian wheat growers was conducted to test these theories developed in Fraser (1997) and Petersen and Fraser (2000). Results indicate that a grower's perception of the scheme's impact on E(I) and EU depends on that grower's expected protein level, which supports the findings of Petersen and Fraser (2000). Growers do not perceive protein premiums and discounts to have affected Var(I) or w-t-p for a forward contract. These latter findings are contrary to the results of Fraser (1997) and Petersen and Fraser (2000), however, the perceptions of growers are understandable as the effects of the scheme on Var(I) and w-t-p are small, especially relative to its effect on E(I).

The paper proceeds as follows. Section 2 presents a brief description of the survey design. Sections 3 contains the empirical testing of theories developed in the preceding studies. This testing relates to the scheme's impact on E(I), Var(I), EU and w-t-p for a forward contract. The paper ends with a conclusion.

2. Survey design

A random, clustered sample of Western Australian wheat growers was chosen for the survey. As the study is testing whether a grower's perceptions of protein premiums and discounts depends on a grower's expected protein level and degree of seasonal variability, the clusters were chosen according to these components. Estimates of expected protein levels and seasonal variability in Petersen and Fraser (1999) were used to choose the clusters.

Cluster 1 was chosen to be the Mukinbudin and Westonia shires where expected protein levels and seasonal variability are relatively high. Growers in this cluster were expected to be advantaged by the scheme due to their expected protein levels. Cluster 2 was chosen to be the Moora shire where expected protein levels are relatively high and seasonal variability is relatively low. Growers in this cluster were also expected to be advantaged by the scheme due to their expected protein levels. Cluster 3 was chosen to be the Narembeen shire where expected protein levels and seasonal variability are relatively low. Growers in this cluster were expected to be disadvantaged by the scheme due to their expected protein levels. In relation to seasonal variability, Fraser (1997) suggested that differences in this variability have an ambiguous impact on a grower's EU. Consequently, in choosing shires with divergent levels of seasonal variability, one of the aims of the analysis is to clarify this ambiguity.

In total, 152 wheat growers were interviewed; 46 in Cluster 1, 54 in Cluster 2 and 52 in Cluster 3. Expected protein level (measured from up to 5 years of farm records) and variability of protein levels (obtained by eliciting the grower's subjective probability distribution for protein) were measured in the survey. Table 1 presents the means of these two variables for the total sample and for the 3 clusters separately.

Table 1 Expected protein levels and perceived variability in protein levels.

	Expected protein levels %	Perceived CV of yield %
Total	10.3	39.6
Cluster 1: Muk/West	10.3	53.3
Cluster 2: Moora	10.6	36.6
Cluster 3: Narembeen	9.8	30.4

The expected protein level for the total sample is greater than 10% (10.3%). Expected protein levels for Clusters 1 and 2 are higher than that of Cluster 3. This is the trend that was expected when choosing these areas.

The perceived coefficient of variation (CV) of wheat yield for Cluster 1 is higher than that of Clusters 2 and 3 as expected. However, perceived variabilites are much higher than the actual CVs presented in Petersen and Fraser (1999). This may be because growers were recalling wheat yields from a longer time frame than the previous 10 years presented in Petersen and Fraser (1999). Additionally, this question may be susceptible to overestimation due to the 'representativeness bias' associated with eliciting subjective probability distributions (where the likelihood of an event is judged by estimating the degree of similarity to the class of event of which is it presumed to be (but may not be) an example (Spetzler and Stael von Holstein 1975;

Hardaker *et al.* 1997) i.e. if growers' classify their seasonal variability to be high after experiencing an extremely variable season in the preceding year).

3. Empirical analyses

Four empirical analyses are presented, namely explanations for growers' perceptions of the impact of protein premiums and discounts on E(I), Var(I), EU and w-t-p for a forward contract. Difficulties arose when designing questions to test these perceptions. For example, in regard to the E(I) effect, if a question had been phrased "Do you think your typical annual income has increased or decreased following the introduction of protein premiums or discounts?" it would not be asking the grower to consider a *ceteris paribus* situation i.e. any change in E(I) since the introduction of protein premiums and discounts may be due to some other factor(s), for example, high yields or high prices.

To overcome this difficulty, respondents were asked to imagine that the AWB Ltd decided they would abolish protein premiums and discounts and instead they would pay the one price for each segregation, and to imagine that they do not change their planned farm management. The respondent was then asked "Do you think that your typical annual income would greatly increase, slightly increase, remain the same, slightly decrease, greatly decrease or you don't know". In phrasing the question in this way, respondents was being asked to consider a *ceteris paribus* situation and they did not have to remember back more then ten years to their situation before the scheme's introduction. Questions designed to elicit growers' perceptions of the impact of the scheme on Var(I), EU and w-t-p were worded in similar ways.

