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Factors Affecting Farmers' Willingness to Grow Alternative Biomass Feedstocks for Biofuels across Kansas

1. Introduction

Renewable energy production has emerged as one of the significant challenges of the 21st century. Among the important options for renewable energy production is the production of biofuels using alternative cellulosic biomass feedstocks. Biomass resources include crop residues, herbaceous crops, and dedicated energy crops. In recent decades, bioenergy production has increased more broadly as a substitute for imported oil in nations with the objective of ensuring a secure supply of energy [1].

Not different from many countries, the United States has responded to its increasing dependency on imported oil by stimulating bioenergy production. Bioenergy is a small but growing fraction of total energy supply in the United States. Renewable energy represents 6.6% of the total U.S. energy consumption, with biomass energy sources among the most promising with a 45% share of renewable sources. However, only a small portion (about 10% of biomass resources) is used to produce biofuels [2]. Nevertheless, the production of biofuel has the potential to increase due to biofuels policies, regulations and incentives. In fact, numerous policies have been developed to stimulate renewable energy alternatives, such as biomass energy. For instance, the Energy Policy Act of 2005 created a Renewable Fuel Standard (RFS) that mandated minimum annual biofuel production levels for the U.S. In addition, in 2006 and 2007, the Advanced Energy Initiative (AEI) and the 20-in-10 Plan were introduced to overcome the United States dependence on oil and to promote the development of energy biotechnologies. In this context, the Energy Independence and Security Act of 2007, which is set to take effect in 2015, has the objective of increasing the production of advanced biofuels (from cellulosic sources) by 36 billion gallons by 2022. Despite this law, only 20,000 gallons of cellulosic was produced by late 2012 [3]. In response to this low level of production, the Environmental Protection Agency expects approximately 17 million gallons of cellulosic biofuel to be produced in 2014, significantly less than the original goal of 1.75 billion gallons[4].

In spite of these policies, the above prediction that cellulosic biofuel production will not increase as expected seems a paradox [4]. While biomass feedstock technology and production for biofuels has potential, especially in the Midwestern United States, several challenges must be overcome to realize the benefits. In particular, farmers and landholders may not be willing to grow bioenergy crops. Thus, in order to develop strategies and guidelines to stimulate bioenergy crop production, policy makers must have information about farmers' willingness to produce alterative biomass feedstocks [4] and [5].

With these concerns in mind, our study advances previous research by evaluating farmers' and landholder's willingness to produce different varieties of cellulosic biofuel feedstocks. However, it is important to note that the basic assumptions governing decision-making models of farm household behavior argue that farmers make decisions about production in relation to available human and natural resources; balance opportunities against constraints; and with consideration of uncertainty and risk. Nevertheless, existing studies are not comprehensive enough in analyzing all these factors due to a lack of data. Thus, taking this into consideration, this paper fills a gap in the literature by examining the effect of farm characteristics, farm management practices, farmer perceptions (such as risk aversion), physical variables (such as soil, weather, and the availability of water for irrigation) on farmers' willingness to produce value-added feedstocks (e.g. corn stover), dedicated annual bioenergy crops (e.g. energy sorghum), and dedicated perennial bioenergy crops (e.g. switchgrass) for biofuel production in Kansas.

2. Data Collection and Study Method

2.1 Data Collection

The data used for analysis in the paper was obtained from a mail survey of Kansas farmers conducted from January to April of 2011. The survey contained questions related to how farmers make their land-use decisions covering a wide array of topics. The survey asked respondents to address their goals in farming; participation in conservation programs; use of irrigation; willingness to grow biofuel crops; views related to price, yield, and weather risk; usage of insurance and marketing options; and characteristics of the farming operations.

After designing the initial draft of the survey, two focus groups were conducted in central and western Kansas in January 2011. The survey was redesigned and utilizing a database of over 23,000 Kansas farmers obtained from FarmMarket ID (a marketing technology company, www.FarmMarketID.com), a pilot study was drawn at the end of January 2011. The final survey consisted of an eight-page survey with 43 questions, leading to more than 400 distinct variables in the survey dataset.

