Area response in wheat production:
The Australian wheat-sheep zone

Richard J. Culas

School of Agricultural and Wine Sciences

Charles Sturt University, PO Box 883, Orange NSW 2800, Australia

rculas@csu.edu.au

Contents

Abstract. This paper investigates the key decision parameters of farmers related to the allocation of land between wheat production and pasture for sheep (wool) production. Wheat area supply response, is estimated across the Australian wheat-sheep zone using data for the period 1991 to 2004. Statistical results reveal that wheat growers in Western Australia are more price responsive than growers in the eastern states. Area adjustment is not significantly different between the regions. Rainfall has a positive influence on wheat production while time-related exogenous factors such as technical progress seemed to have little influence on the wheat yield over this period.

Keywords: wheat area supply response, farmer's decision parameters, wheat production, Australian wheat-sheep zone.

Introduction

Within the Australian grain industry, there are three significant outputs, wheat, coarse grains and oilseeds. Wheat is the largest of the three, with production exceeding that of the other two combined. Wheat is grown all over Australia, but the main locations are the wheat belts of Western Australia and New South Wales. Australia's wheat is exported to over 40 different countries and in recent years Australia has been the fourth largest exporter of cereal grains. Due to Australia's relatively small population, the wheat industry has to depend on exports as its major source of income.

About 25 million tonnes of wheat are produced annually in Australia (ABARE 2007) and about five to six million tonnes are used by the domestic market with the rest being exported mainly to the Middle East and South East Asian countries. Grain yields in Australia are subject to variations in rainfall and seasonal conditions. This is demonstrated in production figures that have ranged from 1.14-2.14 tonnes per hectare over the last decade (AWB 2006). Since the deregulation of the wheat industry in Australia, growers have had the choice of selling directly to consumers and domestic traders utilising cash contracts or wheat pools. The Australian wheat industry is expected to become much stronger in the years to come because of new technologies, increases in global population, high quality products and refined markets.

The world wheat market has been affected greatly by drought in some of the world's largest export countries since 2000. This has resulted in the world indicator wheat price rising to the highest price in ten years (ABARE 2007). In the 2006-2007 droughts in Australia, wheat production fell by roughly 61 percent. The droughts were related to El Nino events, bringing about dramatic decreases in rainfall in Australia's wheat lands (BOM 2006). Australia has since returned to more normal seasonal conditions. There is a wide geographical spread of wheat growing areas in Australia, subjecting growers to various climatic conditions and soil types. These features act to reduce the adverse effects of climatic conditions on national production, though there is still some volatility from year to year. Over the last 20 years, Australian wheat production has increased and in recent years, the area harvested for wheat has also increased significantly. This is due largely to growers switching from wool to wheat production following decreases in the price of wool. The successful long-term future of the Australian wheat industry will be subject to many challenges, including resource sustainability, infrastructure development, climate change, international price distortions and disease risks. Nevertheless it has previously been able to overcome these kinds of challenges.

The development of the Australian wheat industry in the last few years has seen a change in management practices and in the balance between stock and cropping enterprises. Over the coming years, climate will be a major consideration for growers and their intended plantings. Rising fuel and fertiliser cost will influence growers' intensions about area sown. Industry research will keep developing and producing

salt, disease and drought-tolerant wheat varieties. Growers will become accountable for their farming practices as industry and environmentalists' persist with them to adopt better farm practices.

Economists have employed econometric models to analyse the pattern of response of farmers to various factors thought to drive production decision making. Some early estimates of agricultural supply elasticities for the Australian economy are found in Adams (1988). Sanderson et al. (1980) have in particular cited studies with respect to area responses of Australian wheat growers. A more recent study by Rambaldi and Simmons (2000) modelled the Australian wheat growers' supply responses (area planted) under the constraints of price and yield uncertainty and found that risk arising from prices and climate have had a significant influence on producer decision making.

Although estimates from analyses of those previous studies provide useful information on how area responses are influenced by (or related to) key economic and climatic parameters of farmers, further studies could help farmers to improve their decision making under varying agro-ecological regions of the Australian wheat-sheep zone. Therefore the objective of this paper is to investigate the key decision parameters of farmers related to the allocation of land between wheat production and pasture for sheep (wool) production. Wheat area supply response, as well as wheat production response, is estimated across the Australian wheat-sheep zone for the period between 1991 and 2004.

