Impact of Graze-Out in Hard Red Winter Wheat Production

Diwash Neupane And Charles B Moss, University of Florida

Abstract

We investigate the relationship between wheat graze-out and cattle-wheat price ratio and moisture level and examine the impact of graze-out on wheat yield in major wheat-producing states in US. Results indicate that cattle-wheat price ratio and moisture level affect farmers' graze out decision and graze-out have significant impact on wheat yield.

Introduction

Several studies on crop yield and distribution have been published in agronomic and agricultural economics journals. Particularly in agricultural economics literature, normality of crop yield has been highly argued. Most of the researchers disapprove the normal distribution of crop yield and concluded that yield is skewed positively or negatively (Day, 1965; Gallagher, 1987; Moss and Shonkwiler, 1993). However, Just and Weninger (1999) disagreed with the non-normality of crop yield distribution in their analysis and argued against evidence that rejects the normality of crop yield distribution. At the same time, Ramirez (1997) found that corn and soybean are negatively skewed, while wheat yield is normally distributed.

Crop yield distribution is an important consideration, especially while calculating insurance premiums. Goodwin and Ker (1998) addressed the importance of proper yield distribution in order to accurately measure yield risk and insurance premium rates. Similarly, Skees et. al. (1997) stated the importance of central tendency and deviation in yield outcome for area yield insurance such as Group Risk Plan (GRP). Variation in crop yield characterizes normality and non-normality of the yield distribution. Many factors, such as technological advancement (including high chemical usage, improved cultivation practices and better cultivars) and climatic conditions can influence crop yield distribution. Gallagher (1987) provided evidence of skewedness as a result of frequent lower yield in US soybeans. Gallagher discussed possible yield variation as influenced by weather variables. Babcock and Hennessy (1996) estimated the marginal effect of nitrogen on corn yield distribution and found that certain levels of nitrogen application can influence crop yield distribution.

Wheat graze out, where producers let their cattle graze their wheat acreages rather then harvesting grains, might have an impact on wheat crop yield and distribution. Very few economic analyses related to wheat graze out exist in the literature and are mostly limited to enterprise budgeting for different wheat production strategies (Holt and Anderson, 1978; Russel and Dickey, 1983; Doye and Coe, 2002). This analysis uses Hard Red Winter (HRW) wheat acreage, yield, prices and fertilizer use data from USDA/NASS/ERS to evaluate the relationship between graze out and wheat yield. Additionally, to understand why farmers opt to graze out wheat, this study evaluates the relationship between graze out and cattle-wheat price ratio and moisture level.

Results from this analysis have significant economic and policy implications, particularly for area yield insurance coverage, such as GRP and government payment programs. Significant graze out impact suggests reconsideration in wheat yield forecasting or central tendency estimation with inclusion of graze out in the wheat-forecasting model. Government payment programs, such as Graze Out Payment, estimate crop yield based upon Direct and Counter Cyclical Program (DCP) yield (FSA/USDA, 2011). However, in the absence of such yield, farmers' report actual harvested yield from an adjacent field or surrounding areas. Due to the effect of graze out farmers may report higher yield, which results in higher payments for farmers and higher cost for governments. Insurance such as Actual Production History (APH) is based upon average historical crop yield for each individual farmer. Graze out can change the average APH yield by impacting central tendency of yield, which in turn can falsely change the actual coverage for the individual farmers.

Data and Methodology

We will estimate two different models in this analysis. First, we will estimate graze out. We define graze out as proportion of non-harvested cattle fed acres. Let, HA_i be the grain harvested wheat acres in state i (i=1,2,..,8) and PA_i be the planted acres in corresponding state. Then, graze out can be defined and formulated as,

$$Graze\ out = \frac{PA_i - HA_i}{PA_i}$$

By formulation, graze out is proportional with $0 \leq \text{graze out} \leq 1$. Farmer's decision on wheat graze out depends upon numbers of agronomic and economic factors. Doye and Coe (2002) stated that wheat and stockers prices are the key determinant in farmers graze out decision. Other factors, such as drought during the growing period, can be equally important for farmers' graze out decision. Hence, we represent the graze out function as,

$$g = f(z)$$

where, g is the graze out proportion for states and is calculated from the survey data; z represents number of state level variables as discussed earlier and other dummy variables, including state dummies, which influence the farmers' graze out decision.

