ESSAYS ON KANSAS FARMERS' WILLINGNESS TO ADOPT ALTERNATIVE ENERGY CROPS AND CONSERVATION PRACTICES

by

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B.S., North Dakota State University, 2007
M.S., North Dakota State University, 2009

AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

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Abstract

The adoption of new technologies on-farm is affected by socio-economic, risk management behavior, and market factors. The adoption of cellulosic biofuel feedstock enterprises and conservation practices plays an important role in the future of Kansas agriculture. No set markets currently exist for bioenergy feedstocks and farmers may be reluctant to produce the feedstocks without contracts to mitigate uncertainty and risk. Adoption of conservation practices to improve soil productivity and health may be affected by risk considerations also. The purpose of this dissertation is to study how market mechanisms and risk influence Kansas farmers' willingness to adopt cellulosic biofuel feedstock enterprises and conservation practices on-farm.

The first essay examines farmers' willingness to grow switchgrass under contract using a stated choice approach. Data were collected using an enumerated survey of Kansas farmers and analyzed using latent class logistic regression models. Farmers whose primary enterprise is livestock are less inclined to grow switchgrass. In addition, shorter contracts, greater harvest flexibility, crop insurance, and cost-share assistance increase the likelihood farmers will grow switchgrass.

The second essay examines how farmers' risk perceptions impact conservation practice adoption. Factor analysis of survey data was used to identify primary risk management behaviors of Kansas farmers. A multinomial logit model of conservation practice adoption incorporating these risk behaviors was developed. Estimation results indicate that different risk management factors may have no significant impact on practice adoption. Farmers may not consider certain aspects of risk significant in their adoption decision.

The third essay examines the effect of different risk management behaviors on farmers' willingness to produce alternative cellulosic bioenergy feedstocks under contract. Data were collected using a farmer survey with a set of stated choice experiments and analyzed using factor analysis and latent class logistic regression models. While farmers approach risk management differently, the risk management behaviors identified have no significant impact on farmers' willingness to produce corn stover and switchgrass but have a negative impact on farmers' willingness to produce sweet sorghum as a biofuel feedstock. These results may indicate that farmers are indifferent toward adopting new bioenergy cropping enterprises when traditional crop production is profitable and more certain.

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Dedication

To Teresa, Mary Catherine, and Oliver.

Chapter 1 - Purpose and Objectives

1.1 Introduction

Federal mandates requiring the use of "advanced" biofuels have been in place since 2007 (U.S. Congress, 2007). Advanced biofuels are produced from products such as wood chips; agricultural residue or other waste materials; grease; other organic matter; or "sugars from sources other than corn starch" and have greenhouse gas emissions at least 50% below emissions produced from gasoline in 2005 (U.S. Congress, 2007). Lignocellulosic biofuel is biofuel with greenhouse gas emissions at least 60% below baseline GHG emissions (U.S. National Archives and Records Administration, 2010). The Renewable Fuel Standard (RFS) contained in the Energy Independence and Security Act of 2007 and administered by the Environmental Protection Agency (EPA) requires the volume of renewable fuel to increase from nine billion gallons in 2008 to 36 billion gallons annually by 2022 to help meet this goal (U.S. Congress, 2007). In addition, beginning in 2015, the amount of renewable fuel produced from cornstarch should not exceed 15 billion gallons with the remainder coming from advanced biofuels in subsequent years (U.S. Congress, 2007). Important lignocellulosic sources of biomass for advanced biofuel production include agricultural residues, bioenergy crops, woody resources, and algae.

Changes in production from altering cropping systems to produce biomass for biofuel production will impact farm management and bring about additional issues involving processing and transportation at the farm level. This can change the amount of GHG emissions released into the atmosphere (Feng, Rubin, & Babcock, 2008). Next generation biofuels, such as those produced from corn stover, switchgrass, forage sorghum, miscanthus, algae, yellow grease, or a host of other products can help meet EPA's guidelines, particularly with respect to ethanol, and can potentially reduce GHG emissions. However, farmers' willingness to produce bioenergy crops depends on the enterprise's profit potential, farmers' risk aversion, and other economic costs. Well-established infrastructures (production, harvest, storage, price risk management, transportation, etc.) and markets exist for corn, but not for other biomass sources such as switchgrass or corn stover (Epplin, Clark, Roberts, & Hwang, 2007). A great deal of uncertainty still exists regarding biomass production, marketability, storage, and transportation.

1.2 Problem Statement

Much research has assessed the technical feasibility of producing biofuels from lignocellulosic materials on agricultural land in North America (de la Torre Ugarta, English, & Jensen, 2007; Graham, 1994; Graham, Nelson, Sheehan, Perlack, & Wright, 2007; Heid, 1984; Gallagher et al., 2003; Perlack et al., 2005; Walsh, de la Torre Ugarte, Shapouri, & Slinsky, 2003; Nelson et al., 2010). However, technical feasibility studies do not provide "necessary economic and institutional conditions" that a cellulosic biofuel industry requires (Rajagopal, Sexton, Roland-Holst, & Zilberman, 2007). While farmers' ability to produce adequate quantities of biomass for bioenergy is technically feasible, their willingness to do so under different contractual, pricing, storage, and transportation arrangements is unknown, especially with respect to perennial biomass crops such as switchgrass and miscanthus. In addition, evaluating farmers' risk aversion and perceptions about growing bioenergy crops requires study before a market develops, given the potential uncertainty and risk of adopting new crops on-farm.

The lack of an established market adds a great deal to the uncertainty farmers face during development of a nascent industry. Farmers' decisions to grow biomass will depend on profit potential, machinery requirements, markets, government policy, and other subjective criteria specific to each operator (Paine et al., 1996; Mapemba & Epplin, 2004). In addition, farmers' willingness to adopt new technologies or practices often depends on their knowledge of the technology or practice and their skills at operating or implementing the practice (Pannell et al., 2006). Farmers' willingness to grow new crops likely depends on land tenure, demographic, risk, and social characteristics as well. Some research has attempted to determine how these factors affect farmers' adoption characteristics with respect to biofuel crops (Anand et al., 2008; Bransby, 1998; Hipple & Duffy, 2002; Kelsey & Franke, 2009; Jensen et al., 2007). Farmers will grow bioenergy crops if the returns to the crop outweigh production costs, including opportunity costs (Rajagopal et al., 2007). However, the production of dedicated energy crops combined with decreases in traditional crop, forage, and livestock production may cause prices for these displaced commodities to increase in the long term and competition among dedicated energy crops to increase (Dicks et al., 2009; Walsh et al., 2003).

Well-established markets exist for most commodities farmers produce, which decreases uncertainty and risk (Epplin et al., 2007). Given biomass markets are not yet established, it is likely farmers will only grow bioenergy crops under contractual relationships that establish pricing, timeframe, harvest timing, storage requirements, acreage requirements, yield requirements, and other arrangements between farmers and biorefineries (Altman, Boessen, & Sanders, 2007; Epplin et al., 2007; Glassner, Hettenhaus, & Schechinger, 1998; Larson, English, & Lambert, 2007; Stricker, Segrest, Rockwood, & Prine, 2000; Wilhelm, Johnson, Hatfield, Voorhees, & Linden, 2004). A processing plant will value the product as an input, and base the product's value on the eventual output (e.g., ethanol) price. Disparities between biorefineries and farmers' views about the value of the biomass necessitate careful contract design.

Farmers may be extremely risk averse given uncertainty in the market and unfamiliarity with growing a new crop. Thus, understanding farmers' risk attitudes and how it impacts their decisions is important. Farmers' risk takes many forms relating to production (yield), prices (markets), finance, government policies, and the overall business (Dismukes, 2012). Farmers' risk perceptions and attitudes towards these different areas affect their decision-making. These perceptions are often unobserved, yet play an important part in each person's decision-making process. Determining farmers' risk attitudes will help understand how their perceptions of risk and uncertainty affect their decisions whether to adopt a new enterprise or practice.

The purpose of this dissertation is to analyze important contract features that influence Kansas farmers' willingness to grow switchgrass for bioenergy and how risk perceptions affect their decision-making with regard to adopting new enterprises or environmental practices.

1.3 Research Objectives

Popular options for bioenergy crops in Kansas are agricultural residues such as corn stover, sweet or forage sorghum, and perennial crops such as switchgrass. A stated choice survey was administered to Kansas farmers to assess their willingness to produce these potential energy crops under contract. This study has three primary objectives. First, it seeks to determine farmers' willingness to grow switchgrass as a bioenergy crop focusing on contract attributes that farmers deem important. Second, it seeks to determine how farmers' risk perceptions affect their decision-making with respect to adoption decisions, focusing on conservation practice adoption. Third, it seeks to determine how farmers' risk perceptions affect their decisions to adopt alternative cellulosic biofuel feedstocks under contract. The stated choice survey offered respondents alternative contract options with different prices, contract lengths, biomass harvesting arrangements, insurance options, and government incentive or cost-share options to produce three biofuel feedstocks.

The next sections provide brief outlines of the three essays that make up this dissertation.

1.4 ESSAY 1 - Farmers' Willingness to Grow Switchgrass as a Cellulosic Bioenergy Crop: A Stated Choice Approach

Switchgrass has been pushed as a popular biomass crop in the U.S. for production of liquid transportation fuels (i.e., ethanol) to reduce greenhouse gas emissions and dependence on petroleum-based fuel products. While many research studies have assessed farmers' technical feasibility of producing energy crops such as switchgrass, their willingness to do so has received less attention. The most likely market vehicle between farmers and biorefineries will be some kind of contract, but the exact form of the contract is likely to change depending on the attributes contained in the contract. This essay's purpose is to assess Kansas farmers' willingness to grow switchgrass as a bioenergy crop under alternative contracting scenarios using a stated choice survey approach. The research examines other factors affecting farmers' decision-making such as farm size, sales, crops grown, and perceptions about biofuels.

A stated choice survey was administered to 485 Kansas farmers to assess their willingness to produce alternative feedstocks for biofuels. The survey asked about willingness to grow three types of biomass feedstocks: corn stover, sweet sorghum, and switchgrass. After answering a number of questions about their farming operation, respondents were asked about their willingness to produce switchgrass as a cellulosic biofuel feedstock under contract. In addition, respondents were asked about biofuel feedstock production preferences and perceptions; conservation on-farm; risk management practices and perceptions; crop marketing practices; and demographics.

An expected utility model was used to determine farm characteristics, bioenergy contract features, bioenergy production characteristics, and farm characteristics that influence a farmer's decision to produce switchgrass for bioenergy production. A latent class logit model was used to determine which variables and contract attributes are important for decision makers. Results found that differences exist among farmers' willingness to produce switchgrass for bioenergy depending on whether they are livestock producers. Results also show that farmers prefer contracts with higher net returns, shorter contract lengths, an option for the biorefinery to custom harvest, an insurance mechanism, and a cost-share program to help establish biofuel feedstock production.

1.5 ESSAY 2 - Farmer Risk Perceptions and Conservation Practice Adoption

Agricultural producers' risk perceptions are believed to play an important part in their decisions. Assuming farmers maximize utility when deciding whether to adopt a new crop enterprise, purchase machinery, or adopt a conservation practice, it can be shown that they will also consider risk when making these decisions. The purpose of this essay is to study farmers' risk perceptions and how they influence adoption decisions, specifically conservation practice adoption. The objectives are to determine whether risk perceptions related to management, finances, or government policy affect farmers' conservation adoption practices.

A survey was administered by Kansas State University and the Kansas Office of the National Agricultural Statistics Service to assess farmers' willingness to grow crops for biofuels, their risk perceptions, conservation practice adoption, and general information about their operations. The survey asked farmers to self-report their risk perceptions on how they manage financial and personal risk related to their farm operations and families. The respondent used a six-point Likert scale from "strongly disagree" to "strongly agree" to respond to statements requesting their views on a number of personal risk-related issues. In addition, farmers were asked to rank themselves with respect to how their neighbors viewed their risk-taking behavior.

Factor analysis grouped respondents by risk attitudes to determine how they view risk in relation to production, marketing, conservation, and adoption. Factors relating to operational management, insurance use, and off-farm income and investments were found to be the most important for the respondents.

After estimating the risk factors, a multinomial logit regression determined how the respondents use conservation on their farms subject to these risk factors. Results show that their risk attitudes toward management style, insurance use, and off-farm income do not affect their decisions to adopt conservation practices significantly, indicating that certain risk perceptions play a small role in their decisions to adopt practices that may or may not necessarily increase farm profits or reduce risk.

