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Farmers' Willingness to Produce Alternative Cellulosic Biofuel Feedstocks Under Contract in Kansas Using Stated Choice Experiments

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Many studies have assessed the technical feasibility of producing bioenergy crops on agricultural lands. However, while it is possible to produce large quantities of agricultural biomass for bioenergy from lignocellulosic feedstocks, very few of these studies have assessed farmers' willingness to produce these crops under different contracting arrangements. The purpose of this paper is to examine farmers' willingness to produce alternative cellulosic biofuel feedstocks under different contractual, market, and harvesting arrangements. This is accomplished by using enumerated field surveys in Kansas with stated choice experiments eliciting farmers' willingness to produce corn stover, sweet sorghum and switch grass under different contractual conditions. Using a random utility framework to model the farmers' decisions, the paper examines the contractual attributes that will most likely increase the likelihood of feedstock enterprise adoption. Results indicate that net returns above the next best alternative use of the land, contract length, cost-share, financial incentives, insurance, and custom harvest options are all important contract attributes. Farmers' willingness to adopt and their willingness-to-pay for alternative contract attributes vary by region and choice of feedstock.

Keywords: Adoption, Contract, Corn Stover, Sweet Sorghum, Switchgrass, Willingness-to-Pay

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INTRODUCTION

Despite yearly standards set by the Environmental Protection Agency (EPA), the production of biofuels from cellulosic biofuel feedstocks continues to fall short of projected levels, the majority of which are mandated to be from biomass-based diesel, advanced biofuels, and total renewable fuels. The Energy Information Administration (EIA) projects that approximately 5.0 million gallons of cellulosic biofuel will be produced in 2013, which is far short of the original 1.0 billion gallon biofuel production goal set for this year [1]. However, the U.S. EPA proposed mandate for 2013 cellulosic biofuel production is greater at approximately 14 million gallons, but this revised mandate is substantially less than the original mandate [2]. According to the "EPA Finalized 2012 Renewable Fuel Standards" the original target levels may still be attainable [3]; and as per the standards set by the Energy Independence and Security Act of 2007, any new biofuels produced after 2016 must originate from cellulosic feedstocks [4].

A growing body of research concerning the production of biofuels has focused on the technical and economic feasibility, as well as the potential supply of alternative sources of cellulosic biofuel feedstocks [5-14]. These studies establish the feasibility of a market, but do not examine the necessary market and institutional conditions for a market to develop [15]. Rajagopal and Zilberman [16] indicate that their still exists a need to understand the factors that lead to the adoption of biofuel technologies by farmers. Much still remains unexplored and unknown about farmers' potential to commit land, labor and resources to the production of bioenergy crops [17].

Research examining the adoption of alternative cellulosic feedstocks by farmers is limited [18-24]. It is likely that farmers will supply cellulosic feedstocks only if a contract is offered by processors [15]. Contractual arrangements will be affected by many factors, such as contract pricing, timeframe, acreage commitments, risk, timing of harvest, yield variability, feedstock quality, harvest responsibilities (*e.g.* custom harvesting), nutrient replacement, location of biorefineries, available cropping choices, technology, and conservation considerations [9, 25, 26]. Contractual arrangements with individuals or groups of producers (*e.g.*, via a cooperative) is likely necessary to ensure an adequate supply of feedstocks in the long-term [9, 25].

The purpose of this study is to examine farmers' willingness to produce alternative cellulosic biofuel feedstocks under alternative contractual arrangements. Specifically, the study focuses on three feedstocks: corn stover, sweet sorghum and switchgrass, to examine a value-added option, a dedicated annual bioenergy crop, and dedicated perennial energy crop suitable for production in the Great Plains. Farmers' willingness to produce under different contractual arrangements is assessed using an enumerated field survey with stated choice techniques. The survey examines what characteristics farmers prefer in production contracts and their impact on the potential likelihood of a farmer adopting a biomass feedstock enterprise. A stated choice approach following Louviere et al. [27] is used to assess farmers' willingness to adopt and survey results are analyzed using a conditional logistic regression model with error components [28, 29].

