DECLINING COMMODITY PROGRAM PAYMENTS AND ENHANCED ENVIRONMENTAL REGULATIONS: IMPACTS ON ACREAGE ALLOCATION IN THE GREAT PLAINS

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and

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Abstract

Seemingly Unrelated Regression is used to quantify the impacts of decreasing commodity program payments and enhanced environmental regulations on acreage allocations for the five major crops in 105 Kansas counties, from 1970 to 1995. Price and policy elasticities are calculated and policy simulations are conducted for commodity and environmental policies.

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The 1996 farm legislation resulted in a major overhaul of agricultural commodity programs, originally enacted in 1933. Subsidies to producers of program crops were set at a fixed level, and will decline significantly over the next seven years (Barnaby). Simultaneous with this decline in agricultural subsidies is an increase in environmental regulation of agricultural production practices. Water quality has been identified as a significant problem in Kansas, due to the leaching of agricultural chemicals and fertilizer into the water table. Also undergoing change are conservation programs intended to save highly erodible soil. Roughly 50 percent of the 2.9 million Kansas acres currently enrolled in the Conservation Reserve Program (CRP) are unlikely to be renewed (Barnaby). This major reduction in the CRP will result in a significant shift of land out of conservation uses and into cultivated cropland.

Given the rapidly changing relationship between the federal government and agricultural commodity producers, policy makers need accurate and up-to-date information on the impacts of policy shifts on acreage allocation decisions to evaluate the probable consequences of these recent policy changes. The objective of this research is to identify and quantify the determinants of acreage allocation decisions for the five major crops produced in Kansas: wheat, corn, sorghum (also called milo), soybeans, and hay. These five crops account for over 98 percent of all Kansas harvested acres in 1994 (KS Dept of Ag). Zellner's Seemingly Unrelated Regression technique (SUR) is used to estimate a system of simultaneous equations for the five crops. Acreage allocation decisions are found to be determined by prices of outputs and inputs, policy variables, and site characteristics such as soil quality and climatic conditions. The integration of price and policy variables and location-specific factors into econometric analyses requires the use of pooled, cross-section, time-series data to capture both policy changes across time and variability in physical growing conditions across space (Wu and Brorsen). Elasticities are calculated, and policy scenarios are simulated to forecast the likely impacts of changes in commodity programs and environment regulations.

Previous time-series regression analyses have estimated the statistical relationship between crop acreages and government programs (Houck and Ryan, Lidman and Bawden, Houck et al., Chavas et al., and Chavas and Holt). More recently, site characteristics have been found to be important determinants of cropping patterns in multicrop acreage response models (Lichtenberg; Moore and Negri; Wu and Brorsen). Wu and Brorsen estimated a nine-crop model using data from 53 Wisconsin counties for the period 1972 to 1990, and concluded, "The results suggest limited potential to reduce groundwater pollution by using current policies to alter cropping patterns" (p. 95). Based on this result, it is hypothesized that site characteristics play a significant role in land allocation decisions in Kansas.

Model

Data from all 105 Kansas counties are combined with time-series price and policy data to quantify the economic and physical determinants of acreage allocation decisions from 1970 to 1995. Due to the use of pooled, cross-section, time-series data, special consideration was given to the error structure of the regression model. Specifically, Wu and Brorsen combined Kmenta's heteroscedastic and time-wise autoregressive model (HEAR) with Zellner's Seemingly Unrelated Regression technique (SUR) to correct for (1) heteroscedascity, (2) cross-section correlation, (3) time-wise correlation, and (4) contemporaneous correlation across equations. Consider a general expression of acreage allocation for a given county in Kansas:

(1) $A_{ijt} = F_i(P_t,W_t,G_t,S_j)$ $\quad$ i=1,...,5; $\quad$ j=1,...,105; $\quad$ t=1970,...,1995.

where A_{ijt} represents the acreage of crop i in county j at time t; P_t is a vector of expected output prices; W_t is a vector of input prices; and G_t is a vector of government program variables. Note that P_t, W_t, and G_t vary across time, but are constant for all counties. The variable S_j is a vector of site characteristics, constant over time, but variable across counties. Following Lichtenberg; and Wu and Brorsen, a logistic functional form is specified in equation (2) for the five major crops in Kansas:

(2) $ln(A_{ijt}/A_{ojt}) = X_{ijt}b_i + u_{ijt}$ $\quad$ i=1,...,5; $\quad$ j=1,...,105; $\quad$ t=1970,...,1995.

where X_{ijt} is a vector of the variables in P_t, W_t, G_t, and S_j previously defined; b_i are the coefficients to be estimated; A_{ojt} is acres of potential agricultural land that is not used for the five crops (typically grazing land); u_{ijt} is the error term. Greene demonstrates that acreage elasticities for crop i can be calculated as: $e_{ijx}=(b_{ix} - S^5_{k=1}s_{kj}b_{kx})x_j$.

Data

Four categories of data are required to estimate the system of equations in (2) above: (1) crop acreage data (A_{ijt}), (2) expected output and input prices (P_t), (3) commodity program and CRP provisions (G_t), and (4) site characteristics, including a climate variable (S_j). The acreage of potential agricultural land in each county (A_{ojt}) was defined as the maximum number of acres of land in farms in 1970-1995 (Census of Agriculture) minus the sum of acres devoted to wheat, corn, sorghum, soybeans, and hay in each year. Following Wu and Brorsen, this study uses harvested acres, rather than planted acres to measure A_{ijt} because hay is a perennial crop, for which there are no planted acres. Also, harvested acres are more meaningful for policy analysis, since agricultural output is the product of harvested acres and yield per acre.

Several previous acreage response functions have used product prices from previous periods as expected prices (Chavas and Holt; Wu and Brorsen; Houck and Ryan; Tegene et al.). An alterative approach is the use of futures prices to reflect the market expectation at planting time of the cash price at harvest time (Gardner; Chavas et al.). This study measures expected market output prices as the futures market price reported in the month immediately preceding the time of planting for delivery at the time of harvest. Monthly averages of each futures price were used to smooth short-term price fluctuations. Data on corn and soybeans futures prices are from the Chicago Board of Trade; wheat futures price data are from the Kansas City Board of Trade (Knight-Ridder). Sorghum does not have a futures market, because it is a close substitute for corn as a feed grain. Since corn and sorghum prices are highly correlated, the expected market price for sorghum is defined as the corn futures price in May, the planting time for sorghum (table 1).

Hay does not have a futures market price. Since hay is not planted each year, a partial adjustment model is used by using the lagged price of hay as the expected price of hay. Hay prices are marketing year averages for Kansas (USDA, *Agricultural Statistics*).

Input prices for chemicals, fertilizer, fuel, and the wage rate are indexes reported in USDA, *Agricultural Statistics*. All output and input prices are deflated by the USDA's index of prices received by farmers (table 1).

The federal government has legislated commodity programs for wheat, corn, and sorghum in the form of a target price and deficiency payments. The deficiency payment is defined as the difference between the target price and the maximum of the market price or the loan rate, a price floor set by the government. To be eligible for deficiency payments, producers who participate in the government programs are subject to the acreage reduction program (ARP), which requires producers to set aside (abandon) a given percentage of acres devoted to the program crop. To account for this form of income support, the expected price of program crops (wheat, corn, and sorghum) is defined as the maximum of the futures price at planting time for delivery at harvest time and the announced target price [expected price=max(futures price, target price)]. This definition allows for quantification of the impact of government programs on acreage, while avoiding the problem of collinearity between target prices and market prices estimated in the same regression equation (Houck and Ryan).

Acreage reduction program rates are included in the model to account for the mandatory acreage set aside for participating producers. The ARP rates for wheat, corn, and sorghum are highly correlated, so each crop equation includes only its own ARP rate. The corn ARP rate is included in the equations for soybeans and hay, the nonprogram crops. Target prices and ARP rates are described and reported in Green (1970-1990) and USDA, *Agricultural Outlook* since 1990 (table 1). Acres enrolled in the CRP are included in each acreage equation. Since acres seeded to winter wheat in September are unavailable for planting to other crops in the following Spring, acres planted to wheat (PLANTW) are included in the acreage equations for corn, soybeans, sorghum, and hay. Site characteristic data were collected from the USDA NRCS *National Resource Inventory* (NRI) for soil texture and quality, land capability class, slope, and irrigation availability. Climate was defined as the average annual precipitation from 1941 to 1970 in each county (table 1, KS Dept of Ag). Qualitative variables are included for each crop reporting district and a trend variable.

