Determinants of land use in wheat production: The Australian wheat-sheep zone

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Content/presentaion:

1. Australian wheat and sheep/wool industries
2. Economics of land allocation between enterprises (theoretical and empirical models)
3. Data and sources
4. Results (wheat area response; wheat production; wheat productivity; and elasticity estimates)
5. Scope for further analysis (econometric issues - larger sample size; relevance of the results - recent data; relative prices - costs aspects).

1. Australian wheat and wool industries

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- Wheat is produced mainly in the wheat belts of WA and NSW (wheat-sheep zone); important to the Australian grain industry and economy (export).

- Wheat area sown and production have increased over time (although fluctuations in the area sown).

- Wheat productivity (on average) remained unchanged, therefore increase in production is due to increase in the area sown (1990-2012, ABARES).

- Sheep number decreased over the years and total wool production subsequently reduced

- Average wool prices remained unchanged (although some variations over the years)

- Relative prices (wheat price/wool price) is a concern for land allocation for wheat production (including other factors: rainfall and technology)

2. Land allocation between enterprises

The expected farm returns *E(Π)*

$$E(\Pi) = E[\alpha\, a + (1- \alpha)\, b + f\,(\alpha)] \qquad (1)$$

where

***a* = uncertain net return from enterprise A,**

***b* = certain net return from enterprise B and *E(a)* > *b*,**

***α* = proportion of farmland allocated to enterprise A, and**

***f (α)* = incremental net return for enterprise A by interaction with enterprise B.**

The farmer's decision is a choice of α to maximize the expected profit.

The first-order condition for the optimal level of α is

$$Max\ E(\Pi):\ a - b + f'(\alpha) = 0 \qquad (2)$$

where $f'(\alpha) < 0$ and $a - b = - f'(\alpha)$.

From the first-order condition, the optimal level of α can be expressed as a function of net returns for the enterprises A and B

$$\alpha^* = f\,[\,a + f'(\alpha),\ b] \qquad (3)$$

For this functional relationship (3) an optimal level of land allocated to enterprise A can be studied as an area response function .

$$Y_t^* = c + d\,X_t + e\,Z_t + v_t \qquad (4)$$

where

Y_t^* is desired area for the proportion of land α^* 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 for the classical properties.

For enterprise A the producers can adjust their desired area each year; allowed for the adjustment lags;

Nerlovian partial adjustment model is specified:

$$Y_t - Y_{t-1} = \gamma (Y_t^* - Y_{t-1}),\ 0 \leq \gamma \geq 1, \qquad (5)$$

where γ is the coefficient of adjustment.

The partial adjustment model (5) is a dynamic model;

The model implies that the change in actual area is proportional to the difference between the desired and the actual area.

Empirical models

$$Y_t = \beta_0 + \beta_6 D + \beta_2 N_t + \beta_7 N_t D + \beta_5 Y_{i\,t-1} + \beta_8 Y_{i\,t-1} D + \beta_9 T + u_t \qquad (11)$$

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.**

$$Q_t = \lambda_0 + \lambda_1 D + \lambda_2 Y_t + \lambda_3 Y_t^2 + \lambda_4 Y_t^3 + \lambda_5 F_t + \lambda_6 T + w_t \qquad (12)$$

where

Q_t is wheat production,

F_t is average rainfall percentiles, and

w_t is an error term with the classical properties.

$$A_{it} = \mu_0 + \mu_i + \mu_t + \beta Y_{it} + \varepsilon_{it} \quad (15)$$

where

A_{it} is wheat productivity (t/ha),

μ_i is group effect,

μ_t is period effect, and

ε_{it} is error term with classical properties.

(the panel data model includes an overall constant, a group effect for each group and a time effect for each period).

3. Data and sources

Eastern states (103 observations):

Central West (1990-2004), Riverina (1990-2004), Mallee (1990-2004), Wimmera (1990-2004), North pastoral (1990-2002), Eyre Peninsula (1990-2004), and Murrylands and York Peninsula (1990-2004).

Western Australia (30 observations):

Central and South Wheat Belt (1990-2004) and North and East Wheal Belt (1990-2004).