The target population for the survey was all Kansas farmers operating 50 or more acres of arable land and over $10,000 in gross farm annual income in 2010. For the full mailing of the survey, we drew a random sample of 10,000 farmers from the FarmMarketID database. A total of 2,317 surveys with usable data were ultimately received with an overall response rate of approximately 25% after taking into account bad addresses and farmer retirements. Due to missing data (either from questions not answered or entry of an implausible value), 1984 surveys were usable for the analysis in this study.[1]

The dependent variables for the study are pulled from a question in the survey asking about biofuel feedstock production. The question first indicates that in the future there may be a market for cellulosic materials, such as corn stover or switchgrass, to produce ethanol. Then the respondent is asked if they would consider a number of different feedstocks on the farm. These feedstocks included: (i) crop residues such as corn stover; (ii) a perennial bioenergy crop such as switchgrass; and (iii) an annual bioenergy crop such as forage sorghum. The respondents were asked if they would consider producing these feedstocks on a Likert scale from strongly disagree to strongly agree. The responses where then binary coded, set equal to 1 if the respondent agreed or strongly agreed and 0 otherwise. The questions gauge a farmers' preferences for growing these types of feedstocks and not strictly conditioned on a farmer's situation.

To complement the survey data, our analysis also draws upon publicly available data on climate conditions, topography, and soil characteristics at the county level. Soils data was obtained from the Soil Survey Geographic (SSURGO) database [6]. County level averages for each soil variable were obtained for all 105 counties across the state of Kansas by taking spatially weighted averages across soil polygons using the percent of area of arable land represented by each soil polygon as the weighting factor. The only weather variable used was the Palmer Z Index, which measures short term drought on a monthly basis and is more suitable for agricultural purposes [7]. Both the mean and standard deviation over a 10-year period for each county in Kansas were calculated. Soil variables and Palmer Z variables

[1] The response rate matches those for other similar agricultural farmer surveys that did not provide an incentive by the USDA- National Agricultural Statistics Service. In addition, an analysis of nonresponse was not possible as demographic or farm data was not available from nonrespondents to the survey.

values where then assigned to each respondent as the spatially weighted average of the associated county level averages or values using the percentage of their land operated in a given county as the weighting factor.

Summary statistics for the dependent and explanatory (independent) variables derived from the survey, as well as the soil and weather variables are provided in Table 1. To capture heterogeneity in the descriptive statistics across the state due to changes in cultural practices, geography and climate, summary statistics are presented for the eastern, central and western parts of Kansas.

Finally, summary statistics are compared with means from the 2007 Agricultural Census for the state of Kansas (represented in the last row of Table 1) for select explanatory variables. Means from 2007 Agricultural Census data were computed at the state level for all farms with more than 50 acres of agricultural production. On average the census reports that average farm size is 863.01 acres, whereas the average farm size of survey respondents was 1167.68 acres, varying by region (see Table 1). This difference is likely due to the sampling of farms with over 50 acres of cropland production and $10,000 in gross farm sales. The 2007 Agricultural Census reports that on average 47 percent of farms has a member of the household working off the farm, whereas 54 percent of survey respondents had a member of the household working off the farm. Survey respondents have been farming on average 35 years, and the 2007 Agricultural Census indicates farmers have been working on their present farm for 26 years on average. This difference is likely due to the nature of the questions. The survey asked total years farming, whereas the Census asked the number of years working on their present farm. It is likely that survey respondents included time working on their family farm or other farms. Taking this into account and that the average age of a farmer is approximately 55 to 56 years of age in Kansas [8], it is likely the numbers are in agreement, in that the labor pool of farmers that have been farming a significant amount of time, have a lot of experience, and have owned their own operation for about two thirds of their career. Finally the 2007 Agricultural Census indicates that 11 percent of farmers in Kansas are female. This is in contrast to the survey respondent population, where only 4.6 percent of the population is female.

2.2 Model Specification

As true with any decision to adopt a new "technology", the decision to produce a biomass feedstock reflects a very complex relationship between biophysical, economic, and social factors. Using the data described above, we estimate the functional relationship between a farmer's willingness to consider producing a biofuel feedstock -- grow a biofuel feedstock crop or harvest crop residue – and a set of explanatory factors. Towards this end, we model farmer *i*'s willingness or "decision" to produce a biofuel feedstock *j* as a dichotomous choice resulting from a latent utility maximization problem. We model three different choice scenarios for feedstocks potentially faced by a Kansas farmer:

(1) To produce a value-added feedstock option, i.e., harvest crop residue ($j = v$);

(2) To grow a dedicated annual bioenergy crop ($j = a$); or

(3) To grow a dedicated perennial bioenergy crop ($j = p$).

We assume in this analysis that the decisions to grow or harvest each of the biofuel feedstock types being examined will involve different land-use decisions. The harvesting of crop residues is a value-added enterprise that must weigh the conservation and nutrient benefits of leaving crop residues on the soil surface [9-10]. In addition, income from crop residue harvest comes after the harvesting of the cash crop itself, thus it is secondary in nature to the decision to plant the cash crop. A dedicated annual bioenergy crop, such as forage or energy sorghum, can be a substitute for an existing cash crop in a traditional cropping rotation. A dedicated perennial bioenergy crop option is likely to be planted on marginal lands as they are less likely to compete for regular annual crop production and are more economical for perennial crop production [11-14] Thus, a farmer may consider the production of each of these enterprises under different land-use conditions and situations.