1.6 ESSAY 3 - Farmers' Risk Perceptions in Stated Choice Experiments on Adoption of Alternative Cellulosic Biofuel Feedstocks

Much uncertainty surrounds development of a cellulosic bioenergy industry. Production of cellulosic and other "second-generation" biofuels continues to lag U.S. federal government mandates requiring increased use of these fuels. The Renewable Fuels Standard (RFS2) contained in the Energy Independence and Security Act of 2007 (EISA) proposed that 500 million gallons of cellulosic biofuels be produced in 2012. However, under the Environmental Protection Agency's rule-making power, they reduced the amount to 10.45 million gallons based on actual production capabilities (U.S. Environmental Protection Agency, 2012). Due to this industry uncertainty, farmers may be reluctant to participate in new ventures to produce energy crops. Without established markets and prices, farmers may be reluctant to produce a product. In addition, farmer perceptions about biofuels and renewable energy in general will influence their decisions whether to begin producing a bioenergy crop. Traditional crops and livestock have well-established futures and spot markets, so farmers know their production has an outlet, they understand production risks, and they are able to forward contract their production and hedge market risk. In addition, farmers have a variety of insurance products available to cover yield and revenue losses for both crops and livestock.

Much research has studied consumers' willingness to pay for products, tourism amenities, or improved environmental conditions by including consumers' risk perceptions about food, product safety, environmental quality, etc. In a similar way, overall risk perceptions and perceptions about growing non-traditional crops can play an important role in determining whether farmers are willing to produce bioenergy crops. The purpose of this paper is to determine how risk and other unobserved factors affect farmers' choices in stated choice experiments assessing farmers' willingness to adopt cellulosic bioenergy feedstocks.

A survey was administered by Kansas State University and the Kansas Office of the National Agricultural Statistics Service to assess farmers' willingness to grow crops for biofuels, their risk perceptions, conservation practice adoption, and general information about their operations. In addition, farmers were asked to rate the degree to which they agree or disagree with certain statements designed to assess their perceptions about bioenergy crop production. These questions included statements about preferred biofuel crop traits, bioenergy crop contracting options, and farmers' overall willingness to grow bioenergy crops. The survey asked farmers to self-report their risk perceptions on how they manage financial and personal risk related to their farm operations and families. Risk questions included statements on their habits with respect to purchasing medical and life insurance, maintaining a line of credit, marketing, and using information to make decisions. Respondents used a six-point Likert scale where 1 = strongly disagree and 6 = strongly agree to respond to risk perception questions.

A random utility model was used to determine how a farmer's individual-specific characteristics and personal risk perceptions affect his/her decision without focusing only on the choice attributes contained in the study. A latent class model was used to determine how unobserved risk classes fit farmers into different categories when considering three cellulosic biofuel crop options in a stated choice framework. The biofuel crop options are corn stover, sweet sorghum, and switchgrass. Results indicate that risk perceptions do not influence farmers' decisions about whether to adopt cellulosic biofuel feedstocks significantly.

Results also indicate farmers prefer shorter contracts to longer-term contracts for annual bioenergy crops such as corn stover or sweet sorghum, higher returns, and a biorefinery harvest option regardless of the latent class they fall in. In addition, they prefer insurance, government incentives, and an establishment cost-share incentive to produce cellulosic bioenergy feedstocks. Willingness to pay estimates also vary depending on latent class membership.

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Chapter 2 - Farmers' Willingness to Grow Switchgrass as a Cellulosic Bioenergy Crop: A Stated Choice Approach

2.1 Introduction

Federal mandates requiring the use of "advanced" biofuels have been in place for a number of years (U.S. Congress, 2007). Important lignocellulosic sources of advanced biomass include agricultural residues, bioenergy crops, woody resources, and algae. However, large-scale commercial production of these biomass sources is not yet viable economically, and a great deal of uncertainty exists about biomass production, storage, and transportation.

Much research has assessed the technical feasibility of producing biofuels from lignocellulosic materials on agricultural land in North America (de la Torre Ugarta, English, & Jensen, 2007; Graham, 1994; Graham, Nelson, Sheehan, Perlack, & Wright, 2007; Heid, 1984; Gallagher et al., 2003; Perlack et al., 2005; Walsh, de la Torre Ugarte, Shapouri, & Slinsky, 2003; Nelson et al., 2010). However, technical feasibility studies do not assess "necessary economic and institutional conditions" required by a cellulosic biofuel industry (Rajagopal, Sexton, Roland-Holst, & Zilberman, 2007). While farmers' ability to produce adequate quantities of biomass for bioenergy throughout the Great Plains has been ascertained, their willingness to do so under different contractual, pricing, and harvesting conditions is relatively unknown, especially with respect to perennial biomass crops such as switchgrass and miscanthus.

Much of the previous research has assessed the viability of growing bioenergy crops from the perspective of land availability and farmer profitability. But an important consideration is that the shift from the production of traditional crops to energy crops will alter the traditional crop mix. Farmers will likely grow less corn, soybeans, wheat, sorghum, alfalfa, hay, cotton, or rice, and more biomass crops under satisfactory prices and contractual conditions. In addition, land previously enrolled in conservation programs may be moved into energy-crop production to help meet renewable fuel requirements.

The lack of an established market adds a great deal to the uncertainty farmers face during development of this nascent industry. Farmers' willingness to adopt new technologies or practices often depends on their knowledge of the technology or practice and their skills at operating or implementing the practice (Pannell et al., 2006). However, farmers' willingness to grow new crops likely depends not only on knowledge and skill, but also on land tenure, demographic, and social characteristics. Some research has attempted to determine how these factors affect farmers' adoption characteristics with respect to biofuel crops (Anand et al., 2008; Bransby, 1998; Hipple & Duffy, 2002; Jensen et al., 2007; Kelsey & Franke, 2009). Farmers will grow bioenergy crops if the returns to the crop outweigh production costs, including opportunity costs (Rajagopal et al., 2007). However, the production of dedicated energy crops combined with decreases in traditional crop, forage, and livestock production will cause prices for these displaced commodities to increase in the long term, increasing competition for dedicated energy crops (Dicks et al., 2009; Walsh et al., 2003).

Well-established markets exist for most commodities farmers produce, which decreases uncertainty and risk (Epplin, Clark, Roberts, & Hwang, 2007). But because biomass markets are not yet established, it is likely farmers will grow bioenergy crops under contractual relationships that establish pricing, timeframe, harvest parameters, storage requirements, acreage requirements, quality levels, and other arrangements between farmers and biorefineries (Altman, Boessen, & Sanders, 2007; Epplin et al., 2007; Glassner, Hettenhaus, & Schechinger, 1998; Larson, English, & Lambert, 2007; Stricker, Segrest, Rockwood, & Prine, 2000; Wilhelm, Johnson, Hatfield, Voorhees, & Linden, 2004). Processing plants will value the product as an input, and base the value on the price it can receive for the output produced, while farmers' decisions to grow biomass will depend on profit potential, machinery requirements, markets, government policy, and other subjective criteria specific to each operator (Paine et al., 1996; Mapemba & Epplin, 2004). The disparity between biorefineries and farmers' views about the value of the biomass necessitates careful contract design.

One of the popular options for a bioenergy crop in the Great Plains is switchgrass, because switchgrass planting decreases soil erosion over cultivation, uses half as much nitrogen fertilizer as corn, requires one herbicide application in the establishment year, and is both more drought and flood tolerant than traditional crops (McLaughlin & Walsh, 1998). However, switchgrass production is less likely to occur on highly productive land and more likely on marginal land or land already enrolled in conservation programs, such as CRP, to increase revenue (Paine et al., 1996).

This study seeks to determine farmers' willingness to grow switchgrass as a bioenergy crop while helping facilitate contract design and biomass price establishment. Few (if any) studies have elicited farmers' opinions about bioenergy crops and assessed their willingness to produce these crops instead of traditional crops. With farm profitability at near record highs, it is even more important to assess whether farmers are willing to enter into bioenergy crop enterprises or continue with their established practices. A stated choice survey was developed to elicit Kansas farmers' willingness to grow switchgrass as a bioenergy crop under alternative contractual, pricing, and harvesting arrangements. The stated choice format allows farmers to choose among alternatives following Louviere, Rose, and Greene (2005) and survey results are analyzed using a latent class conditional logistic regression model (Greene & Hensher, 2003).

The next section discusses growing switchgrass as a bioenergy crop, followed by a description of the survey and data. The conceptual model and econometric analysis follow the survey discussion. Finally, the results and conclusion end the paper.

2.2 Switchgrass as a Bioenergy Crop

The viability of producing switchgrass as a bioenergy feedstock in the Great Plains has been the topic of much research (Perlack et al., 2005; Mapemba & Epplin, 2004; Epplin et al., 2007; Bangsund, DeVuyst, & Leistritz, 2008). Switchgrass is a perennial grass, native to much of the Great Plains, and has been touted as a significant potential bioenergy crop based on research conducted across 31 locations over several years in the late 1980s and early 1990s (Wright, 2007). It requires low maintenance after its establishment phase, is noninvasive, and is suited to many soil types in different parts of the country, including marginal lands not as productive for high-value crops such as corn or soybeans (Wright, 2007). Harvesting, transporting, and storing switchgrass is similar to well-established hay production practices (Wright, 2007), although long-term biomass storage may reduce ethanol yields (Rigdon, Maier, Vadlani, & Jumpponen, 2011). In addition, planting switchgrass (or other perennial crop) may reduce soil erosion and increases soil carbon content, improving soil health (Wright, 2007; McLaughlin et al., 2002).

Production costs for switchgrass in the initial establishment phase vary depending on the amount of field preparation needed, fertilizer needs, and seeding rate. Establishment costs can range from about $150 to $200 per acre and yield during the first two years' of production are reduced until the crop becomes established (Griffith, Epplin, & Redfearn, 2010). Annualized costs of establishing switchgrass are between $20 and $30 per acre over 10 years (Griffith et al., 2010). Annual production costs can range from $175 to $285 per acre depending on yields of two to six tons per acre, transportation, and capital costs (Griffith et al., 2010). Switchgrass is planted in the spring and weeds are controlled via spraying, mowing, or grazing (Ohlenbusch, 1997). After the crop is well established, 90 to 120 pounds of nitrogen fertilizer can be applied to increase production, followed by phosphorus and potassium if soil testing warrants it (Ohlenbusch, 1997; Teel, Barnhart, & Miller, 2003). Fertilizer rates and costs will vary depending on soil requirements and location.

As a national average, switchgrass has the potential to produce 8.4 tons per acre annually (McLaughlin et al., 2002) with local yields reaching over 15 tons per acre depending on rainfall, length of growing season, soil types, etc. Yields in the plains states may not reach these levels due to extreme growing conditions. In addition, nitrogen use is lower and returns are higher for switchgrass than other types of grasses that have a potential use as a biofuel feedstock (Aravindhakshan, Epplin, & Taliaferro, 2011).

McLaughlin et al. (2002) determined there is potential to produce switchgrass in the United States east of the Rocky Mountains on 16.9 million acres at prices of $39.92 per short ton at the farm gate. This price may entice farmers to plant switchgrass rather than traditional crops. However, high commodity prices in recent years may preclude farmers' planting of switchgrass in favor of traditional cash crops.

2.3 Survey Methods and Data

A stated choice survey was administered from November 2010 to February 2011 in three areas of Kansas by Kansas State University and the USDA, National Agricultural Statistics Service (NASS). The survey assessed 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/or sorghum and the mix of irrigated and dryland production. A random sample of approximately 160 farms over 260 acres in size and $50,000 in gross farm sales were selected from the USDA-NASS farmer list for each area of the state examined. Farmers already participating in other USDA-NASS enumerated surveys (e.g., ARMS) were removed from the sample and replaced with another randomly drawn name. Prior to the survey entering the field, the stated choice component was field tested with focus groups at an annual extension conference hosted by the Department of Agricultural Economics at Kansas State University and the entire survey was tested using face-to-face interviews with farmers in the targeted study areas.