DATA AND METHODS

Survey

A survey was administered from November 2010 to February 2011 by Kansas State University and the USDA, National Agricultural Statistics Service (NASS) to assess farmers' willingness to produce cellulosic biomass in the form of corn stover, sweet sorghum, and switchgrass for bioenergy production under different contractual arrangements. A total of 485 farmers were contacted in northeastern, south central, and western Kansas to participate in the survey. These areas of Kansas were selected based on the number of farms growing corn and sorghum; proximity to future potential cellulosic bio-refinery locations; differences in climatic conditions; and use of irrigation. Western Kansas is the largest producer of irrigated corn, while central Kansas is the largest producer of dryland sorghum. Northeastern Kansas primarily produces corn and soybeans, and is the southwestern fringe of the Cornbelt.

In each area, a random sample of approximately 160 farms with 260 or more acres and a minimum of $50,000 in gross farm sales were selected from USDA-NASS's farmer list. The sampling requirements were set to target only commercial farms that will be more likely to produce cellulosic biomass that could maintain a cellulosic biofuel industry. Farmers already participating in USDA-NASS enumerated surveys (e.g. ARMS) were replaced with other randomly selected farmers from the USDA-NASS farmer list. The stated choice component of the survey was field tested with focus groups at an annual extension conference and then the entire survey was tested using face-to-face interviews with farmers in the targeted study areas.[1]

Potential participants were first mailed a four page flier asking for their participation in the survey and providing information about cellulosic biofuel feedstock production prior to being contacted by USDA-NASS enumerators. USDA-NASS enumerators then proceeded to schedule one hour interviews with the farmers to complete the entire survey, which on average took 57 minutes to complete. Upon completion of the survey and receipt by USDA-NASS, farmers were compensated for their time with a $15 gift card. Of the 485 farmers contacted, 290 completed the survey and 38 were out-of-business, did not farm, or could not be located, giving a response rate of 65 percent. Further, a few surveys (5 to 6) were found to be unusable when analyzing each stated choice experiment due to an incomplete or irregular response. The survey included questions about farmers' farming operations; willingness to produce feedstocks under contract;

[1] Two focus group sessions were held at the Annual Risk and Profit Conference in Manhattan, KS in the summer of 2010. Participants who were identified as farmers were invited to attend the focus group session, of which 12 participated.

biofuel feedstock production preferences and perceptions; on-farm conservation practices; risk management practices and perceptions; crop marketing practices; and demographics. A smaller sample of farmers was surveyed for this study, because all surveys were conducted face-to-face; the use of a more intensive and lengthy survey instrument; and that stated choice experiments do not require as many participants, as each participant provides multiple observations to capture variability in preferences [27].

Farmer demographics taken from the 2007 U.S. Census of Agriculture [30] were used to determine whether the survey respondents are representative of Kansas farmers. Table 1 compares some of the demographics as reported by farmers in the survey to statewide numbers as recorded in the 2007 Census of Agriculture. Farms in the survey are slightly larger in size on average, due to the selection criteria utilized.

Stated Choice Experiments

Stated choice experiments refer to a group of methods where subjects are presented a set of alternatives with varying attributes. The attributes represent different characteristics of the alternatives being offered to the subject. By varying attribute levels or options, subjects can be presented with different sets of alternatives from which they can choose. Subjects are then asked to select the alternative they most prefer [27, 31]. These methods have been used in a variety of settings and disciplines, including marketing, transportation, psychology, environmental valuation, municipal planning and water policy. The approach is based on random utility theory, a rigorous modeling framework [32, 33]. This approach can provide data with more explanatory and predictive power in subsequent analysis than other similar methods [34].