Let A_{ij} reflect each of the decisions to grow a feedstock, where $A_{ij} = 1$ indicates farmer *i*'s willingness to produce feedstock *j* and $A_{ij} = 0$ indicates no willingness to produce feedstock *j*. These three decisions represent the dependent variables in our analysis. Now the set of explanatory variables or factors impacting the decision to produce a biofuel feedstock can be considered. Let $\boldsymbol{X}_i$ be a set of explanatory variables (across all feedstock decisions) representing characteristics of the farm operation (including conservation) and farmer demographics (e.g., farm size, land tenure, education, years of experience, and conservation on-farm); $\boldsymbol{Z}_i$ be a set of explanatory variables representing the physical (weather, landscape and soils) characteristics of the farm (e.g., Palmer Z Drought Index, slope of the landscape, soil properties, etc.); and $\boldsymbol{W}_i$ be a set of explanatory variables representing the farmers' perceptions and management perspectives (e.g., risk attitudes and management goals). The choice of explanatory variables in each set is provided in Table 1. We chose these explanatory variables on the basis of the crop and technology adoption literature reviewed above. Furthermore, due to the potentially high correlation between uncertainty and risk in the context of adopting an unfamiliar cropping enterprise, an interaction term between uncertainty and risk was included in the model, as well.

For farmer i the expected utility from producing feedstock j is given by the following:

$$V_i\,(j,\boldsymbol{X}_i,\boldsymbol{Z}_i,\boldsymbol{W}_i) \text{ for } j = \{v,a,p\} \quad (1)$$

Farmer i produces feedstock j (A_{ij} = 1) if the following condition holds:

$$\Delta V_{i,j}=V_i(j,\boldsymbol{X}_i,\boldsymbol{Z}_i,\boldsymbol{W}_i)-V_i(c,\boldsymbol{X}_i\,,\boldsymbol{Z}_i,\boldsymbol{W}_i)>0, \quad (2)$$

where c represents the state where feedstock j is not adopted. Otherwise, farmer i does not produce feedstock j (A_{ij} = 0). We then specify a model of production for feedstock j by farmer i as follows:

$$\Delta V_{i,j}=\boldsymbol{\alpha_{Xj}}'\boldsymbol{X}_i+\boldsymbol{\alpha_{Zj}}'\boldsymbol{Z}_i+\boldsymbol{\alpha_{Wj}}'\boldsymbol{W}_i+\varepsilon_{i,j} \text{ with } A_{ij} = 1 \text{ if } \Delta V_{j,i} > 0,\ A_{ij}=0 \text{ otherwise,} \quad (3)$$

where $\boldsymbol{\alpha_j = \{\alpha_{Xj},\alpha_{Zj},\alpha_{Wj}\}}$ is an vector of parameters specific to each feedstock. By assuming that the error ε_{ij} is distributed logistic, our modeling of the observed dichotomous choice processes gives rise to a different logistic regression models for each feedstock [9].

To examine if climatic and ecological differences that are not captured directly by the biophysical regressors affect the model a Likelihood Ratio test is conducted to assess if the coefficient estimates change by region (eastern, central and western parts of Kansas) for each feedstock type examined (*i.e.* $j = v,a,p$). The test examines the significance of interaction terms between the explanatory variables and regional dummy variables. If differences are found, separate logistical regression models were then estimated for the eastern, central and western parts of Kansas for that particular feedstock. To further capture cultural differences, fixed effects are incorporated into each model, representing the northern, central, and southern tiers of each region using the crop reporting districts adopted by USDA, National Agricultural Statistics Service [10]. The joint significance of these effects is tested in the model using a Likelihood Ration test. Based on the logistic regression estimates, we derive marginal effects as partial average effects for each of the explanatory variables on the probability of producing feedstock *j* following Greene [17]. We estimate asymptotic standard errors for the marginal effects using the delta method [17]. The significance of each marginal effect is tested using an asymptotic z-statistic, which is distributed standard normal.

3. Results and Discussion

The adoption of a new technology such as bioenergy crop by farmers and landholders is a very complex relationship between biophysical, economic and social factors. For this study, three models were estimated to examine farmers' willingness to produce alternative biomass or cellulosic feedstocks (i.e. value-added feedstocks such as crop residues, dedicated annual bioenergy crops, and dedicated perennial bioenergy crops) for biofuel production for three regions of Kansas. Likelihood Ratio testing results of the sensitivity of coefficient estimates to regional (eastern, central and western) differences not caught by other explanatory variables, shows that coefficient estimates change for the crop residue and annual bioenergy crop models (Table 2). Thus, for these two feedstocks, separate logistic regression models were estimated for each region.