Potential participants received a four-page flier via mail asking for their participation in the survey and providing information about cellulosic biofuel feedstock production on-farm one week prior to being contacted by USDA-NASS enumerators. Enumerators then scheduled one-hour interviews with the farmers to complete the survey and stated choice experiments. Interviews, on average, took 57 minutes to complete. Upon completion of the survey and receipt at the USDA-NASS office in Topeka, 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. Thus, the survey response rate was (290/(485-38)) = 0.65 or 65 percent. Of the 290 respondents who completed the stated choice experiment for switchgrass, six surveys were incomplete due to lack of responses on the switchgrass experiment or refusal to answer demographic questions, leaving 284 usable surveys for this study.

After answering a number of questions about their farming operation, respondents were asked about their willingness to produce switchgrass as a cellulosic biofuel feedstock under contract. Respondents were then asked about biofuel feedstock production preferences and perceptions; conservation on-farm and perceptions; risk management practices and perceptions; crop marketing practices; and demographics.

Farmer demographics taken from the 2007 U.S. Census of Agriculture (National Agricultural Statistics Service, 2009) were used to determine whether the survey respondents were representative of Kansas farmers. Table 2.1 compares some of the demographics reported by farmers in the survey to statewide numbers as recorded in the 2007 Census of Agriculture. The percentage of farmers who are white is the same for both the census and survey. A slightly lower average age is reasonable given our survey sampled larger farms that are likely to be operated by younger farmers. Average farm size and amount of rented land are considerably larger for our survey since we sampled farms over 260 acres in our sample, thus eliminating many small, or hobby farms. More of the survey respondents are male than in the Census figures. Average value of agricultural products found in the survey includes the value reported by Census figures. The survey asked respondents to choose a range in which their agricultural value of sales fell, and the most oft chosen range matches Census data.

2.3.1 The Stated Choice Experiment

A stated choice experiment was designed to assess farmers' willingness to produce switchgrass for biofuel under contract with biorefineries or other biomass processors following Louviere, Hensher, and Swait (2000) and Roe, Sporleder, and Belleville (2004). The survey provided a brief explanation of switchgrass production and explained the contract attributes, shown in Figure 2.1 before requiring a response to the set of stated choice questions shown in Figure 2.2. Survey respondents were asked to consider five independent choice scenarios with options to choose between two contracts or an "opt out" option, as shown in Figure 2.2. Contract options were unlabelled and had five attributes: (1) Net returns above CRP or Hay Production, (2) Contract Length, (3) Biorefinery Harvest Option, (4) Insurance Availability, and (5) Seed Cost-Share Provision. Descriptive statistics for the attributes and levels are shown in Table 2.2 and discussed in the next section.

It is assumed that switchgrass will only be planted on marginal land (that may not be renewed in the Conservation Reserve Program (CRP)) or that is currently in hay production. Therefore, net returns above hay or CRP payments had three levels: 5%, 20%, and 35%. Using the percentage net returns above those earned from traditional crop production practices (assumed to be about $40 per acre), a market price for biomass can be determined using production costs and crop yields, without putting a precise monetary value on the biomass. In addition, using the percentage net return above hay or CRP production will allow prices to "float" to levels that will entice farmers to adopt switchgrass. Farmers understand returns per acre, so asking them to indicate a desired return per acre is useful because many farmers are unwilling to make a decision to grow biomass without knowing production costs and actual dollar returns based on prices and yields. Then, a biomass price can be determined from price and yield combinations that produce the farmers' desired return per acre. Policy makers and the biofuel industry will benefit from the survey results because they will know whether farmers are willing to supply biomass, while realizing prices required for farmers to adopt. The method benefits biorefineries by helping them determine prices they can afford to pay for biomass by knowing how much farmers require to make it a worthwhile enterprise. The attribute is recoded from a percentage to a dollar amount for analysis purposes, using $40 as a base net return.

Contract length has two levels: 7 years and 16 years. Since switchgrass is planted approximately once every ten years, a producer may wish to enter into a contract length of at least seven years. If they choose to continue producing switchgrass, it is likely they would enter into a contract for 16 (or more) years. However, 7- and 16-year contracts allow a producer to discontinue switchgrass production if they chose to transition their land back into regular crop or hay production, or CRP.

To add flexibility to the contract options, an effects coded (−1, +1) biorefinery harvest option is included as a binary choice that offers a custom harvest option at the biorefinery's expense, but does not require the farmer to allow the biorefinery on their land to harvest the biomass. Net returns is assumed to include the cost of biorefinery harvest. Insurance availability is another effects coded binary attribute that indicates whether a crop-insurance type instrument is available for farmers to purchase under the biomass contract. Effects coding helps capture the grand mean of a utility function without confusing a base level mean that can occur when assigning dummy codes or usual (i.e., 1,0) binary coding (Hensher, Rose, & Greene, 2005). In addition, assigning a zero to the value would indicate the attribute is not included in the contract. Finally, a seed-cost share attribute is included with three levels: 0%, 35%, and 70%. The high cost of establishing switchgrass may necessitate the biorefinery's sharing in seed costs. The three levels indicate a percentage of the seed cost the biorefinery would pay under each contract scenario.

The choice scenarios contain two generically labeled contracts with attributed levels assigned randomly and an option to "opt out." Following Louviere et al., (2000) a $(3^2 \times 2^3)^2$ fractional factorial design was used to develop 90 random choice sets in order to identify all main effects and any potential interaction effects between attributes and levels. The choice sets were randomly assigned into 18 blocks (18 survey versions) and each respondent was presented with five choice scenarios (see Figure 2.2).

2.3.2 Summary Statistics

The most popular first choice among respondents was "do not adopt" with 1047 of 1420 responses. This leaves only 373 choices, or 26.3%, where a contract (either A or B) would be adopted. This is expected with an enterprise such as switchgrass. A great deal of uncertainty surrounds switchgrass production with regard to yield, seed, production, and maintenance costs, and net returns. In addition, establishing the crop for ten years (or more) causes some hesitation due to uncertainty with regard to opportunity costs of not growing traditional crops or having a CRP constraint. Finally, farmers may be reluctant to enter into such long-term contractual arrangements. The results section includes a more in-depth discussion of this topic. It is interesting to note, however, that when asked, "Considering you enter into a favorable contract with a biorefinery, would you produce [switchgrass] on your farm?", 69.8% responded they would consider growing switchgrass and initially commit an average of 101 acres to the crop.

Table 2.2 contains a description of the attributes and levels as well as summary statistics for the values of the attributes presented to farmers where the first choice was to adopt a contract (either A or B). Contract length is somewhat shorter when the first choice was to choose a contract, which is expected given that farmers desire shorter contracts. Net returns and seed cost share have higher means for the chosen contract options than the entire sample, indicating farmers choose higher levels of these options when possible. The binary options, biomass harvest and insurance availability, have means near zero, indicating an even number of each was offered as an option and chosen by farmers. However, of farmers who indicated they would be willing to adopt, the average is 0.14, indicating the biomass harvest option has a positive influence on whether a farmer will adopt switchgrass. In the northeast section of the state, 113 (30.3%) respondents chose to adopt a contract as their first choice. In the central part of the state, 139

(37.3%) chose to adopt, and in the west, 121 (32.4%) chose to adopt a contract as their first choice.

2.3.3 Conceptual Model and Econometric Analysis

2.3.3.1 Theoretical Model

Following Roe et al. (2004), assume producers maximize expected discounted random utility when they choose to enter into a switchgrass contract instead of producing hay or CRP. Then, producer *i*'s expected discounted utility for contract *j* is:

(2.1) $$V_{i,j} = V(\Delta R_j, C_j, H_j, I_j, S_j, L_{ki}) + \varepsilon_{i,j}$$

where ΔR_j is the net return above CRP or hay production over time, C_j is the contract length in years, H_j is the biomass harvest option, I_j is biomass crop insurance availability, and S_j is the establishment cost-share attribute. Due to variation in climate and growing conditions across Kansas, a fixed effects location parameter, L_{ki}, is added to account for farmers in the northeast, west, or central portions of the state. Finally, the error term, $\varepsilon_{i,j}$, represents the nonsystematic part of expected utility that is unobserved by the researcher and is assumed to be distributed Type I extreme value (Louviere et al., 2000; Train, 2003).

2.3.3.2 Econometric Model

A latent class model (LCM) is estimated because it takes account of unobserved characteristics of each respondent as well as latent heterogeneity in unobserved factors (Greene & Hensher, 2003). The LCM can relax the independent and irrelevant alternatives (IIA) assumption between classes, but does impose IIA within classes (Greene, 2007). Following Greene and Hensher (2003), a LCM that calculates the probability of respondent *i* from class *q* (*q* = 1, 2, …, *Q*) choosing alternative (contract) *j* among alternatives *j* = 1, 2, …, *J* for choice situation, τ (*w* = 1, 2, …, *T*):

(2.2)

$$\text{Prob[individual } i \text{ choosing choice } j \text{ in situation } w \mid \text{class } q] = \exp(\mathbf{x}'_{i\tau,j}\boldsymbol{\beta}_q) \Big/ \textstyle\sum_{j=1}^{J} \exp(\mathbf{x}'_{i\tau,j}\boldsymbol{\beta}_q)$$

where $\mathbf{x}_{i\tau,j}$ is a matrix of choice attributes chosen by individual *i* and $\boldsymbol{\beta}_q$ is a vector of coefficients for individuals in class *q*. Following Greene and Hensher (2003), this can be written as

(2.3) $$P_{i\tau|q}(j) = \text{Prob}(y_{i\tau} = j \mid \text{class } = q)$$

The probability that an individual, *i*, will fall into a certain class, *q*, in choice set *τ* then becomes

(2.4) $$P_{i|q} = \prod_{\tau=1}^{T} P_{i\tau|q}$$

Latent class probabilities sum to one, so the model estimates *Q* – 1 latent class estimates. A common form to estimate the class probability is a traditional multinomial logit form:

(2.5) $$M_{iq} = \exp(\boldsymbol{\alpha}'_i\boldsymbol{\gamma}_q) \Big/ \textstyle\sum_{q=1}^{Q} \exp(\boldsymbol{\alpha}'_i\boldsymbol{\gamma}_q), q = 1, \ldots, Q \text{ and } \boldsymbol{\gamma}_Q = 0.$$

where M_{iq} is the latent class constant probability, $\boldsymbol{\alpha}_i$ is a vector of respondent *i*'s characteristics and $\boldsymbol{\gamma}_q$ is the latent class parameter estimates. Combining equations (2.4) and (2.5) provides the likelihood that an individual will fall into class *q*:

(2.6) $$P_{iq} = \sum_{q=1}^{Q} M_{iq} P_{i|q}$$

This model allows both contract attributes and respondent characteristics to determine the choice probabilities (Boxall & Adamowicz, 2002).

2.3.3.3 Empirical Estimation

This study's primary interest is assessing direct impacts of contract attributes on farmers' willingness to accept a contract. Therefore, following Roe et al. (2004), the focus becomes the reduced-form representation of expected random utility. A main effects model (Greene, 2007; Louviere et al., 2000) for producer *i* and contract *j* is posited as:

(2.7) $$V_{i,j} = \beta_0 + \beta_1 \Delta R_j + \beta_2 C_j + \beta_3 H_j + \beta_4 I_j + \beta_5 S_j + \beta_6 Cent_i + \beta_7 East_i + \varepsilon_{i,j}$$

for $j = A, B$, or C. Contract choices A and B represent the randomly assigned, unlabeled contract choices for each scenario, while Option C is the "opt out" option. As seen in Figure 2.2, Option C does not contain any attributes, so $\beta_1 = \cdots = \beta_5 = 0$ and $V_{C,i} = \beta_6 Cent_i + \beta_7 East_i + \varepsilon_{i,j}$. This allows the model to control for unobserved individual effects associated with "opting out."

Assuming farmers are profit maximizers, the signs for β_1 and β_5 are expected to be positive since higher net returns and lower-cost seed can both contribute to increased profit. Farmers likely prefer short-term contracts, so the sign of β_2 should be negative. The sign for β_3 may be either positive or negative depending on farmers' views about biorefinery harvest being a cost-saving option, or if farmers are reluctant to allow custom operators on their property and location. The sign for β_4 is expected to be positive since farmers will likely prefer insurance availability as a tool to manage risk, especially on "experimental" crops.