A separate stated choice experiment was designed to assess farmers' willingness to enter into a contract with a bio-refinery or other biomass processor for producing each feedstock alternative: corn stover, sweet sorghum and switchgrass, following Louviere *et al*. [27] and Roe *et al*. [35]. Farmers where presented with information about the production of each feedstock and potential contract attributes before answering the stated choice questions. For each feedstock experiment, survey participants where asked to consider 5 independent choice sets, where they were asked to select between two biomass contracts or an "opt out" option resulting in three contract options for each feedstock choice set (see Figure 1 for an example scenario for each feedstock type). The contract attributes (characteristics), descriptions and levels used to develop the stated choice sets are provided in Table 2. Each choice set presented to a respondent asked them to select between Contract A, Contract B, or a "Do Not Adopt" option (C). The contract attributes selected were tested in focus group sessions with farmers at the Annual Risk and Profit Conference in Manhattan, KS in August 2010 to assess the significant factors that may affect farmers' adoption of cellulosic feedstock production under contract. The attributes selected were further supported by responses of the farmers to survey questions asking why they would adopt, which included net returns, contract length, nutrient replacement, uncertainty and incentive payments/cost-share, in that order of importance. Further analysis of other survey results is provided in Fewell et al. [36].

Following Louviere *et al*. [27], a collective factorial design is adopted, which combines all attributes for all options (i.e. Contract A, Contract B and "Do Not Adopt) in a choice set into one experimental design. The size of the collective factorial is $(L^A)^M$, where M is the number of options in the choice set; A is the number of attributes for each option; and L is the number of levels for a given attribute. A fractional factorial design was then obtained from the collective factorial to obtain the number of choice sets that would allow identification of all main effects and potential interaction effects between contract attributes and levels. A separate choice experiment was designed independently for each feedstock. A $(2^3 \text{ x } 3 \text{ x } 4)^2$ fractional factorial experimental design was used to design the choice sets for the sweet sorghum experiment; a $(2^4 \text{ x } 3)^2$ fractional factorial experimental design was used to design the choice sets for the switchgrass experiment; and a $(2^3 \text{ x } 3 \text{ x } 4)^2$ was used to design the choice sets for the corn stover experiment. PROC OPTEX in SAS was used to develop the fractional factorial design for each experiment from the collective factorial to obtain 90 random choice sets, which were then blocked into 18 blocks of 5 choice sets each.[2] The *D*-optimality criterion was used to obtain an optimal design using a modified Federov search algorithm [37]. Optimal blocking was determined following the method outlined in Cook and Nachtsheim [38].[3] Thus, in each version of the survey, a respondent was asked to consider 5 choice sets for each feedstock alternative, resulting in 18 versions of the survey (from blocking). Each version had all three choice experiments present for each feedstock being examined. To avoid potential bias in the presentation of the experiments, the ordering of the experiments in each survey version was randomized. Survey versions were then randomly assigned to each survey participant. Of the 290 usable surveys completed, 12 to 20 of each version were completed. For statistical analyses of the stated choice data 284, 285 and 284 surveys (providing 1420, 1425 and 1420 observations) were usable to analyze the corn stover, sweet sorghum and switchgrass stated choice experiments, respectively.[4]

[2] The version of software used was SAS 2008. Windows, Version 9.2. SAS Institute, Inc., Cary, NC.

[3] The D-Efficiency (Treatment D-Efficiency) for the corn stover, sweet sorghum and switchgrass choice experiment designs were 93.52 (80.27), 87.12 (70.96), and 91.73 (77.61), respectively.

[4] The number of observations for each stated choice experiment is equal to the number of usable surveys times 5, since each respondent answered 5 choice questions for each experiment.

Model

Following Roe *et al*. [35], we assume that producers want to maximize expected discounted utility when choosing to adopt a contract to produce a cellulosic feedstock. Let producer *j*'s expected discounted utility for contract option *i* be given by:

$$V_{j,i} = V(\Delta R_i, B_i, S_i, C_i, G_i, E_{j,i}) + \varepsilon_{j,i} , \quad (1)$$

where ΔR_i is the net returns above the next best alternative enterprise over time; B_i is a variable indicating if a biomass harvest option is part of contract i; S_i is a variable indicating if crop insurance is available; C_i is the length of the contract in years; G_i is the level of government incentive payment, cost share or nutrient replacement; and $E_{j,i}$ is a vector of error components included to account for choice situation invariant variation. It is assumed that all $E_{j,i}$ are mean zero with variance equal to one [28, 29]). The error term, $\varepsilon_{j,i}$ represents the nonsystematic part of expected utility that is unobserved by the modeler and is distributed with respect to type I extreme value [27].