Area response function and empirical models

A general functional form for area response takes the form

$$Y_t^* = c + d X_t + e Z_t + v_t \qquad (1)$$

where

Y_t^* is desired area for the proportion of land a_t^* allocated to enterprise A,
X_t is expected relative value of economic decision variable (net returns) from enterprises A and B,
Z_t is a set of time related exogenous factors, and v_t is an error term with classical properties.

To allow for the possibility of adjustment lags, a *Nerlovian partial adjustment model* is specified

$$Y_t - Y_{t-1} = \gamma (Y_t^* - Y_{t-1}),\ 0 \leq \gamma \geq 1, \qquad (2)$$

where γ is the coefficient of adjustment.
Substituting and readjusting gives the model

$$Y_t = c\gamma + d\gamma X_t + e\gamma Z_t + (1-\gamma) Y_{t-1} + \gamma v_t$$

$$= \beta_0 + \beta_1 X_t + \beta_4 Z_t + \beta_5 Y_{t-1} + u_t \qquad (3)$$

Thus, in (3) testing the null hypothesis that $\beta_5 = 0$, which means $\gamma = 1.0$, can be used to assess a significant adjustment lag.

The variable X_t can be disaggregated into two components N_t and M_t, where N_t measures relative returns between enterprises and M_t measures agronomic influences such as the benefits of crop rotations or offsetting over time achieved by having perennial pastures and trees in the farming system.

The variable N_t can be measured as the relative gross returns for the enterprises A and B

$$N_t = (P_t^A * Q_t^A - \Sigma\varnothing_{nt}^A * C_{nt}) / (P_t^B * Q_t^B - \Sigma\varnothing_{nt}^B * C_{nt} \qquad ……..(4)$$

where

Q_t^A and Q_t^B are respectively the expected yields for enterprise A and enterprise B,
P_t^A and P_t^B are respectively the expected prices of Q_t^A and Q_t^B,
C is the cost of input n in period t, and
$\varnothing_{nt}^A$ and $\varnothing_{nt}^B$ are respectively the coefficients denote the use of input n for Q_t^A and Q_t^B.

Alternatively this economic decision variable can be measured in terms of relative prices for the enterprise A and the enterprise B as P_t^A / P_t^B. However as the producers extract information from the observed prices in forming price expectations, *the naive model*, $P_t = P_{t-1}$, is considered

$$N_t = P_{t-1}^A / P_{t-1}^B \qquad (5)$$

The second expected economic decision variable M_t is related to agronomic influences and cannot easily be measured in practice, a proxy for land quality or structural changes in the farming system could be employed. In an empirical setting, the effect of M_t on Y_t can be assumed through regional differences in land quality (soil fertility) and addressed by use of a dummy variable, D, for regional differences.

Further the effect of Z_t on Y_t can be assumed by employing a trend variable (time trend) as a proxy for the Z_t in the empirical models.

The conceptual model is defined in equation 6.

$$Y_t = \beta_0 + \beta_2 N_t + \beta_3 M_t + \beta_5 Y_{t-1} + \beta_9 T u_t \qquad (6)$$

Empirical models

Given the above characters of wheat production, an area response function for wheat can be expressed by the empirical model in equation 7 (*Model 1*).

$$Y_t = \beta_0 + \beta_6 D + \beta_2 N_t + \beta_7 N_t D + \beta_5 Y_{t-1} + \beta_8 Y_{t-1}D + \beta_9 T + u_t \qquad (7)$$

where

Y_t is area of wheat grown,

D is a dummy (1 for Western Australia; 0 for South Eastern region of Australia),

N_t is expected relative price between wheat and wool,

Y_{t-1} is lag variable of the wheat area grown,

T is time-trend, and

u_t is an error term with classical properties.

From *Model 1*, the estimated coefficients β_2, β_7, β_5 and β_8 can be interpreted, both statistically and economically, as the farmers' decision parameters for the area responses to wheat.