While respondents ranked their contract choices, this paper only examines their first choice. Thus, equation (2.7) is modeled using a latent class logistic regression model in *NLOGIT 4.0*. The model uses simulated maximum likelihood with Halton draws using the BFGS algorithm (Greene, 2007). Predicted probabilities, estimated marginal effects, and farmers' willingness to pay for alternative contractual features are calculated in MS Excel. Standard errors for all statistics using model results are calculated using the delta method following Greene (2008).

The LCM is estimated with the contract attributes and other farmer characteristics to determine how farmers make decisions amid unobserved classes. Independent variables ($\boldsymbol{\alpha}_i$) in the LCM are shown in Table 2.3. Crop acres is a useful independent variable because larger crop producers may be more willing to adopt another enterprise if they see a benefit to further diversification. Hay and CRP acres are useful independent variables because they indicate whether a farmer has familiarity with growing hay or receive CRP payments, both of which form the basis for the net revenue contract attribute. The percent of cash rented acres should have a negative sign because it is expected that farmers who rent more land on a cash basis will be reluctant to plant a perennial crop such as switchgrass because they may or may not rent the land for the duration of the crop's life. Livestock and baler indicate whether a farmer produces livestock or owns a baler. Farmers with livestock may be unwilling to adopt a switchgrass enterprise because they will use most of their hay acres to feed livestock, and many will own a baler used to make the hay they feed. Age and college are included in the model to determine if older, younger, or more or less educated farmers are willing to adopt a switchgrass enterprise. Younger farmers may be more willing to try something new if they are trying to diversify their operations or competing for land while older farmers may be more willing to maintain the status quo on their operations rather than adopt something new. Finally, risk aversion is useful to determine if more or less risk averse farmers are willing to adopt a switchgrass enterprise in the face of yield and cost of production uncertainty and the lack of a cellulosic biofuel market. Using these variables to determine the latent classes will explain how farmers' characteristics affect their willingness to adopt a switchgrass contract (Jensen et al., 2007; Kelsey & Franke, 2009; Colombo, Hanley, & Louviere, 2009).

2.4 Results

The latent class coefficients are shown in Table 2.4. McFadden's Pseudo-R^2 of 0.5605 indicates data fit the model relatively well. McFadden's Pseudo-R^2 is defined as one minus the ratio of the log likelihood of the full model to the log likelihood of an intercept-only model, and is usually reported when estimating discrete choice models (Greene, 2008). The interpretation is not exactly the same as for the R^2 from ordinary least squares regression, which explains the variation in the dependent variable caused by the independent variables. It is usually assumed that being closer to 1.0 provides a better fit and the model exhibits "good" predictive power although it is unlikely that the Pseudo-R^2 will ever be 1.0 and is often closer to 0.0 (Train, 2003; Greene, 2008). Coefficients for the contract attributes are in line with predictions, where only contract length has a negative effect on a farmer's utility of adopting a switchgrass enterprise.

Table 2.5 contains descriptive statistics of the latent classes for the independent variables. Farmers in latent class one have fewer crop acres, fewer hay acres, more CRP acres, and are slightly older, on average. Approximately 54% of the farmers in latent class one indicated they raise livestock and have a baler while 77% and 71%, respectively of those in latent class two raise livestock and have a baler. About 32% of farmers in latent class one have a college education while about 26% in latent class two indicated they are college educated. An equal number of farmers in each class indicated they are risk averse. Farmers in both classes earn about 29% of their income from livestock. Those in latent class one earn about 76% of their income from crop sales and those in latent class two earn about 70% of their income from crop sales.

2.4.1 Latent Class Descriptions

Results show the willingness of farmers to grow switchgrass as a bioenergy feedstock under each latent class. Interpreting the latent classes is seldom a straightforward exercise. By themselves, the coefficient estimates for the latent classes have little meaning (Greene & Hensher, 2003). However, the classes can be interpreted based on how respondents' characteristics become categorized, taking care to interpret them relative to the base category (where class, or segment parameter estimates are fixed to estimate the model) and each other (Boxall & Adamowicz, 2002). The model was run with two, three, four, and five classes to determine the optimal number of classes. Using the AIC is a common method to determine the appropriate number of classes (Breffle, Morey, & Thacher, 2011; Colombo et al., 2009; Meyerhoff, Bartczak, & Liebe, 2012). Running the model with two latent classes provided the lowest AIC, and a more cogent interpretation of the classes.

As noted in Table 2.4, latent class 1 contains 70% of the respondents and is most likely comprised of producers unwilling to adopt a switchgrass enterprise. The negative coefficients for livestock use may indicate these farmers consider switchgrass would impact their livestock enterprise negatively. Respondents in class 1 are likely younger and have more college education compared to the farmers in latent class 2, although the lack of significance for the coefficients makes it difficult to determine this with much certainty. Farmers in class 1 have about the same likelihood of adopting a switchgrass contract if they are from the central or eastern part of the state. For these producers, increasing returns, offering a biorefinery harvest option, and offering to share some of the establishment costs will increase the likelihood they will adopt a switchgrass contract. However, increasing the contract length will decrease the likelihood of switchgrass adoption.

Latent class 2 contains about 30% of the respondents. This class likely contains farmers who are more willing to adopt a switchgrass enterprise. Farmers in this class from the eastern portion of the state are less likely to adopt a switchgrass contract while those from the central part of the state may or may not be willing to adopt a contract. However, for Kansas farmers, increasing contract length will reduce willingness to adopt a contract while increasing returns, offering a biorefinery harvest option, offering insurance, and having a cost-share option will increase the likelihood of adoption.

2.4.2 Marginal Willingness to Pay

Table 2.6 indicates farmers' marginal willingness to pay (MWTP) for various contract attributes for some net return above hay production or CRP. MWTP is defined as β_i / β_{NR}, following Hensher et al. (2005) and Greene and Hensher (2003), where β_i is the latent class parameter for attribute *i* = contract length, biorefinery harvest, insurance, and seed cost-share in each latent class and β_{NR} is the coefficient on *Net Returns*. MWTP indicates the willingness to pay for a marginal (i.e., one unit) change in the attribute.

As expected, the negative sign on contract length indicates farmers require a payment to enter into longer-term contracts, but positive signs on the other attributes for some of the classes indicate they are willing to pay for these attributes. Contract length is the only attribute with MWTP estimates statistically significant in each class. Farmers in class 1 require \$9.33 per acre more per year of additional contract length to enter into a contract, which is may be expected from non-adopters relative to adopters. Adopters in class 2 only require \$0.72 per acre more per year of additional contract length to enter into a contract. This result may be because of non-adopters' relative unwillingness to adopt, so the relatively small MWTP estimate may not be a determining factor in their willingness to adopt.

Adopters in class one are willing to pay \$11.44 per acre for the biorefinery to harvest if the biorefinery provides the option. However, adopters in class two are willing to only pay \$1.32 per acre for the biorefinery harvest option.

The insurance availability MWTP estimates are not statistically significant for adopters, but non-adopters are willing to pay \$1.61 per acre to have the attribute included in a switchgrass production contract. Finally, farmers' MWTP for the cost share attribute is $0.15 per acre per one percentage increase in the percentage seed costs paid by the biorefinery *ceteris paribus* for farmers in latent class two. This indicates that non-adopters require slightly less compensation to enter into any contract to grow switchgrass—even if the biorefinery is not willing to share all crop establishment costs.

2.5 Conclusions and Further Research

Switchgrass has great potential to help reduce the nation's dependence on nonrenewable sources of energy, but much uncertainty exists as to its viability in Kansas. Kansas farmers were surveyed to assess their willingness to grow switchgrass as a biofuel feedstock under alternative contract scenarios. Results show that contract attributes positively affecting farmers' decisions. These attributes include net returns, biorefinery harvest options, insurance availability, and seed cost-share assistance. Contract length negatively affects farmers' decisions on which contract to choose, who prefer shorter-term contracts.

A latent class model, which is a special case of a multinomial logistic regression, was run to predict the likelihood farmers would choose to adopt a contract to grow switchgrass for bioenergy over "opting out." The model allows for coefficient estimates for each respondent to be aggregated with choice-specific characteristics in a stated-choice framework. Latent classes account for unobserved respondent heterogeneity due to farm or farmer characteristics. Two latent classes observed are comprised of farmers who are more or less likely to adopt switchgrass. Adopters are more likely to enter into a switchgrass contract than livestock producers and are more willing to pay more for a biorefinery harvest option, but require more compensation to enter into long-term contracts.

WTP estimates show that contract length is an important attribute (maybe the most important attribute) in determining whether a farmer will produce switchgrass for bioenergy for each latent class. In each class, farmers require some payment ranging from $9.33 (for adopters) to $0.72 (for non-adopters) per acre per additional year of contract length to produce switchgrass for bioenergy. In addition, farmers see a seed-cost share arrangement as beneficial to entering into a switchgrass producing contract and non-adopters are willing to pay about $0.15 per acre per percentage point increase in the share of establishment costs paid by the biorefinery.

A primary area of further research is to determine how bioenergy crop characteristics, storage, and transportation issues affect farmers' decisions to grow a bioenergy crops. Risk aversion is also important when assessing farmers' willingness to adopt new technology or practices and could affect their decisions. The latent class logit model presented here attempts to control for these, but it does not help explain how farmers base their decisions because of these characteristics specifically.

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Table 2.1. Comparison of Kansas farmer demographics to survey respondents.

	2007 Census of Agriculture	Survey
Percent white	98.9%	98.9%
Age	57.7 years	55.9 years
Percent male principal operators	87.9%	95.9%
Average size of farm	707 acres	2147 acres
Average amount of rented land in farm	863 acres	1388 acres
Average market value of agricultural products	$219,944	$200,000 to $399,999

Table 2.2. Attribute descriptions and summary statistics of attributes and levels for each randomly assigned contract type for the entire sample versus those who chose a contract as their 1st choice.

Attribute	Attribute Description	Levels	Entire Sample (N = 1420)		1st Choice to Adopt (N = 373)	
			Mean	Std. Dev.	Mean	Std. Dev.
Net Returns Above Hay/CRP (%)	Represents the expected percentage gain under the contract above net returns associated with hay production and/or CRP rental payments on your operation.	5% 20% 35%	20.032	12.195	23.981	11.236
Contract Length (years)	Represents the time commitment in consecutive years of the contractual agreement.	7Years 16 Years	11.231	4.493	9.775	4.162
Biomass Harvest Optiona	"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 = 1 No = -1	0.018	1.000	0.137	0.992
Insurance Availabilitya	"Yes" indicates crop insurance is available, and "No" otherwise.	Yes = 1 No = -1	-0.037	1.000	0.046	1.000
Seed Cost Share (%)	Indicates a percentage of seed/establishment costs are covered or cost-shared by the biorefinery or processor due to lower yields during the establishment period. 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% 70%	33.829	28.541	40.161	27.574

a These binary attributes were effects coded.

Table 2.3. Summary statistics for variables included in latent class probabilities. (*N = 284*)

Variable	Mean	Standard Deviation	Maximum	Minimum	Description
Crop acres	1,556	1,398	8620	0	Number of acres used to produce crops.
Hay acres	72	100	500	0	Number of acres used to produce hay.
CRP acres	34	106	1,200	0	Number of acres enrolled in Conservation Reserve Program (CRP).
Percent Cash Rent	32%	39%	100%	0%	Percent of rented acres rented on a cash basis.
Livestock[a]	61%				Percent indicating they have livestock
Use a baler[a]	59%				Percent indicating they use a baler
Age	56	12	85	24	
College[a]	30%				Percent indicating they have a college education
Risk Averse[a]	89%				Percent indicating they are at least somewhat risk averse.

[a]Binary variables.

Table 2.4. Coefficient estimates for the each latent class utility model. Coefficients' signs indicate increased or decreased likelihood of adoption given contract attributes.