The estimates of the logistic regression model are not reported, but are available from the authors upon request. For substantive inference, the marginal effects of the explanatory variables is of more interest, which provides the change in probability of adoption of a biomass feedstock given a one unit or incremental change in the variable being examined. Estimated marginal effects with associated asymptotic standard errors are provided in Table 2. For logistic regression models with linear index functions, the signs of the marginal effects will follow the signs of the associated coefficients in the logistic regression model [17].

The regional fixed effects were not statistically significant for many of the bioenergy feedstock models estimated. Likelihood Ratio tests of the fixed effects were only significant at the 10 percent level in the model for crop residues in western Kansas and the overall model for perennial bioenergy crops (Table 2). The significance of these effects indicates that potential unmodeled cultural differences or other heterogeneity exists between the regions. Thus, the inclusion of the fixed effects helps to correct for any potential bias that could be introduced by not correcting for these unobserved differences.

Many of the marginal effect estimates for the biophysical variables are not statistically significant from zero. The only significant biophysical variables were in the eastern part of the state. This could be due to the differences in soils in the eastern part of the state compared to the central or western parts of the state. The K-W factor measures soil erosion potential and has a statistically significant negative marginal effect for crop residues and dedicated annual bioenergy crops for eastern Kansas. That is, as erosion potential increases, farmers are less willing to harvest crop residues from or grow an annual bioenergy crop on their fields. Farmers in eastern Kansas are more willing to harvest crop residues and grow an annual bioenergy crop when the depth to the water table is deeper and available water content is higher. This result may be due to the increased use of surface irrigation in the eastern part of the state. Furthermore, farmers in the eastern part of the state are more willing to plant a annual bioenergy crop as the depth to water table increases, possibly due to the potential drought tolerance of some of these crops (e.g. energy and forage sorghums).

The Palmer Z Index shows how monthly moisture conditions depart from normal. The average Palmer Z Index was only statistically significant for harvesting of crop residues in western Kansas. Low levels of rainfall on average in the western part of the state may make farmers more risk averse toward harvesting crop residues as taking the residues off the soil surface increase evaporation and deplete valuable water resources that can be reserved for the next cash crop. Higher variability of droughty conditions reduces the willingness of farmers to plant dedicated perennial bioenergy crops across Kansas.

Farmers' perceptions can play an important role in farmers' willingness to plant biofuel crops in Kansas. The results suggest that farmers' objective to maximize profits; avoidance of planting crops with uncertain income; and who are risk avoiders will affect a farmer's likelihood of adopting a biofuel feedstock. A farmer in western Kansas who farms to maximize profits is 14% more willing to plant an annual bioenergy crop.

It is important to note the risk aversion defines farmers' tendency to avoid risks in their decision-making and empirical evidences show that landholders vary in their personal degree of risk aversion [12] and [13]. In the case of Kansas, farmers that are risk avoiders are more likely to consider a dedicated annual bioenergy crop in eastern Kansas and overall across the state for dedicated perennial bioenergy crops. Specifically, farmers who are risk avoiders in eastern Kansas are 8.6% more willing to adopt an annual bioenergy crop option and farmers who are risk avoiders are 5.9 % more willing to adopt a perennial bioenergy crop option overall. It could be the case that these farmers do not perceive these feedstock options as risk increasing. Sorghum is a very common rotational crop option in Kansas and is somewhat drought tolerance. Somer perennials, such as grasses and switchgrass can be grown on marginal land, reducing the impact on the production of annual crops. Uncertainty of financial returns should decrease farmer's attitude to plant bioenergy crops. Farmers in western Kansas who are uncertain about the financial returns from a feedstock enterprise are 11 percent more likely to harvest crop residues. This may be due to the fact that baling crop residues may be much more familiar than planting a new crop. It is important to note that farmer's uncertainty about innovation is high when farmers do not have information, or the quality of information is low.