Further to the area response function, a physical relationship between wheat production and the area of wheat grown is specified by a cubic equation (Griffin et al. 1987), where average rainfall percentiles (for the period from March to October during which wheat is grown) are included as *Model 2* (see equation 8).

$$Q_t = \eta_0 + \eta_1 D + \eta_2 Y_t + \eta_3 Y_t^2 + \eta_4 Y_t^3 + \eta_5 P_t + \eta_6 T + w_t \qquad (8)$$

where

Q_t is wheat production,

P_t is average rainfall percentiles, and

w_t is an error term with the classical properties.

Data and sources

The sample for the current study consists of Grain Research and Development Corporation (GRDC) South Eastern region of Australia and the Western Australia for the period 1991-2004. The two regions are distinguished with respect to their agro-ecological characters as listed in Figures 1 and 2.

The South Eastern data consist of 96 observations from the areas of the Central West, Riverina, Mallee, Wimmera, North Pastoral, Eyre Peninsula, and Murraylands and York Peninsula. The Western Australia data consist of 28 observations from areas of Central and South Wheat Belt, and North and East Wheat Belt (ABARE 1999). A detail of data for the areas covered in the sample with the respective years is given in Table 1.

The data for wheat area, wheat production, price of wheat and price of wool were obtained from the ABARE data base, *AGsurf*, where the price of wheat ($/t) was estimated from the gross receipts for wheat sold during the year and the price of wool (c/kg) was estimated from the gross receipts for total wool sold during the year (ABARE 2006). Data on average rainfall percentiles (mm) during the period from March to October were obtained from the Bureau of Meteorology (BOM 2006).

Results and discussion

Regression results for the *Model 1* (area response) are presented in Table 2. The model was estimated by ordinary least squares (OLS) method. The regression results were also checked and corrected for the first-order autocorrelation following Greene (1993). The results indicate that Regression 4 is the best fit of the data.

The model results in Regression 4 indicate that the expected relative price is statistically significant and positive for both regions. Its effect is, however, stronger for Western Australia than the South Eastern region, which indicates that wheat growers in Western Australia are more (nearly five times) price responsive than growers in the South Eastern region of Australia. This result is related to the specific characters of Western Australia, such as export market dominance, smaller domestic market, grain storage practices and the transport advantage to South East Asian countries. Further the coefficient for the lagged wheat area is close to one, which indicates that the current wheat area is highly dependent on the previous year's wheat area, and also there is no difference between the regions with respect to this area adjustment.

Regression results for the *Model 2* (production function) are presented in Table 3. The model was also estimated by OLS. The regression results were also checked and corrected for the first-order autocorrelation following Greene (1993). The results indicate that Regression 4 is the best fit of the data.

The results suggest that the Western Australia is in general far more productive in wheat than the South Eastern region. Further, an input-output relationship between the land and wheat yield is statistically significant and exhibits linearity which is in line with findings for the other Australian grain industries (ABARE 1999). Furthermore rainfall is statistically significant implying that rainfall, as expected, in general contributes to the yield of wheat. However time related exogenous factors such as technological progress show no significant impact on wheat production as this variable becomes statistically insignificant for the Regression 1 and Regression 3, and is omitted from equation 4.

Conclusions

Statistical results on area responses of wheat growers across the Australian wheat-sheep zone reveal that there are differences between the South Eastern region and Western Australia with respect to relative prices for wheat and wool. The results suggest that wheat growers in Western Australia are more price responsive than growers in the South Eastern region. There is no evidence of a difference between the regions with respect to the area adjustment in current year compared with the previous year.

Although economic conditions which have favoured wheat have prevailed for more than a decade, farmers have rarely switched *completely* out of livestock production. Historically the enterprise diversity within the wheat-sheep zone has also been for farmers to grow a variety of crop species and to vary their sheep flocks or cattle numbers (Ewing et al. 2004).

Recent economic conditions driven by the demand for meat and rising costs of cropping have tended to favour livestock production than cropping. A shift in a farm's enterprise mix ultimately depend on the differences in profit due to the adjustment costs and the investment decisions related to farm infrastructure (Ewing et al. 2004). Further research should be directed towards these issues.