	LC 1 *Non-adopters*	LC 2 *Adopters*
Central	0.6589* (0.3718)	0.1895 (0.1823)
East	-0.8711* (0.5279)	-1.2858*** (0.1757)
Returns	0.0687** (0.0346)	0.1599*** (0.0122)
Contract Length	-0.6409*** (0.0761)	-0.1147*** (0.0113)
Harvest	0.7859*** (0.2149)	0.2113*** (0.0612)
Insurance	-0.0724 (0.1703)	0.2580*** (0.0627)
Cost-Share	0.0149** (0.0061)	0.0234*** (0.0022)
-----------------------------------*Latent class segments*------------------------------------		
Constant	2.3277*** (0.5249)	-----
Crop Acres	-0.0874 (0.1207)	-----
Hay Acres	-0.0216 (1.455)	-----
CRP Acres	0.0323 (1.6722)	-----
Per. Cash Rent	-1.3039*** (0.4706)	-----
Livestock	-1.1953*** (0.3507)	-----
Baler	-0.0048 (0.0078)	-----
Age	-0.0024 (0.0033)	-----
College	0.4198 (0.3407)	-----
Risk Averse	0.5148 (0.3183)	-----
Percent in each class	69.9%	30.1%

Model Fit Statistics	
Number of respondents	284
Number of observations	1420
Restricted Log-Likelihood	-1560.03
AIC	0.99946
McFadden Pseudo R^2	0.5605

***, **, and * indicate statistical significance at $\alpha = 0.01, 0.05$, and 0.10, respectively.
Standard errors in parentheses.

Table 2.5. Descriptive statistics by latent class.†

	Mean		Std. Dev.		Max		Min		Median	
	LC1[c]	LC2	LC1	LC2	LC1	LC2	LC1	LC2	LC1	LC2
Crop Acres	1567	1642	1400	1395	8620	7463	70	186	1100	1200
Hay Acres	115	125	103	110	500	500	0	0	80	90
CRP Acres	138	90	194	127	1200	648	3	0	75	52.5
Per. Cash Rent[a]	39.0	40.4	40.8	36.5	100	100	0	0	23	29
Livestock[b]	54.2%	77.1%								
	45.8%	22.9%								
Baler[b]	54.2%	71.1%								
	45.8%	28.9%								
Age	57	54	12	11	85	85	24	29	56	52
College[b]	31.8%	26.5%								
	68.2%	73.5%								
Risk Averse[b]	89.1%	90.4%								
	10.9%	9.6%								
Per. Crop Sales[a]	76.3	70.3	21.4	21.7	100	97	0	21	85	75
Per. Livestock Sales[a]	29.3	29.2	19.1	20.1	100	73	0	0	25	27

[a]Values are percentages.
[b]Binary variables. Values are percentage of respondents with and without livestock, percentage with and without a baler, percentage with and without a college education, and percentage indicating they are risk averse in each class.
[c]Latent class 1 includes non-adopters while latent class 2 is made up of adopters of a switchgrass enterprise.
†Summary statistics are calculated based on highest probability that a respondent falls in latent class 1 or 2.

Table 2.6. Willingness to pay estimates for returns versus other contract attributes in dollars per acre.

Attribute	LC 1 *Non-adopters*	LC2 *Adopters*
Contract length	-9.33*** (4.087)	-0.72*** (0.061)
Biorefinery harvest	11.44* (6.246)	1.32*** (0.376)
Insurance	-1.05 (2.593)	1.61*** (0.387)
Seed cost share	0.22 (0.139)	0.15*** (0.014)

Standard errors are calculated via the delta method and are included in parentheses.
*** and * indicate statistical significance at α = 0.01 and 0.10, respectively.

SECTION 2A ***PERENNIAL BIOENERGY CROP OPTION: SWITCHGRASS***

This section will ask about your willingness to supply switchgrass, a perennial bioenergy crop, to a biorefinery or intermediate processor (e.g. cooperative) through different contractual agreements. You will be asked to consider 5 scenarios. Each scenario contains three options: two contract options and one for "do not adopt." The final option provides the option to "opt out" if the contracts presented are not favorable to you. Each contract will have different features, which include net returns per acre, contract length, a harvest option, an insurance availability option, and a cost-share provision option.

Switchgrass is a perennial crop that can be grown in place of other annual crops, on hay land, or less productive lands (e.g. CRP land). Harvesting of switchgrass involves cutting, raking and then baling the stalks. Switchgrass has a two-year establishment period with no harvest in the first year, a reduced yield in year two, finally reaching full yield potential in year three. Replanting occurs about every 10 years. Expected biomass yields for switchgrass range from 1 to 8 dry tons per acre, but yields will vary depending on climatic conditions and geography. In the future, biomass yields are expected to increase with improvements in plant breeding and harvest technology. Biomass harvesting can be done by the farmer (with his/her own equipment or by hiring a custom operator) or by the biorefinery. Harvesting would take place in the late fall or could occur during the winter. The annual average cost of production for a switchgrass enterprise ranges from $44 to $142 per acre. In the following scenarios, the biorefinery will be responsible for long-term storage of biomass; a minimum acreage contract will be negotiated between the bio-refinery and farmer; and the contract will include an "Act of God" clause.

Each scenario presented will present different contractual options with the following features:

Contract Feature	Description
Net Returns (*for all features of the contract except the seed/establishment costs*)	Represents the expected ***percentage*** gain under the contract ***above*** net returns associated with hay production and/or CRP rental payments on your operation. As a reference point, on average, returns from hay production or income from land in CRP are expected to be around $40 per acre in Kansas. For example, if your CRP rental rate is $40/acre, a 10% return above $40 per acre will be $44/acre. This amount is received after all expenses, including harvest and insurance are paid, but **does not** include the seed/establishment cost-share payment.
Contract Length	Represents the time commitment in consecutive years of the contractual agreement.
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.
Insurance Availability	"Yes" indicates crop insurance is available, and "No" otherwise.
Seed/Establishment Cost-Share	Indicates a percentage of seed/establishment costs 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.

Figure 2.1. Explanation of switchgrass production practices, costs, and contract attribute descriptions.

Switchgrass Scenarios – For each scenario evaluate the contractual options and please rank the contract options in the order that you would prefer them with 1 = first choice, 2 = second choice, and 3 = third choice.

CONSISDER EACH SCENARIO INDEPENDENTLY .

Scenario 1:

		Contractt A	**Contract B**	**Option C**
Contract Features	**Net Return Above Hay Production/CRP Rental Rates (Base: $40/ac)**	35% Higher/year	5% Higher/year	Do Not Adopt
	Contract Length	16 Years	7 Years	
	Biorefinery Harvest	Yes	No	
	Insurance Available	No	Yes	
	Seed/Establishment Cost-Share	35%	70%	
	Your Ranking (1-3)	☐	☐	☐

Figure 2.2. Example of stated choice question for a switchgrass choice scenario.

Chapter 3 - Farmer Risk Perceptions and Conservation Practice Adoption

3.1 Introduction

Conservation programs in the U.S. have been popular for a number of years to protect soil and water resources. Initially, farmers were encouraged to employ conservations methods that would reduce soil erosion such as planting of tree rows, seeding grass in areas of severe runoff, and using conservation tillage. The U.S. government has subsidized farmers for using conservation practices under a variety of conservation programs (Natural Resources Conservation Service, 2012). While conservation is not necessarily a risk reducing practice, studying farmers' risk perceptions and the effects on conservation practice adoption is important to determine the type(s) of farms that practice conservation.

Assuming farmers maximize utility when deciding whether to adopt a new crop enterprise, purchase machinery, or adopt a conservation practice, economic theory suggests farmers will consider risk when making these decisions. Recent research has studied how farmers' risk perceptions affect their willingness and timing of adopting new technology and practices (i.e., organic farming, conservation, insurance products, etc.) (Greiner, Patterson, & Miller, 2009; Läpple & Van Rensburg, 2011; Mitchell, 2004), and how risk attitudes affect the management of their operation overall (Bard & Barry, 2000; Bard & Barry, 2001).

The purpose of this study is to analyze how risk perceptions about management, finances or insurance, marketing strategies, and government policy influence farmers' conservation practice adoption. A survey administered to Kansas farmers elicited their risk perceptions in a Likert-scale framework and asked them to indicate conservation practices they use. Factor analysis grouped the risk perception questions into management, insurance use, and off-farm income categories. A multinomial logit model is then used to assess how these risk perception categories, farmers' views about the importance of conservation, and farm characteristics influence farmers' decision-making with respect to conservation practice adoption.

The next section contains a brief literature review, followed by a discussion about the survey data, conceptual model, and empirical methods. Finally, a discussion of results and implications for further research conclude the paper.

3.2 Literature Review

Two areas of research studied extensively are farm-level conservation adoption and risk. Often, risk is included in analyzing farmers' willingness to adopt conservation from a technology perspective, where risk is modeled as financial risk associated with the investment or return on adoption. Conservation adoption is modeled in terms of the returns to adopting the practice for the farmer or the analysis determines the effectiveness of government programs designed to encourage conservation adoption. Furthermore, many factors such as farm size, amount of rented land, crops grown, livestock produced, or labor availability go into farmers' decisions about conservation practice adoption.

Soule, Tegene, and Wiebe (2000) analyzed the effect of land tenure on conservation tillage adoption, and found owner-operators and share-renters are more likely to adopt conservation practices than cash-renters. This is due, in part, to their willingness to bear risk. They modeled farmers' decisions to adopt conservation if it maximized the present value of land. To value land, they multiplied the terminal value of land by a land tenure indicator variable and added it to the farmer's share of revenue and costs from adopting conservation. Assuming that share-renters are more risk averse than cash renters, it is possible that share-renters adopt conservation practices because returns under risk or uncertainty are higher for adopting conservation. This may occur because property owners share some of the cost of conservation adoption. However, with respect to highly erodible land (HEL), owner-operators were least likely to adopt conservation tillage except to the degree necessary to qualify for government program payments. Featherstone and Goodwin (1993) also found that farms with rented land were less likely to invest in conservation practices.

Larger farms are more likely to adopt conservation practices (Featherstone & Goodwin, 1993; Soule et al., 2000; D'Emden, Llewellyn, & Burton, 2008; Davey & Furtan, 2008). This may be due to their ability to spread the cost of adoption across more acres. Corporate farms are more likely to invest in conservation practices, possibly due to their ability to reduce personal liability and take advantage of tax incentives associated with the corporate structure (Featherstone & Goodwin, 1993; Davey & Furtan, 2008). Operator age negatively influences a farmer’s probability of adopting conservation practices (Featherstone & Goodwin, 1993; Soule et al., 2000). However, family size and quantity of labor positively influence conservation adoption (Featherstone & Goodwin, 1993; Davey & Furtan, 2008) due to larger families’ ability to spread labor across multiple duties and people, and because they may wish to pass on the farm to the next generation.

While the studies above focused on returns as motivating conservation adoption, some farmers may adopt because of environmental consciousness or concern for their neighbors. Sheeder and Lynne (2011) determined that as farm income increases, farmers are more likely to adopt no-till, but that selfishness and maintaining farm quality also increase the likelihood of adoption. However, farmers are less likely to adopt no-till if control of their farm is threatened.

[1]Greiner et al. (2009) conducted a survey to determine how social and economic characteristics of farmers in the Burdekin River Catchment Area of Northeastern Australia affected their decisions to adopt best management practices (BMPs). Included in their survey were questions categorizing farmers based on risk perceptions and risk management practices. They used principal components analysis to group farmers by risk management practices and found that farmers who considered themselves risk takers with respect to new grazing adoption more often adopted BMPs such as rotational grazing, changing pasture stocking rates, and removing cattle early when faced with drought conditions. They determined farmers implemented conservation measures to comply with government regulations and farmers with high economic or financial motivation were more attuned to risk. Finally, they determined farmers consider themselves risk averse based on emotions, but actual sources of risk such as price, yield, financial, or personal risk lead farmers to evaluate risk using rational thinking. Ultimately, farmers consider personal values and lifestyle motivations when assessing their risk attitudes, risk management strategies, and conservation practices. However, as economic status increases, conservation practice adoption decreases.

Maybery, Crase, and Gullifer (2005) used factor analysis to find relationships among farmers' economic, lifestyle, and conservation attitudes. They found that economic and lifestyle values have a strong relationship relative to conservation values. They also found that economic policies may be necessary to induce farmers to adopt conservation practices if farmers have strong economic (i.e., financial) goals.

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[1] Two types of data-reducing methods are used in the following discussion: principal components and factor analysis. Principal components analysis does a linear transformation on a correlated set of variables and transforms them into a smaller set of uncorrelated variables while maintaining most of the information in the original data (Dunteman, 1989). Factor analysis assumes observed variables are linear combinations of some unobserved "factors" and is useful to reduce the number of observed variables to a smaller set of hypothetical variables (Kim & Mueller, 1978).