Operational and financial characteristics will play a role in the adoption of bioenergy feedstocks both in Kansas and across the Great Plains. Larger farms in eastern and central Kansas are less likely to harvest crop residues, possibly due to the added cost of this enterprise and time constraints of doing the operations. The percent of land rented had a negative effect on harvesting crop residues and planting an annual bioenergy crop in central Kansas, but had a positive effect on planting an annual bioenergy crop in western KS. Given the drought tolerance nature of annual bioenergy crop options, such as forage sorghum, land owners may be willing to support their tenants in having a crop that can be grown in rotation with other annual crops and conserves water. On the other hand, if farmers have a share-crop agreement with the land owner, farmers may be less willing to enter into a bioenergy feedstock enterprise at this time due to a potential negative reaction from the land owner as the income stream may be somewhat uncertain. If a farm already sells to a bio-refinery directly then they are less likely to harvest crop residues in western Kansas. These farmers may not be willing to jeopardize their current relationships with existing bio-refineries for a more uncertain and riskier option. Farms with a higher debt percentage were more willing to produce an annual bioenergy crop in central Kansas and less willing in western Kansas. Farms with a higher percentage of their sales from crop production were less likely to be willing to harvest crop residues in western Kansas. Farmers who produce livestock may not want to plant a feedstock that does not provide silage for their livestock. Farmers in central Kansas who raise livestock were 6.5 less willing to plant an annual bioenergy crop.

Farm demographics can play an important role in the adoption of new technologies [12]. In the case of Kansas, off-farm income was a statistically significant factor for some feedstocks. Farmers were 7.3 % more likely to plant an annual bioenergy crop in western Kansas and 8.2 percent more likely to plant a perennial bioenergy crop across Kansas if they had income from off the farm. Supplemental income from off the farm can provide insurance against potential losses from undertaking new enterprises on the farm. Farmers with more years of experience in western Kansas were less willing to plant a bioenergy crop. Farmers with more years of experience may not be willing to undertake the risk of a new crop [12]. Not surprisingly, farmers who had a college degree were 4.9 % more likely to harvest crop residues in eastern Kansas and 7.1 percent more likely to grow a perennial bioenergy crop across Kansas. In general, beneficial innovations tend to be adopted more quickly by landholders with high levels of education [14]. Of interest, is that female farm operators in central and western Kansas were 17 percent less likely to harvest crop residues, as well as 9.8 percent less likely to plant a perennial bioenergy crop. In contrast, female farm operators in eastern Kansas were 22% more willing to plant an annual bioenergy crop.

Conservation can play a role in adoption of bioenergy feedstocks, given the potential environmental and soil impacts. Removal of crop residues can increase exposure to soil erosion while planting of perennial bioenergy crops may increase soil productivity over time by helping to restore soil health [15] and [16]. In eastern Kansas, farmers who use conservation practices such as no tillage are 7.9% less likely to harvest crop residues. In eastern and central Kansas, farmers who participate in conservation programs are 10 to 13% less likely to harvest crop residues or plant an annual bioenergy crop. In contrast, farmers in western Kansas who have CRP land would be willing to plant a perennial bioenergy crop.

6. Conclusions

The differences in the factors affecting the adoption of alternative cellulosic bioenergy feedstock options highlights the differences between the nature of the different feedstocks and how regional differences can play a significant role. Harvesting of crop residues is a value-added enterprise that may have adverse environmental consequences. Planting of an annual bioenergy crop provides an additional crop for crop rotations in Kansas, which can be diverse. A perennial bioenergy crop option provides an opportunity to transition CRP land or other marginal land into a potentially productive enterprise that can help restore soil health and productivity. Furthermore, the differences across regions highlight the cultural and farming contexts under which adoption will occur. Although more work needs to be done about bioenergy crop adoption, it is important to note that the results of this study can guide decision makers, such as farmers, bio-refineries, and policy makers. For instance, many of the marginal effects for biophysical variables were not significant, which could partially be due to farmers' lack of familiarity with producing biomass feedstocks. Also, farmer's perceptions play an important role in the willingness to plan biofuel crops in Kansas. In other words, farmers that manage farms to maximize profit avoid planting crops with uncertain returns, and who are risks averse will change the biofuel feedstock options they will consider. In addition, regional differences in Kansas can play a significant role in adoption. Thus, the differences across regions highlight the cultural and farming contexts under which adoption will occur.

Finally, all of these results emphasize the need of bio-refineries and industry to adapt their approaches to contracting and outreach to farmers appropriately based on the cellulosic feedstocks they wish to pursue to produce biofuels. Thus, future research should pay attention on programs to create a sustainable market for biofuels from cellulosic sources.