Given the proportional nature of the dependent variable, graze out can be estimated using linear probability model as suggested by the Zellner and Lee (1965). However, due to the fact that graze out is positively skewed (Fig 1, left), we use the natural logarithm of the graze out proportion to normalize the distribution (Fig 1, right).

We estimated the following empirical model to define the relationship between the graze out and independent variables of interest,

$$\ln g_{it} = \beta_0 + \gamma_i \sum_{i=1}^{8} States_t + \beta_1 \ln cwp_{it} + \beta_2 pdsi1_{it} + \beta_3 dum + \varepsilon_{it}$$

where, $\ln cwp$ is the log of the cattle and wheat price ratio, pdsi1 is the palmer drought severity index for the period August-January, dum is the year dummy variable for graze out program(direct payment program) before and after 1995, state is state dummy variable for each state, $\beta's, \gamma$ are the parameters to be estimated and ε_{it} is the disturbance term.

Second, we represent wheat yield as,

$$y = g(x)$$

where, y_{it} is the state level observed wheat yield, and x s' are independent variable of interest, which influences wheat yield. g defines relationship between independent variables and yield.

We estimate the wheat yield using the following linear relationship.

$$\ln y_{it} = \alpha_1 + \delta_i \sum_{i=1}^{8} State_t + \alpha_2 t + \alpha_3 t^2 + \alpha_4 \ln n_{it} + \alpha_5 \hat{g}_{it} + \alpha_6 pdsi2_{it} + \mu_{it}$$

where, t represents time trend with 1964 as a base year(1), which captures technological advancement in wheat production, t^2 is a second order polynomial in time, n denotes state level per acre nitrogen application, $\hat{g}_{it}$ is the predicted graze out from the previous regression, $pdsi2$ represents the Palmer Drought Severity Index for wheat growing period after the graze out decision is made, state is a dummy variable for each state, $\alpha's, \mu$ are the parameters to be estimated and μ_{it} is yield disturbance. All the variables used in the estimation techniques are directly related to the agricultural policy in the sense that they influence the crop yield. As discussed earlier, fertilizers and weather variables were shown by the earlier studies to impact crop yield and the distribution, while the impact of graze out in the crop yield has not been studied and is lacking in the literature of agricultural economics.

We estimated the above yield specification using the standard Ordinary Least Squares (OLS) technique. Maximum Likelihood Estimation (MLE) estimation with nonlinear maximizing procedure was also used to analyze the impact of variable of interest on the wheat yield. While estimating given empirical models, we mostly focus on making predictions as correct as possible.

Data

This study uses survey data provided by USDA/NASS/ERS. USDA/NASS provides state level data for the major HRW wheat producing states (Colorado, Kansas, Montana, Nebraska, North Dakota, Oklahoma, South Dakota and Texas). Data include information on planted acreages, harvested acreages, per acre wheat yield, HRW wheat price and livestock (steer cattle of 500 lbs.) price. Nitrogen use is taken from the USDA/ERS's fertilizer use data. We use data for the period 1965 through 2009. However, some years with missing information on key variables were dropped from the analysis.

Palmer Drought Severity Index (PDSI) is taken from the National Climatic Data Center/NOAA. PDSI is used to make an inference on the impact of moisture on the crop yield. PDSI1 and PDSI2 are computed in accordance to timing of graze out decision. PDSI1 is the average Palmer Drought Severity Index in each state for the months of August through January. PDSI12 is the average drought index for the months of February through June. Graze out decision is made sometime around February. The range for the PDSI index is ± 7, where -4 and below is extremely drought conditions, whereas +4 and above is extremely moist conditions. Similarly, 0 refers to a normal condition.

We use state dummy variables to capture state level characteristics. Due to the unavailability of graze out payment data, we use a payment dummy variable to see if the government payment has any impact on farmers' graze out decision. Each state has 38 years of observations. Table 1 provides variables description and summary statistics.