In a study about organic farming adoption, Läpple and Van Rensburg (2011) found off-farm income did not affect adoption and that larger farms are less likely to adopt practices such as organic farming or other labor-intensive practices. They also found that a high profit motive negatively affected the likelihood of early adoption, but heightened environmental concern positively affected early adoption. Information about organic farming and personally knowing organic farmers is also an important consideration for early adopters' adoption patterns. Finally, they found that late adopters tend to be less risk averse, but there is not a significant relationship with early adopters and risk aversion.

Flaten, Lien, Koesling, Valle, and Ebbesvik (2005) found that farmers who were willing to adopt organic dairy farming practices in Norway thought of themselves as less risk averse than conventional farmers. In addition, using financial tools (i.e., hedging), insurance, and disease prevention were the most important risk management strategies. Both organic and conventional producers desire stable governmental agricultural policy.

Akcaoz and Ozkan (2005) used factor analysis to relate risk averse, risk neutral, and risk seeking farmers' attitudes toward risk in the Cukurova region in Turkey. For each group, they found eight risk factors relating to the environment, prices (market risk), catastrophes (i.e., floods, fire, and landslides), input costs, production and technology risk, political uncertainty, financing risk, and family relationships (including family labor). Risk averse farmers were most concerned about changes in government policy, output costs variability, the overall economy, crop prices, crop yields, and their debt load. Risk seeking farmers were most concerned with changes in input costs and crop prices and least concerned about health problems. Risk neutral farmers were most concerned with input costs and least concerned with family relationships.

Risk averse and risk seeking farmers used crop rotations as a risk management strategy but risk neutral farmers were more likely to spread sales to reduce risk exposure.

This paper will contribute to the previous literature by using factor analysis to group farmers' responses to risk perception questions and determine how these risk perceptions affect conservation practice adoption using a random utility model.

3.3 Data and Methods

This section explains the data, reviews the theoretical utility framework for farmers maximizing utility, and then discusses the empirical model that is useful to analyze farmers' conservation adoption subject to risk perceptions.

3.3.1 Data

A stated preference survey was administered from November 2010 to January 2011 to 485 farmers with more than 260 crop acres and at least $50,000 in gross sales throughout Kansas. The USDA National Agricultural Statistics Service (NASS), Kansas Field Office administered the survey using field enumerators. The survey was tested on focus groups in August 2010, then with face-to-face interviews in October 2010. Finally, NASS enumerators were trained during a two-day session and began interviewing farmers in early November. Interviews took 57 minutes (on average) to complete and farmers were compensated for their time with a $15 gift card. 290 surveys were completed and returned while 38 farmers were out of business or could not be reached, resulting in a 65% response rate (290/(485-38) = 0.65).

Kansas farmers were asked to self-report perceptions on how they manage financial and personal risk related to their operations and families. Appendix A3 contains the list of risk-related questions presented to each farmer. The questions were asked on a six-point Likert scale from "(1) strongly disagree" to "(6) strongly agree" with statements requesting their views on a number of personal risk-related issues. In addition, farmers were asked to answer questions regarding how they thought others viewed their aversion to or preference for risk, whether they used crop/hail insurance, whether they kept an open credit line, and how they categorized their debt-to-asset ratio. Table 3.1 and Table 3.2 report summary statistics for the risk-related questions.

As reported in Table 3.1, 89% of farmers indicate their neighbors see them as at least somewhat risk averse to risk averse (questions 1 to 3), about 5% are risk neutral, and about 6% would be considered risk takers. Table 3.2 reports summary statistics of the remaining risk-related questions. About 94% of the farmers indicated they use crop insurance, but just over half (54%) purchase hail insurance. About 85% indicated they maintain an open line credit with their lender. The Likert-scale questions garnered at least some agreement on most issues with average responses over 4.0 (somewhat agree). In general, farmers have adequate current assets to pay liabilities; use sound marketing practices; have adequate insurance to cover threats to health, life, and their operation's liability; have well-kept machinery; try to maintain a low debt-to-asset ratio; have adequate backup management; try to reduce yield risk by spreading crops across a larger geographic area; try to be low-cost producers; and incorporate finances into their decision making.

Only three questions have a somewhat disagree to disagree answer, on average. Respondents indicated they "somewhat disagree" and "disagree" with Questions 10 (Off-farm income is important for the survival of my family) and 11 (Off-farm investments are important sources of income for my family), respectively, with average responses of 3.53 and 2.81. These questions concern off-farm income and investments as being important for family survival. The other question farmers somewhat disagree with is that they are prone to making last minute decisions with an average of 3.38.

Table 3.3 reports the summary statistics for independent variables not related to risk or conservation practices. On average, farmers in the survey data set farm about 1536 acres and have 36 acres of CRP. Approximately one-third of the land these farmers farm is rented on a cash basis. About 59% of the farmers in the data set produce livestock including cattle, hogs, or sheep. About 38% of the farmers in the survey are from Central Kansas and 26% from Eastern Kansas, leaving about 36% from Western Kansas.

The conservation practice questions in the survey asked farmers their perceptions on conservation as well as which conservation practices they use. Appendix B3 contains the list of conservation practice questions presented to each farmer and Table 3.4 contains summary statistics for these questions. Most farmers in the survey (81.9%) have a conservation plan for their farm. The conservation practice section of the survey used a Likert scale from "(1)-strongly disagree" to "(6)-strongly agree" asking farmers if (a) they consider themselves to be first adopters, (b) the importance of conservation on their farm, and (c) the importance of profit maximization versus environmental stewardship on their farms. The average response of the first question, 4.09, indicates farmers somewhat consider themselves to be first adopters, with the most often reported value being 4 – "somewhat agree". This is important because it can determine farmers' willingness to adopt new conservation practices. The second assesses farmers' views on the importance of conservation. Farmers agree that soil and water conservation is important on their farms with an average response of 5.30. The third question assesses whether farmers place more importance on farm profits than maintaining the environment. With an average response of 3.13, it appears that farmers are neutral on this question and may weigh profits and environmental stewardship equally. "Conservation tillage" included any type of conservation tillage including no-till, reduced till, strip till, and ridge till. Nearly all farmers (95.4%) indicate they use some type of conservation tillage. Of the 290 farms in the data set, 221 (76.2%) indicated they practice no-till on at least some of their crops. Only 9.8% of farmers used cover crops. However, 22.8% use variable rate technology, which is technology that helps avoid over- or under-applying fertilizer and chemicals by applying the correct amount for a specific area of the field based on soil-testing results. Table 3.4 shows that 21.8% of farmers plant filter/buffer strips, which are grassy areas planted to reduce runoff into waterways. Finally, statistics show that nearly half (48.1%) of the farmers use manure on their farms. Farmers were asked to indicate how often they have their soils tested. On average, they have their soil tested every two to three years.

Many combinations or "bundles" of conservation practice adoption result from farmers' choices in the survey. Table 3.5 shows frequencies of adoption for the potential conservation practice bundles available from the list of conservation practices found in Appendix B3. The most often reported conservation practice bundle was no-till, followed by no-till with manure use. Twenty-two farmers indicated they do not use any of the conservation practices listed, so are considered non-adopters. Only 28 farmers indicated they use cover crops but cover crops were never chosen alone. Since the practice was always chosen in combination with at least one other practice, it is bundled with other practices to be included in the estimation.

3.3.2 Methods

3.3.2.1 Theoretical Framework

Much risk preference research has used an expected utility framework to analyze risk preferences with respect to some kind of wealth measure. This paper does not attempt to assess risk attitudes with regard to actual wealth; rather it attempts to assess how farmers may view certain types of potentially risky situations and how these situations affect farmers' decisions about conservation practice adoption. Random utility models are usually used in stated preference studies and are also useful in adoption studies.

An expected utility framework is useful to analyze whether a farmer maximizes utility, $U(x)$, using a certainty equivalent approach. Pennings and Garcia (2001) modeled intrinsic risk attitudes elicited from a set of rating questions using an expected utility framework with negative exponential and power utility functions. These functions allow study of the traditional Pratt-Arrow risk aversion coefficient, $-U''(x)/U'(x)$. However, to model intrinsic risk attitudes, Pennings and Garcia use indirect utility as derived from a preference function, $V(x)$, and utility $U(x)$ so that $U(x) = f(V(x))$. Then the "Pratt-Arrow" risk aversion coefficient is $-U''(V(x))/U'(V(x))$. This approach indicates it is possible to use rating-type questions and an expected utility framework to assess risk aversion. They incorporated certainty equivalence, a rating method, an intrinsic risk attitude, and a Likert-scale method to assess similarities in methods of determining risk aversion among farmers. These four measures are grouped into a global risk attitude construct (GRAC) that better assesses farmers' risk aversion than a single measure. Correlations among the methods are used to determine that the methods produce similar results when assessing farmers' risk attitudes.

Random utility maximization (RUM) models are well suited to analyze people's decision-making when considering choices people make regarding purchasing products or adopting new technology. RUM models are often used within a stated choice framework to determine preferences for choices among products or services (Train, 2003). Random utility assumes decision makers act by choosing alternatives that maximize utility, is derived from ordinal utility, and requires repetition among choices (Batley, 2008). Using RUM models to determine risk attitudes is not common. Risk is usually conceptualized using expected utility models that require ordinal utility measures such as: if x is preferred to y, then $U(x) \geq U(y)$ (Batley, 2008). However, random utility models can provide results similar to expected utility models and can provide the same interpretation if utility, U, is defined as:

$$U = V_{ij} + e_i = X_i\beta + e_i \tag{3.1}$$

where V_{ij} is the systematic random utility of farmer i for conservation practice bundle $j, (j = 1, \dots, J)$; X_i is a set of farmer characteristics, conservation practice adoption, and risk perceptions; and e_i is a random error distributed Type I extreme value. Since the random utility component of expected utility in (3.1) will maximize expected utility, maximizing random utility will provide the same result as maximizing expected utility. Random utility for farmer i adopting conservation practice bundle, j, is V_{ij}, and can be modeled as:

$$V_{ij} = \sum_{j=1}^{J} \exp(X_i\beta) \tag{3.2}$$

where farmer i chooses conservation practice bundle, $j, (j = 1, \dots, J)$, X_i is the set of farmer characteristics, and β is the coefficient on each X_i.

Then, expected utility can be defined as:

$$E(U) = \ln \sum_{j=1}^{J} \exp\left(V_{ij}\right) \tag{3.3}$$

Farmer i will choose the bundle of practices, $j, (j = 1, \dots, J)$, that maximizes expected utility, $E(U)$, by maximizing random utility, such that they:

$$\max \left(E(V_{i1}), \dots, E\left(V_{iJ}\right)\right). \tag{3.4}$$

In other words, a random utility model can be used to approximate a decision maker's decision to adopt, the same as in an expected utility framework.

3.3.2.2 Empirical Estimation

Factor analysis is used to condense the risk perception factors from the survey. Factor analysis is a useful tool for grouping respondents by risk attitudes because it reduces data dimensionality (Khattree & Naik, 2000). Some studies have used factor analysis (at least in part) to determine how farmers view risk in relation to production, marketing, conservation, and technology adoption (Greiner et al., 2009; Maybery et al., 2005; Flaten et al., 2005; Bard & Barry, 2001; Bard & Barry, 2000; Akcaoz & Ozkan, 2005). Risk in agriculture is often broken into production, marketing, and financial categories (Bard & Barry, 2000). Other categories of risk include price risks (input and output), personal risks (i.e., death, health, or family relationships), and institutional risks (i.e., government policy) (Meuwissen, Hardaker, Huirne, & Dijkhuizen, 2001).

A basic factor analysis model can create common factors that determine a relationship among a set of observations and reduce data to a manageable level. A basic factor model following Khattree and Naik (2000) is:

(3.5)
$$\mathbf{z} = \mathbf{Lf} + \boldsymbol{\varepsilon}$$

where **z** is a $p \times 1$ vector of observations, or risk perceptions, **f** is a $k \times 1$ vector with elements f_1, …, f_k which are common factors; **L** is a $p \times k$ matrix of unknown constants, or factor loadings; and **ε** is a vector of elements ε_1, …, ε_p known as specific factors. Assume that **f** and **ε** are uncorrelated. Then, a given z_i is considered a linear combination of factor elements, f_1, …, f_k and a specific factor, ε_i as:

(3.6)
$$z_1 = l_{11}f_1 + \cdots + l_{1k}f_k + \varepsilon_1$$
$$z_2 = l_{21}f_1 + \cdots + l_{2k}f_k + \varepsilon_2$$
$$\vdots$$

$$z_p = l_{p1}f_1 + \cdots + l_{pk}f_k + \varepsilon_p$$

where l_{ij} is the $(i,j)^{th}$ element of **L** and becomes the factor loading, or coefficient, of z_i on the j^{th} common factor f_j. Then, $\mathbf{L}^{-1}$ is multiplied by the **z** vector of individual i's risk perception responses to arrive at a $p \times 1$ vector of risk factors, **λ**.