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Appendix

Table 1. Detail of data for the areas covered with the respective years	
South Eastern region of Australia	Western Australia
Central West (1991-2004)	Central and South Wheat Belt (1991- 2004)
Riverina (1991-2004)	North and East Wheat Belt (1991-2004)
Mallee (1991-2004)	
Wimmera (1991-2004)	
North Pastoral (1991-2002)	
Eyre Peninsula (1991-2004)	
Murraylands and York Peninsula (1991-2004)	

Table 2. Results of the area response model (standard errors are in parenthesis)				
Dependent variable: Y_t (wheat area in ha)				
Explanatory variable	Regression 1	Regression 2	Regression 3	Regression 4
Constant term (South Eastern region of Australia)	-23.936 (12.958) *	-27.797 (12.49) **	-22.064 (12.557)**	-26.320 (11.888)**
D (dummy for Western Australia)	-140.489 (41.659) ***	-133.94 (41.245)***	-143.785 (41.476)***	-136.367 (40.866)***
N_t (expected relative price)	59.529 (19.674) ***	56.994 (19.558)***	63.371 (18.218)***	59.912 (17.924)***
$N_t * D$	285.636 (79.333) ***	309.263 (76.904)***	293.028 (78.631)***	313.407 (76.388)***
Y_{t-1} (lagged wheat area)	0.965 (0.037) ***	0.998 (0.022)***	0.968 (0.037)***	0.999 (0.022)***
$Y_{t-1} * D$	0.050 (0.046)		0.048 (0.046)	
T (time trend 1991-2004)	0.641 (1.238)	0.462 (1.238)		
ρ (autocorrelation coefficient)	-0.014 (0.090)	-0.007 (0.090)	-0.002 (0.090)	0.001 (0.090)
degrees of freedom	117	118	118	119
Adjusted-R^2	0.976	0.976	0.977	0.976
***significant at one percent **significant at five percent *significant at ten percent				

Table 3. Results for the production function (standard errors are in parenthesis)				
Dependent variable: Q_t (wheat production in tonnes)				
Explanatory variable	Regression 1	Regression 2	Regression 3	Regression 4
Constant term (South Eastern region of Australia)	-11.439 (64.115)	9.889 (58.047)	-23.888 (53.426)	13.459 (47.430)
D (dummy for Western Australia)	105.036 (50.107) **	104.574 (49.240) **	93.404 (48.774) *	79.988 (48.238) *
Y_t (wheat area in ha)	1.369 (0.341) ***	1.076 (0.169) ***	1.303 (0.066) ***	1.331 (0.064) ***
Y_t^2 (wheat area squared)	-0.403 X 10^{-3} (0.581 X 10^{-3})	0.173 X 10^{-3} (0.119 X 10^{-3})		
Y_t^3 (wheat area cubic)	0.289 X 10^{-6} (0.280 X 10^{-6})			
P_t (average rainfall in mm)	1.929 (1.121) *	2.015 (1.107) *	2.057 (1.110) *	1.990 (1.116) *
T (time trend 1991-2004)	5.140 (4.012)	6.184 (3.796)	5.549 (3.783)	
ρ (autocorrelation coefficient)	-0.239 (0.087) ***	-0.260 (0.087) ***	-0.262 (0.087) ***	-0.260 (0.087) ***
degrees of freedom	117	118	119	120
Adjusted-R^2	0.847	0.841	0.838	0.836
***significant at one percent **significant at five percent *significant at ten percent				

Figure 1. South Eastern region of Australia

- Temperate climate
- Relatively infertile soils
- Yield depends upon reliable spring rainfall
- Smaller enterprise size
- Diverse production patterns and opportunities
- Large and diverse domestic market
- Phase farming innovator
- Shift in intensive livestock production and demand for feed grains to this region

Figure 2. Western Australia

- Mediterranean climate
- Low soil fertility
- Yield depends upon good winter rains as spring rainfall is generally unreliable
- Large enterprise size
- Narrower range of crop options
- Export market dominant, domestic market smaller
- Leader in grain storage practice; and transport advantage to SE Asia

Source: http://www.grdc.com.au/about/reg_panel.htm