Results and Discussion

Estimation from the graze out and the wheat yield model are presented in Table 2 and Table 3 respectively. In both tables, second column represents parameter estimates, while third, fourth and fifth columns represent standard error, t-values and p-values respectively.

Determinants of Graze Out

In the graze out estimation, both of the primary variables, the log of cattle wheat price ratio and the drought index are significant at 5% and 1% respectively. Coefficient of the price ratio is positive which tells us that increment in the price spread will increase the graze out proportion. The result suggests that a 10% increment in cattle and wheat price ratio will increases the graze out by almost 3.5%. This result makes sense since higher price spread implies cattle price gain over wheat price. Therefore, farmers are more likely to feed their cattle rather than harvest grains. Albeit small, coefficient for the PDSI1 is significant and negative, suggesting that an increment in moisture level tends to influence graze out negatively. Since higher moisture level means more favorable condition for plants growth, farmers expect better yield, and are more reluctant to graze out. Payment dummy, although positive, is non significant in the estimation. Coefficients for the state level dummy variables capture state specific factors that were not included in the model. Compared to the base state of Colorado, Kansas, Montana and Nebraska are negatively and significantly correlated to the graze out, whereas Oklahoma and Texas has significantly positive correlation to the graze out. Significant coefficient of state dummy reflects some of the important factors not included in the model but can possibly affect the overall estimation. The Bruesh Pagan test for heteroskedasticity was non significant. Similarly, Jarque Bera test for the normality suggests that the random errors are normally distributed.

One potential problem while estimating proportional dependent variable is the predicting power of the model, where predicted values of proportion may be out of the range of 0 and 1 (Papke and Wooldridge, 1996). Since, the predicted values from the estimation are in the range of 0-1, the model seems to be a good fit. Furthermore, this model is also able to explain almost 49 percent of variability in the graze out.

Determinants of Crop Yield

Coefficients for most of the variables of interest are positive and highly significant in the wheat yield regression. Coefficient for the time trend t, suggests positive increment in the wheat yield. Coefficient for the drought index or PDSI2 suggests that a unit increment in the moisture level tends to increase the yield by 7 percent. Coefficient for the graze out is positive and a 10 percent increment in the graze out increases the yield by almost 3 percent. This is a small, but significant result. To explain the positive impact of the graze out on the yield, lets assume that a farmer's total planted acres can be divided into two groups, one with a good crop standing acres and another, a marginal or poor yielding acres. As a rational farmer, he tends to graze out marginal acres and harvest grains from the good standing acres. Acres with possibly lower yield are grazed which will result in increment in the average yield for that particular farmer. However, coefficient for nitrogen is non-significant and is not included in the result.

Finally, to capture the effect of state specific factors, that are not included in the model, we included state dummy variables in the model. Kansas, Montana, Nebraska are positively and significantly correlated with the yield, whereas Oklahoma and Texas is negatively correlated with the wheat yield. Although the model explains almost 54 percent of the variability in the yield, significant state dummy reveals that the model is missing some important variables, which can significantly influence the wheat yield. Estimation from the MLE was almost similar to that of the OLS. Therefore, only OLS estimation results are reported in the table.

Conclusion

Using state level data for major wheat producing states, this study first investigates the farmer's decision to graze out and then evaluates the impact of graze out on the wheat yield. Finding from this study suggests that the cattle/wheat price spread and the drought condition affect farmer's graze out decision. Further estimation shows that the graze out increases the total wheat yield.

As stated earlier, findings from this study can be important for wheat producers, the government and the private crop insurance providers. Since graze out has a significant effect on the crop yield, incorporating the impact of the graze out can considerably change premium for policies, such as Group Risk Plan, that depend upon the level of the crop yield. Furthermore, such effect can also impact government payments and subsidies policies that are based on average crop yield information.