It should be emphasized, that the inclusion of ΔR_i captures the return above the next best alternative for sweet sorghum and switchgrass. This is unique to this experimental set-up and important in that bioenergy crops may compete for land traditionally planted for other cash crops. For example, a farmer may replace grain sorghum or wheat in a crop rotation with sweet sorghum (as a dedicated annual bioenergy crop) if the returns for production are higher for sweet sorghum. Thus, the opportunity cost from alternative land uses be taken into consideration. For sweet sorghum, we assumed a farmer could plant corn or sorghum at an average return of $50 per acre instead of sweet sorghum, based on net return data from the Kansas Farm Management Association [40]. Similarly, we assume a farmer could produce hay or keep land in the Conservation Reserve

Program (CRP) for an average return of $40 per acre [40]. Thus, the experimental set-up takes into account the potential next best alternative for the land.

The econometric model adopted is based upon a main effects model with error components following Bhat [28]. The reduced-form representation of expected utility for equation (1) [35], for producer j and contract i:

$$V_{j,i} = \beta_0 + \beta_1 \Delta R_i + \beta_2 C_i + \beta_3 B_i + \beta_4 S_i + \beta_5 G_i + \gamma_1 W_i + \gamma_2 C_i + \sum_j \theta_j E_{j,i} + \varepsilon_{j,i}, \ j=A,B,C, \quad (2)$$

where θ_j represents the standard deviation of the error component or random effect associated with $E_{j,i}$. The additional variables W_i and C_i represent regional dummy variables equal to 1 if a producer is from western (W) or Central (C) Kansas, respectively. The inclusion of the regional dummies is to capture differences in cultural practices, climate and farmer demographics across different regions of Kansas. The error components allow the model to capture correlations among contract options and between the alternative choice scenarios facing a respondent [29, 39]. For the "opt out" option in each choice scenario, $\boldsymbol{\beta} = 0$ and $\boldsymbol{\gamma} = 0$, thus, $V_{O,i} = \theta_O E_{O,i} + \varepsilon_{j,i}$, where O designates the option to not adopt or opt out. Models are estimated using NLOGIT 4.0 using simulated maximum likelihood with 1000 Halton draws using the BFGS Quasi-Newton Algorithm [29].

A common use of the econometric model results is to estimate what a producer would be willing to pay (WTP) for a given contract attribute. For example, what would a producer be willing to pay to reduce their contract length by 1 year? Following Greene [39], a producer's willingness to pay for a (one unit change) in a contract attribute would be equal to $\frac{\beta_k}{\beta_1}$. Here, values of k = 2,3,4 designates the coefficients on other contract attributes. The asymptotic standard error for the WTP measures estimated using the above formula can be determined using the delta method as suggested by Greene [39].

RESULTS

Based on other data collected in the survey, under favorable contractual conditions, 56.6, 84.9 and 83 percent of farmers would be willing to adopt a value-added feedstock enterprise, such as corn stover, in western, central and northeastern Kansas, respectively. For a dedicated annual bioenergy crop, such as sweet sorghum, 60.6, 68.8 and 61.1 percent of farmers would be willing to adopt the crop in western, central and northeastern Kansas, respectively. Finally, 36.4, 54.3 and 45.3 percent of farmers would be willing to adopt a perennial bioenergy crop option, such as switchgrass, in western, central and northeastern Kansas, respectively. Thus, adoption of these options does vary by region and the difference in adoption rates between alternative feedstocks likely indicates the differences in how farmers view each of these feedstock options. For example, corn stover is a value-added enterprise, sweet sorghum can be rotated with traditional cash crops, and switchgrass is a perennial option that may be grown on marginal lands. Further, crop residue may be desired for moisture conservation as you move west across Kansas given the drier climate. That is, crop residues, such as corn stover, can provide soil coverage, helping to increase soil moisture content.