Results

The presence of heteroscedasticity was confirmed for each crop with a Lagrange Multiplier Test. A modified Breusch-Godfrey test (detailed in Wu and Brorsen) rejected the null hypothesis of no autocorrelation in all five equations. The data were transformed following Kmenta's HEAR model prior to SUR estimation. The acreage response model estimated by SUR-HEAR fits the data well: the system R-square equals 0.9052. Model parameters appear in table 2, and acreage elasticities are reported in table 3. Three of the five own-price elasticities were positive and statistically significant: soybeans and hay own-price elasticities were not statistically significant. The insignificant own-price elasticity for hay may reflect that site characteristics and weather may be more important determinants of the number of acres of hay harvested than the price of hay. Also, the lagged hay price may not contain much information about the price of hay at the time of harvest. Six of the eleven cross-price elasticities were significant and negative, the anticipated sign for substitute crops.

Input price elasticities were also found to be significant determinants of cropping patterns in Kansas: 17 of the 20 input price elasticities were statistically significant, and the signs and magnitudes are as expected. One possible exception to this is chemical price: an increase in the price of chemicals is associated with a movement out of soybeans, which is expected, and into the other four crops. Corn, like soybeans, is a chemical-intensive crop relative to the wheat, sorghum, and hay. The positive elasticity of corn with respect to the price of chemicals is unexpected. The chemical price index may be correlated with productivity enhancement: higher chemical prices reflect greater effectiveness. To the extent that this is true, the price elasticity of corn with respect to chemicals may reflect responsiveness to both price and quality increases. The wage rate exerts a strong negative impact on corn and soybean acres, with estimated elasticities of -3.448 and -2.157, respectively (table 3). As farm labor becomes more expensive, the model suggests that producers will allocate fewer farm acres to all five crops, particularly corn and soybeans.

The estimated coefficients on the price variables for wheat and corn reported in table 2 reflect both market prices and government programs, due to the inclusion of target prices in the definition of expected prices for these program crops. The corresponding acreage elasticities in table 3 indicate that decreasing commodity program payments are likely to result in a decrease in the allocation of land to program crops, and an increase in acreage devoted to soybeans and hay. These shifts, however, are partially offset by the simultaneous decrease in the acreage reduction program (ARP) requirements for program participation.

Site characteristics are found to be important determinants of land allocation between the five major crops in Kansas. Of the 45 estimated coefficients on location variables, 42 were statistically significant, and of the anticipated sign. Two results merit attention: the variable SLIMIT measures a soil limitation of "shallow, drought, or stony soil" (NRI), yet the estimated coefficients are positive and statistically significant. A close examination of the data reveals that Kansas counties located in the major wheat-producing region of the state have a high percentage of crops (and little pasture), and are characterized by shallow soils. The regression results indicate that PRIME farmland, soil with no limitations, is associated with decreased quantities of land devoted to all five crops: counties in the Flint Hills region of Kansas are characterized by small acreages of cropland, but the cropland that is found among river and creek valleys, is of high quality, resulting in a negative estimated elasticity of PRIME on crop acreages. While the price and policy variables perform reasonably well, the site characteristics explain more of the variability in the crop allocation model. The dominance of the site characteristics was quantified with the partial R-square measurement (Kennedy, p. 50) of site characteristics, holding price and policy variables constant is equal to 0.45, whereas the partial R-square of price and policy variables holding site variables constant equaled 0.05.