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Table1: Variable description and summary statistics (pooled along 8 states)

Variable	Mean	Std. Dev.	Min	Max
State Level Variables				
Yield Bu/acre, y	30.83	7.03	13.00	49.00
Nitrogen lb/acre, n	49.01	20.37	6.00	112.00
Wheat price each marketing year average	2.88	1.01	1.09	5.27
500 lbs steer cattle price each marketing year average	54.46	20.36	17.47	107.03
Cattle Wheat Price ratio, cwp	19.51	5.39	8.36	35.09
pdsi1, drought index (Aug-Jan)	0.89	1.97	-4.79	6.76
pdsi2, drought index (Feb-Jun)	0.74	1.97	-3.67	6.20
Graze out Proportion	0.18	0.14	0.02	0.75
Production Bu. In log	17.88	1.37	13.30	20.03
Dummy for Government Payments (=1 if year >1995)	0.21	0.41	0.00	1.00
State Dummy Variable (Excluding Colorado)				
Kansas	0.13	0.33	0.00	1.00
Montana	0.13	0.33	0.00	1.00
Nebraska	0.13	0.33	0.00	1.00
North Dakota	0.13	0.33	0.00	1.00
Oklahoma	0.13	0.33	0.00	1.00
South Dakota	0.13	0.33	0.00	1.00
Texas	0.13	0.33	0.00	1.00

Source: NASS, Economic Research Service, US Department of Agriculture, 1965-2009

Table 2: Results from Graze Out Estimation

log graze	Estimates	Std. Err.	t	P>|t|
Constant	-2.974	0.359	-8.290	0.000
State Level Variables				
log cwp	0.340	0.116	2.930	0.004
pdsii	-0.103	0.017	-6.050	0.000
dum	0.032	0.083	0.380	0.704
State Dummy Variables				
Kansas	-0.392	0.130	-3.010	0.003
Montana	-0.446	0.131	-3.400	0.001
Nebraska	-0.430	0.130	-3.300	0.001
Oklahoma	0.533	0.131	4.080	0.000
Texas	1.014	0.131	7.750	0.000
R-squared	0.4863			

Table 3: Results from wheat yield regression

log yield	Estimates	Std. Err.	t	P>|t|
costant	3.581	0.172	20.760	0.000
t	0.0097	0.0030	3.2600	0.0010
tsq	-0.0001	0.0001	-0.9100	0.3610
State Level Variables				
pdsi2	0.0717	0.0068	10.5000	0.0000
ghat	0.3156	0.0586	5.3900	0.0000
State Dummy Variables				
Kansas	0.2780	0.0413	6.7400	0.0000
Montana	0.2624	0.0450	5.8300	0.0000
Nebraska	0.3549	0.0430	8.2600	0.0000
Oklahoma	-0.1900	0.0405	-4.7000	0.0000
Texas	-0.3815	0.0631	-6.0500	0.0000
	R-squared 0.5436			

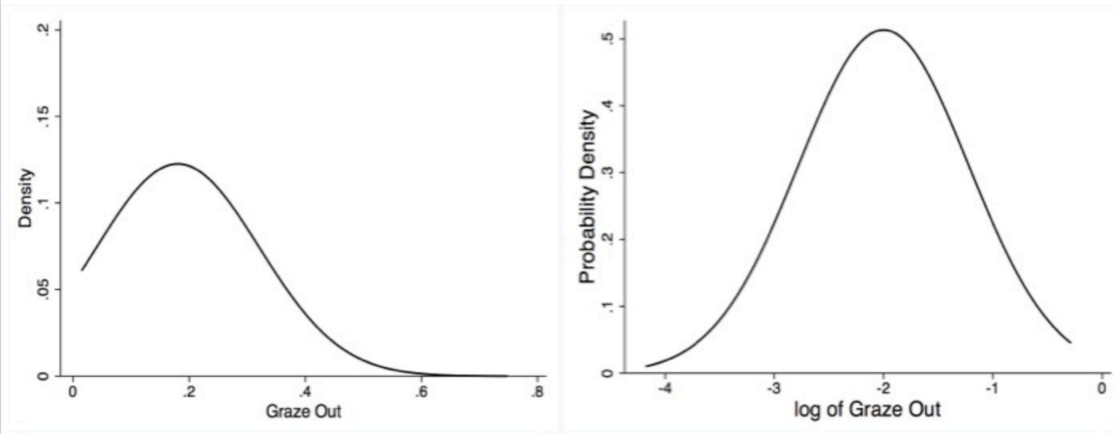

Fig 1: Graze out distribution