Table 3 shows the econometric modeling results and select willingness-to-pay measures for the conditional error component logistic regression models estimated for corn stover, sweet sorghum and switchgrass. The McFadden Pseudo-R^2 values indicate a relatively good fit for the models to the data. Two regional dummy variables (for the western and central regions) to capture differences across regions were included in each model. The western regional dummy variable was statistically significant for corn stover and switchgrass, while the central regional dummy variable was statistically significant for sweet sorghum and switchgrass. These estimation results indicate that farmers in Western, KS are less likely to harvest corn stover and more likely to plant a perennial bioenergy crop, such as switchgrass, compared to farmers in northeastern, KS. Similarly, farmers in central, KS are more likely to plant sweet sorghum and switchgrass than farmers in northeastern, KS. These results confirm the willingness to adopt statistics for the feedstocks presented above.

The error components were only significant for Option C in the corn stover equation and for Contract B in the sweet sorghum equation. Inclusion of the error components allows for substitution between the options in estimated conditional logistic regression models estimated, by relaxing the independence of irrelevant alternatives assumption of the conditional logistic regression model. The results suggest that there is likely some heterogeneity between respondents for the corn stover and sweet sorghum model. This heterogeneity may arise due to differences in survey respondents' preferences for different contract attributes and feedstock options. Not taking account of preference heterogeneity may bias model results.

Coefficient estimates in Table 3 indicate, that as net returns per acre under the contract increase (relative to the next best alternative) the likelihood of producing a feedstock will increase. All of the coefficient estimates on the contract attributes are statistically significant at a 1 percent level of significance. Furthermore, as the length of a contract increases, the likelihood of production for each feedstock decreases, indicating farmers find longer contracts undesirable, possibly due to reduced management flexibility for the farmer. Having a biorefinery harvest option increases the likelihood of producing all of the feedstocks, providing more flexibility for timing of farming operations. The availability of insurance increases the likelihood of farmers producing both sweet sorghum and switchgrass, reducing the potential risks faced by farmers under contract.

For corn stover, nutrient replacement is a significant concern [41]; and farmers are more likely to harvest corn stover if the nutrients are replaced.

As shown in other literature previously described, results indicate incentive payments and establishment cost share will both increase the likelihood of producing sweet sorghum and switchgrass. Given the 2 to 3 year period needed to establish switchgrass, biomass revenues during this time may be substantially reduced, necessitating the need for cost-share to influence farmers to adopt [42,43]. Incentive payments for biomass delivered to a bio-refinery, similar to those under the Biomass Crop Assistance Program administered by the USDA, Farm Service Agency, will likely increase adoption of annual and perennial bioenergy crops; but the timing of incentive payments is important. Incentive payments that dwindle out after an initial payment period may reduce adoption in the long-run [44]. Thus, policymakers need to keep in mind that not only is the level of the incentive important, but the timing and type of incentive matters as well.

Farmers may be willing to give up or require more net returns, depending on the favorability of the contract negotiated. Results in Table 3 show farmers' willingness to pay for different levels of certain contract attributes, which are all statistically significant at the 1 percent level of significance. Longer contracts may provide less flexibility for farmers, especially in an uncertain market. Based on model results, farmers would be willing to pay or willing take a reduction in net returns equal to \$1.60, \$2.16 and \$1.03 per acre under contract to reduce the length of the contract by 1 year for corn stover, sweet sorghum and switchgrass, respectively. The willingness to take a reduction for switchgrass is the least, which is expected given it takes a number of years to reach full maturity and yield potential. In contrast, sweet sorghum has the highest WTP, which may be due to the fact that it can be rotated with other cash crops and a farmer may be willing to pay more to have increased flexibility with the crop rotation.