Policy simulations for four commodity program changes and environmental regulations are summarized in table 4. The 1996 farm legislation is represented by a 10% decrease in the wheat target price and ARP rate. The simulation model shows that this policy change is likely to decrease the total number of acres devoted to wheat in Kansas. A 10% reduction in CRP acres would result in an increase in wheat, soybeans, and sorghum acres, and a decrease in corn and hay acres. A 10% tax on fertilizer, intended to increase water quality in Kansas, would result in a decrease in acreage of all five crops, with corn acres reduced by 11.3%.

Conclusions

An acreage allocation model for the five major crops grown in Kansas was estimated with cross-sectional, time-series data from 105 counties in Kansas from 1970 to 1995, using a Seemingly Unrelated Regression, corrected for heteroscedasticity and timewise autocorrelation (SUR-HEAR). Elasticities were calculated for a broad range of input and output prices, policy variables, and site characteristics, including soil quality and climate. Site characteristics were found to dominate the crop acreage patterns in Kansas, indicating that environmental policy objectives will be difficult to attain through price and policy incentives of the current commodity programs. Policy simulations were estimated for likely commodity program changes and environmental regulations, demonstrating the impact of decreasing commodity program payments and enhanced environmental regulations on acreage allocations: declining commodity programs will decrease acreage devoted to the program crops, wheat, corn, and sorghum; corn acres would decline significantly if fertilizer was taxed; if major reductions in the CRP program take place, wheat and sorghum acres will increase.

Table 1. Variables Included in the Kansas County Acreage Allocation Model: 1970-1995.

Variable	Definition	Source
Price and Policy Variables:		
CHEMP	Chemical price index, deflated by prices received index.	USDA
FERTP	Fertilizer price index, deflated by prices received index.	USDA
FUELP	Fuel price index, deflated by prices received index.	USDA
WAGE	Labor price index, deflated by prices received index.	USDA
EWP9	Expected Price of *Wheat* at *Wheat* planting time, September.	Knight-Ridder
EPS9	Expected Price of *Soybeans* at *Wheat* planting time, September.	Knight-Ridder
EPC9	Expected Price of *Corn* at *Wheat* planting time, September.	Knight-Ridder
HAYP	Kansas Hay price, marketing year average.	USDA
LHAYP	Expected Price of Hay = Lagged Kansas Hay price.	USDA
EPC5	Expected Price of *Corn* at *Soybean*, *Sorghum* planting time.	Knight-Ridder
EPS5	Expected Price of *Soybeans* at *Soybean*, *Sorghum* planting time.	Knight-Ridder
EPC4	Expected Price of *Corn* at *Corn* planting time.	Knight-Ridder
EPS4	Expected Price of *Soybeans* at *Corn* planting time.	Knight-Ridder
PLANTW	Planted wheat acres (acres).	KS Dept of Ag
ARPW	Wheat Acreage Reserve Program Rate (%).	USDA
ARPC	Corn Acreage Reserve Program Rate (%).	USDA
ARPM	Sorghum Acreage Reserve Program Rate (%).	USDA
CRP	Kansas Enrolled Acres in Conservation Reserve Program.	KS Dept of Ag
Site Characteristic Variables:		
MEDIUM	Percent of county acres with Medium-textured soils (%).	NRI
FINE	Percent of county acres with Fine-textured soils (%).	NRI
LDCLASS	County average land capability class. Range: 2-8, 2 is best land.	NRI
ELIMIT	Percent of county acres with Erosion risk (%).	NRI
SLIMIT	Percent of county acres with shallow, drought, or stony land(%).	NRI
PRIME	Percent of county acres with no limitations: prime farmland (%).	NRI
STEEP	Percent of county acres with slope greater than 8%(%).	NRI
IRRIGATE	Percent of county acres with irrigation available (%).	NRI
CLIMATE	County precipitation, 1941-1970 annual ave. (inches/year).	KS Dept of Ag
Qualitative Variables:		
NW DIST	=1 if county is in NW Crop Reporting District; otherwise =0.	--
WC DIST	=1 if county is in WC Crop Reporting District; otherwise =0.	--
SW DIST	=1 if county is in SW Crop Reporting District; otherwise =0.	--
NC DIST	=1 if county is in NC Crop Reporting District; otherwise =0.	--
C DIST	=1 if county is in C Crop Reporting District; otherwise =0 (default).	--
SC DIST	=1 if county is in SC Crop Reporting District; otherwise =0.	--
NE DIST	=1 if county is in NE Crop Reporting District; otherwise =0.	--
EC DIST	=1 if county is in EC Crop Reporting District; otherwise =0.	--
SE DIST	=1 if county is in SE Crop Reporting District; otherwise =0.	--
TREND	Time trend variable, 1970=1.	--

Table 2. Seemingly Unrelated Regression Results: Kansas Acreage Allocation, 1970-1995.