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Table 1: Descriptive Statistics for Dependent and Explanatory Variables for Biofuel Feedstock Adoption Models

Variable	Description	Mean (Standard Deviation)[a] Eastern	Central	Western	2007 Ag Census (State Mean)[b]
	Dependent Variables				
Agricultural Residues	Equal to '1' if farmer would be willing to harvest agricultural residues (binary).	0.252 (0.434)	0.209 (0.407)	0.220 (0.415)	---
Annual Bioenergy Crops	Equal to '1' if farmer would be willing to grow an annual bioenergy crop in rotation (binary).	0.285 (0.452)	0.286 (0.452)	0.311 (0.464)	---
Perennial Bioenergy Crops	Equal to '1' if farmer would be willing to grow a perennial bioenergy crop (binary).	0.277 (0.448)	0.246 (0.431)	0.222 (0.416)	---
	Regional Explanatory Variables (Fixed Effects)				
Northern	Equal to '1' if operates in USDA-NASS KS agricultural reporting district 10, 40 or 70 (binary).	0.38	0.28	0.35	---
Central	Equal to '1' if operates in USDA-NASS KS agricultural reporting district 20, 50 or 80 (binary).	0.33	0.39	0.34	---
Southern	Equal to '1' if operates in USDA-NASS KS agricultural reporting district 30, 60 or 90 (binary).	0.31	0.39	0.38	---
	Weather Explanatory Variables				
Average Palmer Z Index	Mean Monthly Palmer Z Drought Index over past 10 years	0.53 (0.16)	0.56 (0.038)	0.46 (0.084)	---
Standard Deviation Palmer Z Index	Standard Deviation of the Palmer Z Drought Index over past10 years.	2.05 (0.16)	2.04 (0.095)	2.02 (0.14)	---
	Landscape and Soil Explanatory Variables				
Depth to Water Table	Spatially weighted average minimum depth to water table (cm) in counties farmer operates.	51.10 (15.91)	46.77 (33.05)	30.55 (27.82)	---
K-W Factor	Spatially weighted average K-W factor (for soil erosion) in counties farmer operates.	0.34 (0.029)	0.29 (0.10)	0.25 (0.15)	---
Organic Matter Percentage	Spatially weighted average organic matter percentage in the soil in counties farmer operates.	1.99 (0.45)	1.38 (0.65)	0.89 (0.57)	---
Available Water Content	Spatially weighted average available water content in counties farmer operates.	0.17 (0.022)	0.16 (0.057)	0.14 (0.083)	---
	Farm Management and Perception Explanatory Variables				
Environmental Protection	Equal to '1' if farmer manages farm to protect soil and/or land quality (binary).	0.91	0.89	0.91	---
Profit Maximizer	Equal to '1' if farmer manages farm to maximize profits (binary).	0.92	0.90	0.89	---
Uncertainty	Equal to '1' if farmer avoids planting crops with uncertain income (binary).	0.55	0.58	0.62	---
Risk Avoider	Equal to '1' if farmer describes themselves as a risk avoider (binary).	0.38	0.42	0.42	---
	Farm Operation and Characteristic Variables				
Percent of Land Rentedai	Percent of total land that is rented (0 to 100).	39.36 (35.82)	43.50 (37.37)	40.52 (38.30)	---
Percent of Land Irrigated	Percent of total crop land that is irrigated (0 to 100).	1.43 (8.90)	4.58 (15.96)	10.07 (22.36)	---
Farm Size	Size of farm (acres).	692.11 (790.23)	953.33 (1078.53)	2299.47 (14157.01)	863.01
Break Crop Rotation	Equal to '1' if farmer broke their crop rotation in 2010 (binary).	0.25	0.22	0.20	---
Raise Livestock	Equal to '1' if the farmer raises livestock (binary).	0.61	0.54	0.44	---

Table 1 continued.

Variable	Description	Mean (Standard Deviation)[a] Eastern	Central	Western	2007 Ag Census (State Mean)[b]
		Farm Financial Explanatory Variables			
Percent of Sales from Corp Production	Percentage of sales from crop production in 2010 (0 to 100).	64.61 (30.76)	68.52 (27.64)	67.23 (30.16)	---
Percent of Sales from Government Payments	Percentage of sales from government agricultural payments (0 to 100)	4.62 (10.33)	6.03 (10.15)	9.73 (14.34)	---
Sell Grain to Bio-refinery	Equal to '1' if farmer contracts directly to a bio-refinery (binary).	0.059	0.041	0.082	---
Debt Percentage	Percent of farm assets financed with debt (0 to 100).	19.06 (22.74)	19.56 (23.49)	21.39 (24.49)	---
		Demographic Explanatory Variables			
Off-Farm Income	Equal to '1' if a member of the farm household works off the farm (binary).	0.55	0.54	0.54	0.47
Years Farming	Number of years the operator has been farming.	36.47 (14.11)	34.63 (15.11)	35.17 (14.95)	26.14[c]
Female Operator	Equal to '1' if the farm operator is a female (binary).	0.042	0.041	0.062	0.11
College Degree	Equal to '1' if the farm operator has earned a college degree (binary).	0.30	0.39	0.39	---
		Conservation Management Explanatory Variables			
Total CRP Acres	Total acres in the Conservation Reserve Program	18.82 (53.75)	34.16 (106.08)	93.62 (245.53)	---
Participate in EQIP and/or CSP	Equal to '1' if the farmer participates in EQIP (The Environmental Quality Incentives Program) and/or the CSP (Conservation Stewardship Program) (binary).	0.15	0.10	0.13	---
Use No Tillage	Equal to '1' if the farmer uses no tillage on-farm (binary).	0.67	0.64	0.71	---
Number of Observations		624	923	437	---