- Data for wheat area grown (hectare), wheat production (tonne), price of wheat ($/tonne) and price of wool (cents/kg) were obtained from ABARE *AgSurf* data base (ABARE 2006).

- The price of wheat was estimated from the gross receipts for wheat sold during the year and the price of wool was estimated from the gross receipts for total wool sold during the year.

- Data on average rainfall percentiles (mm) for the period from March to October were obtained from the Australian Government Bureau of Meteorology (BOM 2006).

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Table 3. Estimates for the area response model (*Model 1*)

(Standard errors are in parenthesis)

Dependent variable: Y_t (wheat area in ha)				
Explanatory variables	*Model 1(a)*	*Model 1(b)*	*Model 1(c)*	*Model 1(d)*
Constant term (eastern states)	-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				

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Table 4. Estimates for the production function (*Model 2*)

(Standard errors are in parenthesis)

Dependent variable: Q_t (wheat production in tonnes)				
Explanatory variables	*Model 2(a)*	*Model 2(b)*	*Model 2(c)*	*Model 2(d)*
Constant term (eastern states)	-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)	-0.403×10^{-3} (0.581×10^{-3})	0.173×10^{-3} (0.119×10^{-3})		
Y_t^3 (wheat area cubic)	0.289×10^{-6} (0.280×10^{-6})			
F_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				

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Table 5. Estimates for the wheat productivity (*Model 3*) ©			
Dependent variable: A_{it} (wheat productivity in t/ha)			
Constant term		1.7430 (0.2330)***	
Y_{it} (wheat area in ha)		0.0004 (0.0007)	
μ_i (group effects)		μ_t (period effects)	
NSW Central West	0.1950 (0.1692)	1991	-0.1745 (0.1506)
NSW Riverina	0.8029 (0.1929)	1992	-0.0929 (0.1571)
VIC Mallee	-0.0865 (0.1174)	1993	0.3015 (0.1482)
VIC Wimmera	0.6204 (0.1942)	1994	0.4360 (0.1491)
SA North Pastoral	-0.6811 (0.1572)	1995	-0.8420 (0.1475)
SA Eyre Peninsula	-0.4975 (0.1545)	1996	0.2114 (0.1448)
SA Murray Land and York Peninsula	0.2548 (0.1547)	1997	0.3070 (0.1436)
WA Central and South Wheat Belt	-0.0360 (0.1176)	1998	-0.1057 (0.1431)
WA North and East Wheat Belt	-0.6692 (0.5404)	1999	0.0889 (0.1431)
© Standard errors are in parenthesis		2000	0.0237 (0.1455)
***significant at one percent		2001	0.2046 (0.1520)
Adjusted-R^2 = 0.6439		2002	0.4833 (0.1482)
Degrees of freedom = 101		2003	-1.0951 (0.1669)
Model test: F (22, 101) (prob) = 11.11 (0.0000).		2004	0.1487 (0.1893)

Table 6. Estimated own-price and cross-price elasticity for the regions			
	Western Australia	Eastern states	Wheat-sheep zone (Western Australia and eastern states combined)
Wheat-wheat	0.499	0.716	0.445
Wheat-wool	-0.285	-0.489	-0.241

4. Results/key points

- Wheat growers in the WA are more (relative expected) price responsive than the growers in the eastern states.

- Current wheat area is highly depended on the previous year's wheat area and the area adjustment is also not significantly different between the regions.

- Wheat yield is positively influenced by the area sown.

- Wheat own-price and the cross-price elasticities are with the expected signs and all less than unity, though the cross-price elasticities are more inelastic.

- Rainfall also has positive influence on the wheat yield but the time-related exogenous factors had only minor influence on the yield.

- The insignificant effect of wheat area (land size) on the productivity can be due to *the remoteness (distance)* of the wheat growing areas and *the lack of technological progress* in the wheat-sheep zone.

5. Scope for further analysis:

- Dominance of lag dependent variable on the regression results (other econometric methods and larger sample size required).

- Relevance of the results (recent data would appropriate to analyse since there have been reasonable changes in the grain industries).

- Relative prices matter (but costs aspects are important to consider in decision making).