		WHEAT		SOYBEANS		SORGHUM		HAY		CORN	
Variable	Mean	b	t-stat	b	t-stat	b	t-stat	b	t-stat	b	t-stat
INTERCEPT	1.00	0.09	2.53	-0.14	-3.73	0.01	0.07	-0.07	-1.84	0.06	1.75
CHEMP	95.19	0.01	5.33	-0.01	-0.60	0.01	4.48	0.01	6.16	0.03	7.80
FERTP	93.56	-0.01	-2.42	-0.01	-0.58	-0.01	-3.21	-0.01	-3.77	-0.01	-4.04
FUELP	117.80	0.01	7.98	0.01	7.26	0.01	0.88	0.01	6.57	-0.01	-5.12
WAGE	111.63	-0.01	-6.43	-0.02	-3.94	-0.01	-6.40	-0.02	-10.09	-0.04	-7.91
EPW9	3.10	0.16	6.38	--	--	--	--	--	--	--	--
EPS9	5.00	0.02	1.43	--	--	--	--	--	--	--	--
EPC9	2.25	-0.15	-3.19	--	--	--	--	--	--	--	--
HAYP	44.81	--	--	-0.01	-1.64	-0.01	-5.71	--	--	-0.02	-6.58
LHAYP	44.25	-0.01	-0.37	--	--	--	--	-0.01	-1.82	--	--
EPC5	2.15	--	--	-0.13	-0.87	0.27	5.25	--	--	--	--
EPS5	4.88	--	--	-0.05	-1.19	-0.01	-0.93	--	--	--	--
EPC4	2.17	--	--	--	--	--	--	-0.06	-1.72	0.30	2.74
EPS4	4.83	--	--	--	--	--	--	-0.04	-2.85	-0.05	-1.48
PLANTW	0.33	--	--	-5.02	-15.86	-2.48	-24.13	-1.54	-22.24	-3.95	-16.49
ARPW	0.07	-0.53	-5.44	--	--	--	--	--	--	--	--
ARPC	0.06	--	--	2.72	5.41	--	--	0.11	0.93	-1.51	-3.94
ARPM	0.05	--	--	--	--	0.63	4.02	--	--	--	--
CRP	0.03	-0.86	-3.86	-0.84	-0.95	-2.15	-7.49	-0.28	-1.36	0.82	1.30
MEDIUM	0.66	-0.05	-0.68	-3.08	-12.34	-1.27	-14.05	-0.77	-11.39	-1.41	-6.68
FINE	0.26	0.04	0.63	-1.73	-6.37	-0.53	-5.51	-0.53	-7.44	-0.80	-3.65
LDCLASS	2.53	-0.15	-5.12	-1.46	-12.63	0.17	4.74	-0.17	-7.26	-0.63	-8.99
ELIMIT	0.64	0.04	0.59	-1.38	-4.52	0.15	1.63	-0.44	-6.46	-1.74	-9.11
SLIMIT	0.04	2.23	18.94	1.62	4.22	2.47	17.11	0.40	3.78	1.41	4.42
PRIME	0.10	-0.63	-5.85	-2.35	-5.87	-1.95	-12.48	-1.69	-17.58	-5.18	-17.63
STEEP	0.08	-0.86	-8.68	-3.49	-10.62	-2.41	-17.49	-1.53	-20.68	-0.95	-3.54
IRRIGATE	0.10	1.85	22.13	7.00	20.16	4.14	33.54	1.85	21.46	11.04	44.55
CLIMATE	28.72	-0.01	-3.50	0.20	21.76	0.01	5.00	0.05	22.80	0.13	17.58
NW DIST	0.08	-0.42	-11.92	-1.65	-8.79	-0.73	-14.79	-0.94	-27.20	1.71	16.25
WC DIST	0.09	-0.16	-4.70	-1.63	-9.79	-0.30	-6.42	-1.28	-36.68	0.45	4.35
SW DIST	0.13	-0.47	-13.02	-2.34	-13.49	-0.91	-17.44	-1.31	-31.51	-0.64	-5.59
NC DIST	0.10	0.01	0.01	0.92	11.86	0.37	11.13	0.06	2.92	1.25	14.12
C DIST	0.10	--	--	--	--	--	--	--	--	--	--
SC DIST	0.12	0.35	12.24	-0.32	-2.76	-0.54	-9.58	-0.14	-3.98	-0.12	-1.28
NE DIST	0.10	-0.87	-21.19	1.88	11.22	-0.18	-2.77	0.20	5.69	1.23	8.67
EC DIST	0.13	-1.50	-49.75	0.14	1.00	-1.29	-33.51	-0.55	-19.43	-0.56	-4.76
SE DIST	0.13	-1.40	-45.90	0.29	2.30	-1.11	-34.22	-0.67	-26.91	-1.42	-12.78
TREND	13.50	0.02	6.25	0.12	9.62	0.04	8.73	0.03	10.22	0.10	10.28