[a] Standard deviations are provided for continuous variables, but not for binary variables, as they are function of the mean. That is, the standard deviation of a binary variables is equal to $\sqrt{p(1-p)}$, where p is the mean of the binary variable.
[b] Means are computed using data from the 2007 Agricultural Census (USDA-NASS, 2012) for all farms with more than 50 acres in agricultural production.
[c] This figure represents the average number of years on the present farm in the 2007 Agricultural Census.

Table 2: Marginal Effects Estimates and Fit Statistics by Cellulosic Feedstock Alternative and Region in Kansas for Estimated Logit Models[a]

Variable	Crop Residues East	Crop Residues Central	Crop Residues West	Annual Bioenergy Crop East	Annual Bioenergy Crop Central	Annual Bioenergy Crop West	Perennial Bioenergy Crop
Weather Explanatory Variables							
Average Palmer Z Index	-0.12	-0.23	-0.83*	0.093	0.13	-0.12	0.015
	(0.39)	(0.45)	(0.51)	(0.40)	(0.49)	(0.53)	(0.12)
Standard Deviation Palmer Z Index	0.043	-0.047	0.013	0.31	-0.046	-0.16	-0.11**
	(0.20)	(0.13)	(0.13)	(0.20)	(0.14)	(0.13)	(0.05)
Landscape and Soil Explanatory Variables							
Depth to Water Table	0.0022*	0.0008	0.0003	0.0025*	-0.0006	-0.0008	0.0004
	(0.0013)	(0.0007)	(0.0008)	(0.0013)	(0.0008)	(0.0009)	(0.0004)
K-W Factor	-2.64***	-0.45	-1.15	-3.16***	0.10	-0.0087	-0.025
	(1.08)	(0.68)	(1.20)	(1.11)	(0.78)	(1.37)	(0.40)
Organic Matter Percentage	-0.059	0.057	-0.029	-0.043	-0.0001	0.18	0.025
	(0.047)	(0.049)	(0.15)	(0.047)	(0.055)	(0.17)	(0.024)
Available Water Content	2.70*	0.37	3.08	0.98	-0.50	-0.023	0.15
	(1.48)	(1.17)	(2.79)	(1.50)	(1.33)	(3.18)	(0.71)
Farm Management and Perception Explanatory Variables							
Environmental Protection	0.082	-0.015	-0.11	0.051	-0.019	-0.17	0.050
	(0.054)	(0.045)	(0.09)	(0.059)	(0.051)	(0.090)	(0.032)
Profit Maximizer	-0.021	-0.012	0.068	0.032	-0.013	0.14**	-0.020
	(0.070)	(0.047)	(0.058)	(0.066)	(0.054)	(0.063)	(0.037)
Uncertainty[b]	0.021	0.031	0.11***	-0.056	0.037	0.044	0.019
	(0.042)	(0.030)	(0.044)	(0.042)	(0.033)	(0.047)	(0.022)
Risk Avoider[b]	-0.058	-0.018	-0.031	0.089**	-0.0045	-0.031	0.053**
	(0.040)	(0.030)	(0.044)	(0.044)	(0.033)	(0.048)	(0.023)
Farm Operation and Characteristic Variables							
Percent of Land Rented	-0.0003	-0.0006*	0.0005	-0.0003	-0.0008*	0.0016***	-0.0004
	(0.0005)	(0.0004)	(0.0006)	(0.0005)	(0.0005)	(0.0006)	(0.0003)
Percent of Land Irrigated	-0.0031	-0.0006	0.0001	-0.0028	-0.0009	0.0004	-0.0007
	(0.0025)	(0.0009)	(0.0009)	(0.0025)	(0.0010)	(0.011)	(0.0007)
Farm Size	0.0000*	-0.0000*	-0.0000	0.0000	0.0000	-0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Break Crop Rotation	0.0001	-0.018	-0.062	0.0089	0.0028	-0.020	0.028
	(0.041)	(0.032)	(0.046)	(0.042)	(0.037)	(0.054)	(0.024)

Table 2 continued.