The addition of a biomass harvest option, where the farmer has the option to have the bio-refinery harvest their crop, can provide additional flexibility for the farmer, especially if the timing of practices for other cropping enterprises overlap or interfere. A farmer's willingness to pay to have this option in the contract is equal to $10.95, $7.04 and $4.25 per acre for corn stover, sweet sorghum and switch grass, respectively. One way to view these WTP estimates is by the amount a farmer would be willing to pay to have the option of the refinery or a custom harvester harvest and collect the biomass from the field.

Farmers would be willing to pay (or give up in net returns) $5.15 and $2.96 per acre to have insurance available for sweet sorghum and switchgrass production under contract, respectively. The lower WTP for switchgrass compared to sweet sorghum may indicate that the farmer requires higher net returns to adopt switchgrass under contract. This may be due to the fact that farmers are likely to be risk-averse [44]. Insurance for both the annual and perennial crops options are highly statistically significant, potentially indicating that farmers desire insurance due to the uncertainty in this nascent market. For the harvest of crop residues, farmers are willing to pay $11.03 per acre for a nutrient replacement option in a contract to harvest corn stover as a biofuel feedstock. While this amount may not reflect the actual loss in nutrients due to residue removal and potential soil loss [45, 46], the amount indicates that farmers are aware of this loss and would like to have the option to be compensated for it when choosing a contract. The nutrient loss may lower yield potential of the crop planted after removal [26, 47].

CONCLUSIONS

The paper examines farmers' willingness to produce alternative cellulosic biofuel feedstocks under alternative contractual arrangements. Specifically, conditional error components logistic regression models were estimated to assess farmers' preferences for adopting corn stover, sweet sorghum and switchgrass under contract given different contractual attributes, including net returns, contract length, a bio-refinery harvest option, availability of insurance, nutrient replacement and incentive payments. Data was obtain from an enumerated survey with three stated choice experiments examining farmers' willingness to adopt each of the three feedstocks examined, as well as farm demographics and biofuel preferences. The effect of contract attributes on contract selection and feedstock adoption, as well as, willingness to pay for contract attributes was estimated.

The study finds that both the different regions (and surrounding areas) in Kansas accounts for different adoption patterns for alternative cellulosic biofuel feedstocks. It is likely that sweet sorghum (and possibly other varieties of energy sorghum) will be adopted in central Kansas and similar regions. This has implications for the location of bio-refineries producing cellulosic ethanol. In addition, contracts for producing needed cellulosic feedstocks will affect production, as well. The study finds that the level of net returns above the next best alternative land-use, contract length, having a biorefinery harvest option, availability of insurance, and having monetary incentives/cost-share are important contract attributes. Bio-refineries and other intermediate processors trying to establish a local market will have to take these considerations into account when trying to negotiate contracts with farmers. Contracts accepatable to farm managers may vary considerably by region. Furthermore, the impact of different contract attributes on contract adoption depends on the feedstock being considered. This is further supported by the WTP estimates for the contract attributes. Farmers' were willing to reduce their net returns from $1.03

(sweet sorghum) to $2.16 (switchgrass) per acre to reduce contract length by a year; and willing to pay $4.26 (switchgrass) to $10.95 (corn stover) to have the option of the biorefinery harvest biomass. The differences in WTP varied by feedstock, indicating that farmers viewed the management and production of these feedstocks differently, which must be considered by bio-refineries and other intermediate processors when contracting. Given that bio-refineries may use multiple feedstocks, refineries and processors may have to consider different contracts with farmers for each feedstock being considered. Thus, the choice of feedstock and contract being offered will affect the local supply of total biomass available.

The results here provide avenues for further research. Probabilities of farmer adoption under alternative contractual scenarios could be incorporated into logistic and supply chain models for cellulosic biomass being converted to ethanol to provide more realistic estimation of supply and demand in these markets. In addition, it is likely that farmer demographics, such as age, education, risk attitudes, etc. would impact farmers' willingness to produce alternative cellulosic feedstocks. Future research will integrate these factors into probabilistic models of farmer adoption to assess their impact on contract selection and bioenergy crop adoption.