Table 2 presents a definition of the four dependent variables used in each analysis. Each variable is discrete with five or three possible values.

Table 2 Definition of dependent variables

N^o	Abbreviation	Description
1	EXPI	If protein premiums and discounts were removed,
		1 – E(I) would greatly decrease
		2 – E(I) would slightly decrease
		3 – E(I) would remain the same
		4 – E(I) would slightly increase
		5 – E(I) would greatly increase
2	VARI	If protein premiums and discounts were removed,
		1 – Var(I) would greatly decrease
		2 – Var(I) would slightly decrease
		3 – Var(I) would remain the same
		4 – Var(I) would slightly increase
		5 – Var(I) would greatly increase
3	EXPU	If protein premiums and discounts were removed,
		1 – EU would greatly decrease
		2 – EU would slightly decrease
		3 – EU would remain the same
		4 – EU would slightly increase
		5 – EU would greatly increase
4	WTP	If protein premiums and discounts were removed,
		-1 – if a grower is willing to pay less for a forward contract
		0 – if there is not difference in a grower's willing to pay
		+1 – if a grower is willing to pay more for a forward contract

3.1 The effect of protein premiums and discounts on expected income

Although the theory suggests that at an expected protein level of 10.3%, a grower's E(I) with and without protein premiums and discounts is equal, it is too difficult for a grower to identify impacts with this level of precision. Hence, it is assumed that growers will perceive this level to be at 10% and that at protein levels above 10%, E(I) is increased as they receive a premium, and below this level E(I) is decreased as they receive a discount. Hence the hypothesis for this

analysis states: "Growers with expected protein levels less than (greater than) 10% will perceive their E(I) to have decreased (increased) with the introduction of protein premiums and discounts".

Box 1 presents a print-out of STATA results of an ordered probit regression with dependent variable, EXPI, and independent variable, PROT (a continuous variable described as expected protein level in Table 1). The variable has a p-value less than 0.05 and so it is significant at the 5% level. The relationship between EXPI and PROT is an inverse one i.e. the greater the grower's expected protein level the greater the decrease in E(I) if protein premiums and discounts were removed.

Box 1 STATA results of the ordered probit regression with dependent variable, EXPI, and independent variable, PROT.

```
Ordered Probit Estimates                          Number of obs =     107
                                                  chi2(1)       =   52.11
                                                  Prob > chi2   =   0.000
Log Likelihood = -107.30061                       Pseudo R2     =   0.195


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    EXPI |     Coef.  Std. Err.      z    P>|z|     [95% Conf. nterval]
---------+--------------------------------------------------------------
    PROT |   -1.038      .155    -6.695   0.000        -1.342    -.734
---------+--------------------------------------------------------------
   _cut1 |  -12.611     1.716              (Ancillary parameters)
   _cut2 |  -10.323     1.574
   _cut3 |   -9.386     1.536
   _cut4 |   -8.066     1.496
```

At the bottom of the STATA results presented in Box 1 there are four "cuts". These cuts can be presented as follows:

$$EXPI^* = \beta PROT \qquad\qquad (1)$$

where *EXPI** is unobserved but the following can be observed:

$$
\begin{aligned}
EXPI \quad &= 1 \text{ if } \beta PROT > \text{-}12.611 \\
&= 2 \text{ if } -10.323 < \beta PROT < -12.611 \\
&= 3 \text{ if } -9.386 < \beta PROT < -10.323 \\
&= 4 \text{ if } -8.066 < \beta PROT < -9.386 \\
&= 5 \text{ if } \beta PROT < -8.066 \qquad\qquad (2)
\end{aligned}
$$

Considering the definition of EXPI presented in Table 2, that if EXPI = 3 then E(I) would remain the same if protein premiums and discounts were removed, then the range of $\beta PROT$ where the scheme has no effect on E(I) is between –9.386325 and –10.32261. Dividing these values by β (from Box 1 β = -1.038136) gives the range of expected protein levels, 9.04% and 9.94%. The upper bound (9.94%) is very close to 10%, and although the lower bound seems to be somewhat lower than 10%, considering the standard errors presented in Box 1 for each of these cuts, and accounting for uncertainties associated with eliciting growers' perception rather than actual values, this lower bound is not excessively different from 10%.