Following the utility framework from Davey and Furtan (2008), utility V_{ij} from using a conservation practice or combination of conservation practices is

(3.7) $$V_{ij} = \beta_j F_i + \gamma_j \lambda_i + \varepsilon_{ij} \qquad \forall j$$

where F_i is a set of farmer i's operational and personal characteristics; λ_i is farmer i's risk perception; β_j, and γ_j are parameter vectors; and ε_{ij} is an error term for farmer i choosing conservation practice j and is distributed Type I extreme value.

A multinomial regression can be used to assess farmers' adoption of conservation practice bundles. Multinomial logit models use responses individuals make when presented with multiple choices to determine the probability a decision maker will choose one or more of $J + 1$ choices (Greene, 2008). The multinomial logit model was estimated following Greene (2008), so the probability, P, of farmer i with farm characteristics $\mathbf{x}_i$ choosing conservation practice bundle j will be

(3.8)

$$\text{Prob}(Y_i = j \mid \mathbf{x}_i) = P_{ij} = \frac{e^{\mathbf{x}_i'\beta_j}}{1 + \sum_{k=1}^{J} e^{\mathbf{x}_j'\beta_k}}$$

where $j = 0, 1, \ldots, J$; β_j is a parameter estimate; and $\beta_0 = 0$ since probabilities must sum to 1. The vector of farm characteristics includes crop and CRP acres, percent of land rented, location, conservation perceptions, and risk perceptions.

The *management risk factor* was expected to influence adoption positively because farmers who manage potential operational risks will adopt conservation if it has some potential of reducing erosion or limiting other environmental damage that may shorten land productivity. The *insurance* and *off-farm income risk factors'* signs were not known. The sign of *crop acres* was unknown because higher crop acreage is not necessarily a reason to adopt conservation, but it may not necessarily preclude a farmer from adopting conservation practices. *CRP acres* were expected to influence adoption positively because these farmers may be more conservation-minded. A higher *percentage of cash-rented land* should decrease adoption (Soule et al., 2000), so the sign was expected to be negative. *Livestock* was expected to have a positive sign for the conservation practice bundles involving manure use. The signs for a farmer's self-consideration of being a *first adopter*, placing a *priority on conservation*, or valuing the *environment over profit* were expected to be positive because adopting conservation is more likely for first adopters, placing conservation as a top priority on their operations, or putting more importance on environmental stewardship than profits. Because rainfall increases from west to east across Kansas, it may become less likely that farmers will adopt conservation, especially no-till, in Eastern Kansas as contrasted against Western Kansas. Finally, increasing *soil-testing* frequency was expected to increase the likelihood of adopting conservation practices.

Conservation practice bundles and the frequency with which farmers choose them are listed in Table 3.5. Thirty-two different conservation practice bundles are available from the choices in the survey. However, farmers only use 15 and only eight are modeled in the multinomial logit regression. For some bundles, the number of regressors in the regression exceeds the number of respondents, which does not leave enough degrees of freedom to estimate the coefficients for that bundle reliably. Therefore, these observations are dropped from the estimation. If a combination bundle is used less than 15 times, it is dropped from the estimation because it is unlikely to have a significant effect on the outcome and may cause spurious results (Bergtold & Molnar, 2010). The conservation practice bundles: Variable Rate Technology (*V*); Filter/Buffer Strips (*F*); Variable Rate Technology and Filter/Buffer Strips (*VF*); Variable Rate Technology and Manure (*VM*); Filter/Buffer Strips and Manure (*FM*); No-till, Variable Rate Technology, and Filter/Buffer Strips (*NVF*); and No-till, Variable Rate Technology, Filter/Buffer Strips, and Manure (*NVFM*) are removed from the estimation for these reasons.

3.4 Results

On average, about 94% of respondents indicated they are risk averse to risk neutral, as indicated in Table 3.1. Only 6.1% indicated they enjoy taking risks or consider themselves to be risk seeking. These results differ somewhat from other studies' results on similar questions indicating farmers are somewhat more risk seeking (Fausti & Gillepie, 2006; Pennings & Garcia, 2001; Akcaoz & Ozkan, 2005; Greiner et al., 2009), but concur with some research indicating famers are more risk averse to risk neutral (Flaten et al., 2005; Meuwissen, Huirne, & Hardaker, 2001).

3.4.1 Risk factors from factor analysis

Choosing eigenvalues greater than or equal to 1.0 is the most common method for determining the correct number of factors. Eigenvalues explain the amount of variance in the factors (Hayton, Allen, & Scarpello, 2004; Costello & Osborne, 2005; Khattree & Naik, 2000; Kaiser, 1960). Under this method, as long as the eigenvalues are greater than one, the factor explains a sufficient amount of the variance in factors to warrant its inclusion in the analysis. However, it is also important that the researcher be able to explain the factors and that the factors are reliable (Kaiser, 1960). Choosing reliable factors is left to the researcher's discretion to some degree. If the factors make intuitive sense in helping answer the research question but the eigenvalue is slightly less than 1.0, it may make sense to include them to draw conclusions (Kaiser, 1960). Jolliffe (1972) found that 0.70 might be a “good” cutoff if the factor makes sense and can explain variation in the data adequately.

Factor analysis separated the risk perception questions into four categories, or factors, as shown in Table 3.6. The first factor contains risk perceptions associated with management including production, technology, and marketing activities. Factor 2 includes using personal insurance as a risk response (financial risk). The third factor included in the analysis is off-farm income/investments as important for family survival. Factor 4 is included in Table 3.6 for completeness, but since it explains little of the variation in the data with an eigenvalue of only 0.66, it is not considered a significant factor and is not included in further analysis.

Eigenvalues for the first three factors are greater than or equal to one and explain 87% of the variance in the data. Larger correlations (in absolute value) determine where each risk statement should be grouped within the factors. If farmers are concerned about production, marketing, and financial risk, the factors should group questions related to each different type of risk (Bard & Barry, 2000). Meuwissen, et al. (2001) found factors relating to farm family health, farm finances, legislation, production, and changes in farming situation to be significant sources of risk. Akcaoz and Ozkan (2005) found similar results with respect to these risk factors. The fourth factor has an eigenvalue of only 0.66, and does not explain much of the variance in the data. In addition, the fourth factor only has one question (I believe recent changes in government agricultural policy has substantially increased the risk of my farming operation.). Therefore, while it could be considered a government policy risk factor, it does not make sense to include the factor in the multinomial regression because it does not add significant information and a factor should have more than one element.

Factor loadings explain the variation each risk statement has on the factors and farmers' decisions to adopt conservation. No specific criterion determines how high a factor loading should be to warrant inclusion in the analysis. If the factor loadings are too low, it may indicate they do not fit well with any factor, and have no effect on farmers' decisions. Alternatively, if they are highly correlated with more than one factor, it becomes difficult to determine in which factor they fit better. For this analysis, factor loadings greater than or equal to 0.30 (in absolute value) are used to make inference about farmers' risk perception effects on conservation adoption. Survey questions with factor loadings less than 0.30 (in absolute value) were dropped when calculating the risk factor variable for the multinomial logit regression (Greiner et al., 2009). All the factor loadings are reported in Table 3.6 for comparisons. The dropped questions are: 1."I have enough cash on hand or assets that can be easily converted to cash to pay all my bills.", 6."I spread the sale of my commodities over the year.", 9. "Maintaining a low debt-to-asset ratio is important to me." and 15." I consider myself to be a low cost producer."

Factor 1, *management risk*, includes questions 2, 10, 11, 12, 13, 16, 17, and 18 from Table 3.6. These indicate farmers see using market information, maintaining machinery, spreading their operations geographically, having adequate backup labor/management, planning ahead, and using financial information in decision-making as risk-reducing management. Question 16 has a negative correlation of -0.328 indicating that being prone to making last minute decisions has an adverse effect on what might be called "good" management. Question 18 asks about passing land onto the next generation and indicates the farmer is concerned about the longevity of his/her operation and likely takes care to maintain property, land, and machinery while ensuring a financially sound operation.

Factor 2, *insurance risk*, includes questions 3, 4, and 5 relating to life, medical, and liability insurance, respectively, from Table 3.6. In each case, the factor loadings are high, indicating the questions are highly correlated with the factor, as expected. In this case, the insurance factor shows farmers view life, health, and liability insurance as important risk-reducing strategies.

Factor 3, *off-farm income risk*, includes questions 7 and 8 from Table 3.6. This factor is important for farmers who depend on off-farm income to supply basic household needs. In some cases, these may be small farms, while in others, it may indicate poor management if the farm is unable to provide a living for the farm family, as indicated by the negative sign on the factor loading under the management risk factor for question 7.

3.4.2 Multinomial logit regression results

The multinomial logit regression was run with conservation practice bundles as the dependent variable while independent variables included the three risk factors, crop and CRP acres, the percent cash-rented land, self ratings of farmers' adoption patterns and environmental versus profit concerns, whether the farm raised livestock, the area of Kansas each farmer is from, and soil-testing frequency.

Table 3.7 contains coefficient results and model fit statistics from the multinomial regression. Coefficients should be interpreted relative to farmers only using no-till as a conservation tool, which is the most common response and considered the base response. Overall, the model has a reasonable fit with a Pseudo-R^2 of 0.255 and a chi-squared statistic of

259 with 105 degrees of freedom, resulting in a p-value of 0.00 for the likelihood ratio test to determine whether the full model predicts better than an intercept-only model.

While the coefficients' signs are useful for interpreting an increased or decreased likelihood of adoption, the marginal effects prove to have more meaning with respect to probability of an individual making a choice (Greene, 2008) and are reported in Table 3.8. Marginal effects in a multinomial logit model incorporate sub-vectors of the estimated coefficients in each marginal effect. This implicitly includes the effects of choosing or not choosing other conservation practice bundles (Greene, 2008). Marginal effects show the changes in the probability that a respondent will choose any particular choice given a change in an explanatory factor.

Marginal effects in Table 3.8 show that overall, risk factors have little effect on conservation practice adoption with only one statistically significant effect at the 10% level for the three risk factors and self-risk assessment question. The self-risk assessment, management risk factor, and off-farm income risk factor have no statistically significant marginal effects, even at the 10% level. These risk factors do not play a significant role in farmers' decisions to adopt conservation practices. Off-farm income is not expected to influence whether a farmer will adopt a conservation practice (Davey & Furtan, 2008), but management characteristics should have had some impact on adoption. Management and off-farm income risk factors may have statistically insignificant impacts on conservation practice adoption because farmers view the potential risks as affecting their day-to-day farm operations and family livelihood. Whether a farmer adopts conservation or not has no impact on these activities in most cases. For instance, it is unlikely that a farmer concerned about having adequate backup management, spreading sales throughout the year, maintaining machinery, or locating fields in different areas will relate these to conservation practice adoption. Likewise, it is unlikely that farmers will relate having off-farm income to supplement family living with conservation practice adoption. The personal insurance risk factor decreases the likelihood of adoption of the no-till with manure combination (*NM*) by about 4%, but the risk factor was not significant for any other conservation practice bundles.

None of the marginal effects is significant for non-adopters (*O*). However, for those adopting cover crops, increasing crop acres increases the probability of adopting by 4.2%. Having Conservation Reserve Program (CRP) acres increases the likelihood of using no-till with filter/buffer strips (*NF*) by 32.5% and decreases the likelihood of using no-till and manure (*NM*) by 134%.

The next variable in Table 3.8 is percentage of cash-rented acres. An increase in the percentage of cash-rented acres negatively affects the use of no-till (*N*) by itself, which may be an expected result given some landowners will not allow tenants to practice no-till if it interferes with the "looks" of a field (Carolan, Mayerfeld, Bell, & Exner, 2004). However, no-till is a more cost effective practice and cash-renters may look for natural cost-reducing practices on rented land (Watkins, Hill, & Anders, 2008). At the same time, renters put forth less effort to adopt conservation practices compared to owners with a long-term interest in maintaining their land (Lynne, Shonkwiler, & Rola, 1988). Increasing the percentage of cash-rented acres increases the likelihood of using cover crops (*CC*) in combination with other practices by nearly 11%. This may indicate that farmers see value in cover crops because they can decrease crop fertilizer expenses, even though they may increase herbicide expenses for no-till producers (Bergtold, Duffy, Hite, & Raper, 2012; Larson, Jaenicke, Roberts, & Tyler, 2001).