Variable	Crop Residues			Annual Bioenergy Crop			Perennial
	East	Central	West	East	Central	West	Bioenergy Crop
Raise Livestock	0.0065	0.0012	-0.033	-0.0025	-0.065*	-0.0001	-0.024
	(0.042)	(0.033)	(0.044)	(0.043)	(0.036)	(0.0017)	(0.023)
Farm Financial Explanatory Variables							
Percent of Sales from Crop Production	0.0001	-0.0001	-0.0015*	-0.0001	-0.0004	-0.0012	-0.0006
	(0.0007)	(0.0006)	(0.0008)	(0.0007)	(0.0007)	(0.0009)	(0.0004)
Percent of Sales from Government Payments	0.0005	-0.0001	0.0001	0.0023	-0.0023	-0.0001	-0.0001
	(0.0019)	(0.0006)	(0.0015)	(0.0020)	(0.0018)	(0.0017)	(0.0009)
Sell Grain to Bio-refinery	-0.091	-0.0041	-0.17***	0.056	-0.031	-0.082	-0.0045
	(0.065)	(0.070)	(0.045)	(0.086)	(0.075)	(0.074)	(0.043)
Debt Percentage	0.0011	0.0005	-0.0013	0.0010	0.0012*	-0.0025***	0.0005
	(0.0008)	(0.0006)	(0.0009)	(0.0008)	(0.0007)	(0.0010)	(0.0004)
Demographic Explanatory Variables							
Off-Farm Income	0.036	-0.018	0.050	0.030	0.031	0.073*	0.082***
	(0.038)	(0.029)	(0.040)	(0.038)	(0.032)	(0.045)	(0.021)
Years Farming	0.0004	-0.0000	0.0012	-0.0009	0.0004	0.0002	-0.0027***
	(0.0014)	(0.0010)	(0.0014)	(0.0014)	(0.0011)	(0.0015)	(0.0007)
Female Operator	0.14	-0.17***	-0.17***	0.22**	-0.019	-0.11	-0.098**
	(0.099)	(0.036)	(0.050)	(0.10)	(0.073)	(0.084)	(0.041)
College Degree	-0.015	0.049*	-0.0008	0.030	-0.019	0.039	0.071***
	(0.040)	(0.029)	(0.041)	(0.041)	(0.032)	(0.047)	(0.022)
Conservation Management Explanatory Variables							
Total CRP Acres	-0.0002	-0.0001	0.0001	-0.0003	-0.0002	0.0000	0.0002**
	(0.0004)	(0.0002)	(0.0001)	(0.0004)	(0.0002)	(0.0001)	(0.0001)
Participate in EQIP and/or CSP	0.0026	-0.13***	-0.013	-0.099**	-0.093**	0.0061	0.040
	(0.051)	(0.035)	(0.059)	(0.047)	(0.047)	(0.068)	(0.031)
Use No Tillage	-0.079*	-0.038	0.039	-0.024	-0.050	0.089*	0.059***
	(0.043)	(0.030)	(0.047)	(0.043)	(0.033)	(0.053)	(0.022)

Table 2 continued.

Variable	Crop Residues			Annual Bioenergy Crop			Perennial Bioenergy Crop
	East	Central	West	East	Central	West	
				Fit Statistics			
Log-Likelihood	-338.7	-450.8	-206.4	-352.5	-537.1	-250.0	-1040.2
AIC	737.3	961.5	472.8	765.0	1134.1	560.0	2140.4
Psuedo-R^2	0.04	0.05	0.10	0.07	0.03	0.10	0.06
Within Sample Prediction %	75	79	79	73	71	71	75
Likelihood Ratio Test Statistic for Significance of North, Central and South Fixed Effects (p-value)	3.96 (0.27)	1.73 (0.63)	6.17 (0.10)	5.76 (0.12)	0.89 (0.83)	0.93 (0.82)	6.78 (0.079)
Number of Observations	624	923	437	624	923	437	1923
Likelihood Ratio Test Statistic for Equality of Coefficients Across East, Central and West (P-value)[c]		77.83 (0.061)			86.21 (0.015)		65.16 (0.30)

[a] Asymptotic standard errors are in parentheses. '***', '**' and '*' denotes statistical significance at the 1, 5 and 10 percent levels. Significance levels are determined by using a z-statistic to test whether the marginal effect is statistically different from 0.

[b] An interaction between risk and uncertainty was included in the estimated logit model to capture the relationship between these factors in the model. Marginal effects for these two factors are estimated accordingly.

[c] The likelihood ratio test is conducted to test if the coefficients between the separate models for East, Central and West for each feedstock are statistically different. This is done using a stratified logistic regression model with regional dummy variables for central and western Kansas interacted with each explanatory variable in the model for each feedstock type. The likelihood ratio test is testing the significance of the additional interaction terms.