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Table 1. Comparison of Kansas Farmer Demographics to Survey Respondents

	2007 Census of Agriculture[a]	Survey (N = 290)
Age	57.7 years	55.1 years
Average size of farm	707 acres	2172 acres
Average amount of rented land on farm	863 acres	1271 acres
Average amount of owned land on farm	381 acres	900 acres
Average amount of permanent pasture land on farm	398 acres	594 acres
Average market value of agricultural products	$219,944	$200,000 to $399,999[b]

[a] *Source*: National Agricultural Statistics Service, USDA [30]

[b] Category represents the one chosen with the highest frequency by respondents.

Table 2: Contract Attributes and Levels for Stated Choice Experiments for Corn Stover, Sweet Sorghum and Switchgrass

Contract Attribute	Description	Levels
Net Returns (for all features of the contract except cost-share and government payments)	*For Corn Stover*: Represents the ***average annual expected net return*** above variable costs under the contract to the farmer on a per acre basis. This amount is received after all expenses are paid, including harvest and nutrient replacement. *For Sweet Sorghum and* Switchgrass: Represents the expected ***percentage*** gain under the contract ***above*** net returns associated with corn/sorghum production for sweet sorghum and hay production and/or CRP rental payments for switchgrass on a farmers operation. As a reference point, on average, returns from corn/sorghum production are expected to be $50 per acre and hay production or income from land in CRP are expected to be around $40 per acre in Kansas.	*For Corn Stover:* $0, $10, $20 and $30 *For Sweet Sorghum*: 0%, 15%, 30% and 45% *For Switch-grass*: 5%, 20% and 35%
Contract Length	Represents the time commitment in consecutive years of the contractual agreement.	*For Corn Stover and Sweet Sorghum*: 2,5 and 8 years *For Switch-grass:* 7 and 16 years
Biorefinery Harvest	"Yes" indicates the bio-refinery will harvest the biomass at their expense, and "No" means the farmer is responsible for harvest (including cutting, raking, baling and transportation to the bio-refinery). Harvest charges are included in the percentage net return. That is, the charges are considered paid regardless of who harvests the biomass.	Yes or No
Insurance Availability (Sweet Sorghum and Switchgrass Only)	"Yes" indicates crop insurance is available, and "No" otherwise.	Yes or No
Nutrient Replacement (Corn Stover Only)	"Yes" indicates the bio-refinery will provide the farmer a negotiated amount for lost nutrients (N, P and K) from biomass removal, and "No" otherwise. This amount is assumed to be included in the annual expected net returns. In other words, a "Yes" includes net returns with nutrient replacement costs accounted for.	Yes or No
Government Incentive Payment (Sweet Sorghum Only)	This incentive payment is provided at two levels for production of cellulosic biofuel feedstocks delivered to a bio-refinery. The incentive levels are either none (0) or 25 percent of the price per dry ton of biomass delivered to the refinery. The incentive received is in addition to the net returns above production.	0% and 25%
Seed/Establishment Cost Share (Switchgrass Only)	Indicates a percentage of seed/establishment costs for a perennial are covered or cost-shared by the biorefinery or processor during the first two years of production or after planting due to lower yields during the establishment period. Establishment costs can range from $150 to $200 per acre. This will be provided every time the crop is replanted. This cost-share is provided in addition to the net returns indicated above.	0%, 35% and 70%

Table 3: Conditional Error Component Logistic Regression Results and Willingness-to-Pay Estimates for Selected Attributes for Corn Stover, Sweet Sorghum and Switchgrass