These results support the hypothesis that growers with expected protein levels less than (greater than) 10% will perceive their E(I) to have decreased (increased) with the introduction of protein premiums and discounts.

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3.2   The effect of protein premiums and discounts on the variance of income

Fraser (1997) and Petersen and Fraser (2000) suggest that protein premiums and discounts cause Var(I) to decrease. However, this decrease was found to be small and it is hypothesised that growers do not perceive the scheme to have affected Var(I).

During the survey process, it became clear that the concept of income variability was difficult for the survey respondents to understand. Although much thought was given to the drafting and redrafting of the questions associated with Var(I), many growers found the question confusing and some further explanation was often needed, increasing the risk of interviewer error. After consultation with the team of interviewers, it was estimated that only 50% of growers understood the question and were able to accurately indicate their perception of the effect of protein premiums and discounts on Var(I). Hence, to allow for this 50% confusion error, instead of testing the hypothesis that all growers perceive the scheme to have had no affect on Var(I), the hypothesis will be modified to test that only 50% of growers perceive the scheme to have had no affect on Var(I) (this affects p in the hypothesis test below).

A Test for Proportions (described in Hamilton (1990)) will be used to test this hypotheses. Given the definition of VARI presented in Table 2, growers would perceive no change in Var(I) associated with the removal of protein premiums and discounts if VARI = 3.   Therefore, if:

p = the expected probability that protein premiums and discounts have no effect on Var(I); and

$\hat{p}$ = the observed probability that protein premiums and discounts have no effect on Var(I)

then the hypothesis can be written as follows:

H_0: $p = 0.5$

H_1: $p < 0.5$

The Test for Proportions is only valid where $np \geq 10$ and $n(1-p) \geq 10$, where n is the sample size. If these rules are not met, or if the population is less than 10 times as large as the sample, then accurate inference requires more elaborate procedures (Moore and McCabe 1993). For this analysis these rules are met. As the sample is sufficiently large, $\hat{p}$ approximates a normal distribution with mean $\mu_{\hat{p}} = p$ and standard deviation $\sigma_{\hat{p}} = \sqrt{p(1-p)/n}$. $\hat{p}$ is known ($\hat{p} = 0.459$), hence, standardising $\hat{p}$ produces a z statistic as follows (Moore and McCabe 1993):

$$z = \frac{\hat{p} - p}{\sqrt{\dfrac{p(1-p)}{n}}} \tag{3}$$

The z statistic is calculated to be -0.95 which is greater than the critical value (z = -1.64 for a one-tailed test) and has a p-value greater than 0.05 ($Pr(Z \leq -0.95) = 0.17$), hence H_0 should be accepted. This suggests that, allowing for inaccuracies caused by confusion over the survey question, of the estimated proportion of respondents who understood the question, those growers perceive protein premiums and discounts to have had no effect on Var(I).

3.3 The impact of protein premiums and discounts on expected utility

The scheme's impact on a grower's EU is dependent on the scheme's effect on E(I) and Var(I). However, the analysis of the previous section suggests that growers' perceive that protein premiums and discounts have had not effect on Var(I). It is therefore hypothesised that the impact of the scheme on EU depends on E(I) only. Hence, for the model:

$$EU = \alpha + \beta_1 EXPI + \beta_2 VARI + \varepsilon \tag{4}$$

the hypotheses can be written as follows:

H_0: $\beta_1 \neq 0$ and $\beta_2 = 0$

H_1: $\beta_1 = 0$ and/or $\beta_2 \neq 0$, or

     $\beta_1 \neq 0$ and $\beta_2 \neq 0$

An ordered probit regression was applied to these variables and results are presented in Box 2. The variable EXPI is significantly different from zero (p-value < 0.05) and the variable VARI is not significantly different from zero (p-value > 0.05). Hence, H_0 is accepted. Box 3 presents the model with the independent variable EXPI only. The χ^2 statistic is 126.04 and the p-value for the entire model is 0.000 suggesting that the model is highly significant. The pseudo R^2 is 0.3089 suggesting the model has a relatively high goodness-of-fit for a cross-sectional study. It should also be noted that EXPI and EXPU are positively correlated as is expected.