System R-Square: 0.9052.

Partial R^2, Site Characteristics: 0.405. Partial R^2, Price and Policy Variables: 0.045.

Table 3. Acreage Elasticity Estimates for Kansas Cropping Patterns, 1970-1995.

	Elasticity of:				
	Wheat	Soybeans	Sorghum	Hay	Corn
Price and Policy Variables:					
CHEMP	0.600	-0.564	0.504	0.538	2.714
FERTP	-0.161	-0.103	-0.285	-0.260	-1.131
FUELP	0.300	1.329	-0.121	0.144	-0.973
WAGE	-0.658	-2.157	-0.898	-1.153	-3.448
EPW9	0.389	0.000	0.000	0.000	0.000
EPS9	0.081	0.000	0.000	0.000	0.000
EPC9	-0.275	0.000	0.000	0.000	0.000
HAYP	0.000	-0.301	-0.345	0.000	-0.940
LHAYP	-0.013	0.000	0.000	-0.093	0.000
EPC5	0.000	-0.318	0.552	0.000	0.000
EPS5	0.000	-0.247	-0.051	0.000	0.000
EPC4	0.000	0.000	0.000	-0.126	0.657
EPS4	0.000	0.000	0.000	-0.178	-0.246
PLANTW	0.000	-1.505	-0.664	-0.352	-1.151
ARPW	-0.030	0.000	0.000	0.000	0.000
ARPC	0.000	0.148	0.000	-0.000	-0.093
ARPM	0.000	0.000	0.031	0.000	0.000
CRP	-0.014	-0.013	-0.051	0.003	0.034

Table 4. Policy Simulation Results for Kansas County Cropping Patterns.

		Commodity Program Changes				Environmental Regulation Changes			
		10% decrease in Wheat Target Price		10% decrease in Wheat Acreage Reduction Program		10% Decrease in Kanas CRP Acres		10% increase in Fertilizer Price	
Crop	1995 Baseline Acres	% Chg	Acreage Change	% Chg	Acreage Change	% Chg	Acreage Change	% Chg	Acreage Change
Corn	1970000	0.0	0	0.0	0	-0.3	-6776	-11.3	-222780
Wheat	11000000	-3.9	-427900	0.3	33000	0.1	15103	-1.6	-176819
Soybeans	2050000	0.0	0	0.0	0	0.1	2711	-1.0	-21061
Sorghum	3100000	0.0	0	0.0	0	0.5	15735	2.9	-88406
Hay	2600000	0.0	0	0.0	0	-0.0	-742	-2.6	-67725
Total	20720000	-3.9	-427900	0.3	33000	0.4	26032	-19.4	-576791

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