	Corn Stover		Sweet Sorghum		Switchgrass	
Variable (Attribute)[c]	**Coefficient Estimate (Standard Error)[a]**	**Willingness-to-Pay[b]**	**Coefficient Estimate (Standard Error)[a]**	**Willingness-to-Pay[b]**	**Coefficient Estimate (Standard Error)[a]**	**Willingness-to-Pay[b]**
Intercept	-4.49** (0.62)	---	-4.01** (0.69)	---	-6.96* (0.96)	---
Net Returns	0.13** (0.0084)	---	0.14** (0.0080)	---	0.16* (0.018)	---
Contract Length	-0.21** (0.029)	-$1.60** (0.20)	-0.31** (0.025)	-$2.16* (0.17)	-0.16* (0.016)	$-1.03* (0.12)
Biorefinery Harvest Option	0.73** (0.075)	$10.95** (1.09)	0.51** (0.073)	$7.04* (1.01)	0.33* (0.077)	$4.26* (0.97)
Insurance Availability	---	---	0.37** (0.074)	$5.15* (1.01)	0.23* (0.087)	$2.96* (1.06)
Nutrient Replacement	0.74** (0.067)	$11.03** (1.16)	---	---	---	---
Government Incentive Payment	---	---	0.041** (0.0064)	---	---	---
Seed/Est-ablishment Cost Share	---	---	---	---	0.025* (0.0028)	---
Western, KS	-1.26* (0.76)	---	0.41 (0.81)	---	1.94* (1.05)	---
Central, KS	0.99 (0.70)	---	2.37** (0.80)	---	3.74** (1.03)	---
			Error Components			
Contract A	0.32 (14.96)		0.84 (10.41)		0.38 (2.66)	
Contract B	0.49 (17.87)		3.50* (1.93)		2.63 (6.31)	
Option C (Do Not Adopt)	3.58* (2.01)		2.14 (4.32)		4.01 (4.33)	
			Fit Statistics			
Log-Likelihood	-738.85		-851.46		-675.64	
McFadden Pseudo R^2	0.53		0.46		0.57	
AIC	1.05		1.21		0.97	
Number of Observations[d]	1420		1425		1420	

[a] * indicates statistical significance at the 0.10 level, and ** indicates statistical significance at the 0.01 level.
[b] Willingness-to-Pay for an attribute is calculated as the attribute coefficient divided by the *net returns* attribute coefficient following Greene [37]. Estimates are not made for incentive payments and seed/establishment cost share due to interpretability. Asymptotic standard errors were estimated using the delta method [37].
[c] All binary attributes are all effects coded for model estimation.

[d] The number of observation is equal to the number of usable surveys times 5, given each respondent answered 5 choice questions for each stated choice experiment conducted.

Corn Stover Scenario:

		Contract A	Contract B	Option C
Contract Features	**Net Returns**	$0/acre/year	$30/acre/year	Do Not Adopt
	Contract Length	2 years	2 years	
	Biorefinery Harvest	Yes	No	
	Nutrient Replacement	No	Yes	
	Your Ranking (1-3)	2003 ☐	2004 ☐	2005 ☐

Sweet Sorghum Scenario:

		Contract A	Contract B	Option C
Contract Features	**Net Return Above Sorghum/Corn Production (Base: $50/ac)**	45% Higher/year	0% Higher/year	Do Not Adopt
	Contract Length	5 Years	2 Years	
	Biorefinery Harvest	Yes	No	
	Insurance Availability	No	No	
	Gov. Incentive Payment	None	25%	
	Your Ranking (1-3)	2048 ☐	2049 ☐	2050 ☐

Switchgrass Scenario:

		Contract A	Contract B	Option C
Contract Features	**Net Return Above Hay Production/CRP Rental Rates (Base: $40/ac)**	35% Higher/year	35% Higher/year	Do Not Adopt
	Contract Length	7 Years	16 Years	
	Biorefinery Harvest	Yes	Yes	
	Insurance Available	No	Yes	
	Seed/Establishment Cost-Share	70%	None	
	Your Ranking (1-3)	2069 ☐	2070 ☐	2071 ☐

Figure 1: Example Choice Scenarios/Questions for Stated Choice Experiments