Box 2 STATA results of the estimated ordered probit regression with dependent variable EXPU and independent variables EXPI and VARI.

```
Ordered Probit Estimates                       Number of obs =    132
                                               chi2(2)       = 129.17
                                               Prob > chi2   =  0.000
Log Likelihood = -115.52519                    Pseudo R2     =  0.359


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    EXPU |    Coef.  Std. Err.     z    P>|z|     [95% Conf. Interval]
---------+--------------------------------------------------------------
    EXPI |    1.650      .173    9.562  0.000       1.311    1.988
    VARI |   -.175      .126    -1.388  0.165       -.422     .072
---------+--------------------------------------------------------------
   _cut1 |    1.910      .505            (Ancillary parameters)
   _cut2 |    3.994      .562
   _cut3 |    5.059      .605
   _cut4 |    7.586      .843
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```

Box 3 STATA results of the estimated ordered probit regression with dependent variable EXPU and independent variable EXPI.

```
Ordered Probit Estimates                       Number of obs =    150
                                               chi2(1)       = 126.04
                                               Prob > chi2   =  0.000
Log Likelihood = -140.98517                    Pseudo R2     =  0.309


------------------------------------------------------------------------
    EXPU |    Coef.  Std. Err.     z    P>|z|     [95% Conf. Interval]
---------+--------------------------------------------------------------
    EXPI |    1.468      .149    9.824  0.000       1.175    1.761
---------+--------------------------------------------------------------
   _cut1 |    2.166      .336            (Ancillary parameters)
   _cut2 |    4.141      .410
   _cut3 |    5.054      .459
   _cut4 |    7.163      .664
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```

3.4 The effect of protein premiums and discounts on a grower's willingness-to-pay for a forward contract

Fraser (1997) and Petersen and Fraser (2000) found that protein premiums and discounts do effect a grower's w-t-p for a forward contract, however, this effect was found to be small. Hence, the hypothesis tested in this section is that the introduction of protein premiums and discounts has not resulted in a differences in a grower's w-t-p for a forward contract.

Let p = the expected probability that a grower's w-t-p for a forward contract does not change with the removal of protein premiums and discounts; and

$\hat{p}$ = the observed probability that a grower's w-t-p for a forward contract does not change with the removal of protein premiums and discounts.

If p is set equal to 1 (i.e. all growers will exhibit no change in w-t-p with the removal of the scheme) then the rules concerning the Test for Proportions are violated and accurate statistical inference would require a far more complicated technique. Hence, a 10% margin of error will be tolerated (i.e. the hypothesis will be accepted if 90% of growers exhibit no change in w-t-p with the removal of the scheme). The hypothesis can be written as follows:

H_o: $p = 0.9$

H_1: $p < 0.9$

From the survey results, $\hat{p} = 0.843$. On conducting the Test for Proportions, the $z = -2.34$ and the p-value $= 0.01$. Hence, H_0 should be rejected at the 5% significance level but can be accepted at the 10% significance level. Therefore, it can be stated with a relatively high level of confidence that the introduction of protein premiums and discounts has not resulted in a difference in a grower's w-t-p for a forward contract.

4. Conclusions

Petersen and Fraser (2000) found that, for a grower with an expected protein level less than 10.2%, protein premiums and discounts cause expected income and the variance of income to decrease, and the expected income effect is dominant causing expected utility to decrease. For a small protein window (approximately 10.2% to 10.3%), the scheme causes the expected level and variance of income to decrease but the variance effect is dominant causing expected utility to increase. For expected protein levels greater than approximately 10.3%, expected income increases and the variance of income decreases, both effects positively influencing expected utility.

Petersen and Fraser (2000) also considered the scheme's effect on a grower's willingness-to-pay for a forward contract and found that a grower with an expected protein level less than approximately 10% is willing-to-pay more for a forward contract in the presence of the scheme, and a grower with expected protein more than this amount is willing-to-pay less.

A personal survey of Western Australian wheat growers was conducted to elicit growers' perceptions of the impact of protein premiums and discounts on their income stream, utility and w-t-p for a forward contract. Results confirmed that a grower's perceptions of the impact of protein premiums and discounts on expected income and utility depends on the grower's expected protein level. Growers with expected protein less than 10% preceived their expected income and utility to have decreased and growers with expected protein greater than 10% preceived their expected income and utility to have increased with the introduction of the scheme.

Additionally, growers do not perceive protein premiums and discounts to have affected the varance of income or their w-t-p for a forward contract. These findings are contrary to previous studies of actual rather than perceived effects. However, the perceptions of growers are understandable given that the scheme's effect on the variance of income is small relative to its effect on the level of expected income. Overall, growers with relatively low expected protein levels were perceived to be disadvantaged by the scheme, a finding that is consistent with studies of actual levels.

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