Farmers with livestock are 35.5% less likely to use no-till (*N*) alone, but 29.7% more likely to use conservation practices related to manure use when including no-till (*NM*). Livestock farmers are also 6.1% more likely to use no-till, manure, and filter/buffer strips (*NFM*). Other results for livestock producers are not statistically significant. This result is not unexpected since farms depending on livestock for a larger share of income will be less inclined to adopt conservation practices (Featherstone & Goodwin, 1993; Walton et al., 2012).

Table 3.8 shows that considering oneself a first adopter decreases the likelihood of using only no-till by approximately 8.7%. While it may make sense that first adopters will be more likely to use no-till, it is possible that farmers who practice no-till have been doing so for many years and the practice has become more accepted. In addition, first adopters are more likely to use other conservation practices in combination with no-till rather than practicing no-till alone. First adopters are about 5.6% more likely to use no-till in combination with variable rate technology (*NV*). In addition, first adopters are more likely to choose some practice that includes cover crops (*CC*) by about 5%. These results are not unexpected because variable rate technology is relatively new and first adopters will adopt new technology as risk-reducing or cost-saving before later adopters (Boz & Akbay, 2005).

Valuing conservation for environmental reasons and profit reasons can be different for different types of farmers. Early adopters may be less willing to adopt a practice if they are motivated by profits, while profit motives have little effect on late adopters' decisions to adopt conservation (Läpple & Van Rensburg, 2011). Farmers who identify conservation as a priority on their farm are 7.9% less likely to adopt no-till and manure use, while farmers who place a greater value on profits than the environment are about 4.6% less likely to adopt conservation practices involving cover crops (see Table 3.8). This result is not unexpected due to potential costs of growing and inexperience with cover crops.

Regional variables indicate that, relative to Western Kansas, farmers in Central and Eastern Kansas are 30% and 19%, respectively, less likely to use no-till alone. These results are expected given annual precipitation falls from eastern to western Kansas and no-till adoption should increase in drier climates. Central Kansas' farmers are 16% more likely to use no-till and filter/buffer strips (*NF*) together, as indicated by higher rates of CRP participation in Central Kansas. Farmers are 13% and 17.3% less likely to use no-till and manure (*NM*) in Central and Eastern Kansas, respectively. Central Kansas' farmers are 11.5% more likely to adopt conservation practice bundle with cover crops (*CC*). Again, this is possibly due to farmers' familiarity with soil benefits from using cover crops.

The last variable shown at the bottom of Table 3.8 is soil-testing frequency. Decreasing the frequency of soil testing decreases the likelihood a farmer will adopt no-till with filter/buffer strips by nearly 3%. Coefficients for conservation practice bundles including manure use were not significant, which is somewhat unexpected since research has shown farmers should test soils before spreading manure to reduce over- or under application (Fuglie & Bosch, 1995).

3.5 Conclusions

This paper attempted to determine whether farmers' risk perceptions affected the likelihood that they use conservation on their farm. Data gathered from an enumerated survey of Kansas farmers, which included conservation practice use, risk perceptions, conservation views, and farm operation variables were considered. Factor analysis was used to group farmers' responses to risk perception questions and the resulting risk factors were included in a multinomial regression to determine the probabilities of adopting different conservation practice bundles. Factor analysis grouped the risk perceptions into three categories: management risk; personal insurance risk; and off-farm income/investment risk. These risk factors play little or no role with respect to farmers' conservation adoption. Only the insurance risk factor was statistically significant at the 10% level, and had a negative impact on the likelihood of farmers using no-till and manure (*NM*) together.

The insignificance of risk perceptions on conservation practice use is somewhat puzzling since it would seem that if conservation can ensure the longevity on their farm's productivity, farmers would adopt. However, if farmers are profit maximizers in the short run, they may be less willing to adopt conservation if the monetary costs are high, regardless of the short-term environmental costs. Since these risk perceptions have essentially no effect on conservation practice adoption, it seems that farmers do not consider the types of risk examined here when adopting conservation, and consider other factors in their decisions. While not used in this study, it is possible that monetary incentives play a larger role in conservation adoption than an individual's risk perception.

Most Kansas farmers already practice some form of conservation tillage, indicating they recognize the need to conserve soil and moisture. Farmers who indicated they see themselves as a first adopter are more likely to use practices involving variable rate technology and cover crops, which is not unexpected since technology adoption is probably something first adopters will adopt and cover crops are not widely used in Kansas. Farmers who have livestock naturally practice conservation related to manure management. Central Kansas farmers are likely to adopt conservation practices possibly due to less irrigation use than Western Kansas farmers, and less rainfall than Eastern Kansas farmers receive.

More work remains in the area of farmers' risk perceptions and the effects on conservation practice adoption. This study attempted to relate risk perceptions to conservation practice adoption and found no relationship. It is possible that the risk questions were asked in a way such that they do not extract farmers' true risk aversion. Eliciting risk aversion through a different method may provide researchers with a better understanding of how farmers' risk perceptions and risk management strategies affect conservation adoption.

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Table 3.1. Summary statistics of self-risk assessment question. This is the first question in Appendix A3. (N = 283)

Question: For your farm/ranch mgmt., how would your neighbors describe your risk taking behavior?	N	Percentage of Total	Cumulative Percentage
1. An extreme risk avoider	5	1.8%	1.8%
2. Cautious	104	36.7%	38.5%
3. Willing to take risks after adequate research	143	50.5%	89.0%
4. Not really concerned about risk	14	4.9%	94.0%
5. Enjoy taking risks in my business	16	5.7%	99.6%
6. A real gambler	1	0.4%	100.0%
Average	2.77		
Standard Deviation	0.83		
Median	3		

Table 3.2. Summary of risk-related questions. (See Appendix A3 for questions and types of answers required.)

Question	N	Average	St. Dev	Median	Mode	Max	Min
1. Do you purchase federal or private crop insurance?[a]	287	270			1		
2. Do you purchase insurance to cover hail damage to your crops?[a]	286	153			1		
3. Do you keep a line of credit open at your primary lender?[a]	254	215			1		
4. I have enough cash on hand or assets that can be easily converted to cash to pay all my bills.	279	4.65	1.49	5	6	6	1
5. I rely heavily on market information (for example: government reports, private market news services, extension) in making my marketing decisions.	281	4.37	1.21	4	5	6	1
6. I do have adequate life insurance.	278	4.34	1.63	5	5	6	1
7. I do have adequate health insurance.	280	5.10	0.99	5	5	6	1
8. My farming operation does have adequate liability insurance.	279	5.25	0.80	5	5	6	1
9. I spread the sale of my commodities over the year.	277	4.69	1.09	5	5	6	1
10. Off-farm income is important for the survival of my family.	279	3.53	1.81	4	5	6	1
11. Off-farm investments are important sources of income for my family.	277	2.81	1.52	2	2	6	1
12. Maintaining a low debt-to-asset ratio is important to me.	279	5.03	0.93	5	5	6	1
13. Most of my machinery is new and/or in good repair.	279	4.46	1.19	5	5	6	1
14. I have fields in different locations to reduce yield risk.	282	4.28	1.35	5	5	6	1
15. In case of emergency, I have sufficient back-up management and labor.	278	4.03	1.39	4	5	6	1
16. I see myself as a person who plans ahead.	281	4.73	0.87	5	5	6	2
17. I believe recent changes in government agricultural policy have substantially increased the risk of my farming operation.	279	4.23	1.23	4	5	6	1
18. I consider myself to be a low cost producer.	280	4.36	1.04	5	5	6	1
19. I am prone to making last minute decisions.	279	3.38	1.23	3	4	6	1
20. I use financial information in decision-making about my farm.	280	4.71	0.95	5	5	6	1
21. Passing my land onto my children is important to me.	280	5.10	1.16	5	6	6	1
22. D/A ratio categories[b]	273	4.69	2.37	5	6	9	1

[a]Indicates a binary response. Only "yes" responses are included.

[b]A total of 10 options ranged from "0%" to "over 90%". The most common response was "20 to 29%", and no one chose "over 90%". See Appendix A3. Questions are asked on a Likert-scale from 1="Strongly Disagree" to 6="Strongly Agree".

Table 3.3. Summary statistics for independent variables not related to risk perceptions or conservation practices.

Variable	N	Mean	Std. Dev.	Min	Max
Crop acres	256	1536	1380	0	8620
CRP acres	256	36	111	0	1200
Percent cash rent	256	33.4	39.3	0	100
Livestock[a]	256	0.59			
Central KS[a]	256	0.38			
Eastern KS[a]	256	0.26			

[a]Binary variables. where 1=yes, 0=no.

Table 3.4. Summary statistics for conservation practices. (See Appendix B3 for questions and types of responses required for each question.)

Question	N	Average/Count	St. Dev	Median	Mode	Max	Min
1. Do you have a conservation plan for your farm?	277	227			1		
2. I usually adopt new technology (e.g. no-till, new seed varieties, GPS, etc.) before my neighbors.[a]	287	4.09	1.23	4	4	6	1
3. Conservation of soil and water resources is a top priority in the management of my farming operation.[a]	287	5.30	0.83	5	6	6	1
4. Maximizing farm profit is more important than environmental stewardship.[a]	287	3.31	1.18	3	4	6	1
5. Conservation tillage (No-till[c], Strip-till, Reduced-till, Ridge-till)	285	272			1		
6. Cover Crops	285	28			0		
7. Variable Rate Application/Field Mapping	285	65			0		
8. Filter or Buffer Strips	285	62			0		
9. Use of Manure	285	137			0		
10. Cost Share for: Conservation tillage	262	31			0		
11. Cost Share for: Cover Crops	28	2			0		
12. Cost Share for: Variable Rate Application/Field Mapping	64	3			0		
13. Cost Share for: Filter or Buffer Strips	62	39			1		
14. Cost Share for: Use of Manure	130	4			0		
15. Soil Testing Frequency[b]	284	2.51	1.25	3	1	5	1

[a]Likert-scale response required. Responses ranged from 1 = “Strongly Disagree” to 6 = “Strongly Agree”.
[b]Responses were: 1=annually, 2=every 2 years, 3=every 3 years, 4=every 4 years, 5=never.
All other questions are binary where 1 = “Yes” and 0 = “No”. The number of “Yes” responses is reported.
[c]Note that 221 (76.2%) farmers indicated they practice no-till on at least some of their crops.

Table 3.5. Use frequencies and percentages of conservation practice bundles.

Conservation Practice Bundle	Abbreviation	Frequency	Percent
Non-adopters	O	22	7.80
No-till	N	70	24.82
Variable Rate Technology	V	2	0.71
Filter/Buffer Strips	F	2	0.71
Use of Manure	M	16	5.67
No-till/Variable Rate Technology	NV	18	6.38
No-till/Filter-Buffer Strips	NF	16	5.67
No-till/Use of Manure	NM	54	19.15
Variable Rate/Filter-Buffer Strips	VF	2	0.71
Variable Rate/Use of Manure	VM	5	1.77
Filter-Buffer Strips/Use of Manure	FM	6	2.13
No-till/Variable Rate/Filter-Buffer Strips	NVF	6	2.13
No-till/Variable Rate/Use of Manure	NVM	16	5.67
No-till/Filter-Buffer Strips /Use of Manure	NFM	15	5.32
No-till/Variable Rate/Filter-Buffer Strips /Use of Manure	NVFM	4	1.42
Cover Crop in Combination	CC	28	9.93

Total number of observations is 282. The percent is the number of farmers using each conservation practice bundle divided by 282.

Table 3.6. Factor Loadings for Risk Categories.

	Factor 1 *Management*	Factor 2 *Insurance*	Factor 3 *Off-farm*	Factor 4 *Govt. Risk*
a. I have enough cash on hand or assets that can be easily converted to cash to pay all my bills.	0.2903	0.2027	-0.2346	-0.0905
b. I rely heavily on market information (for example: government reports, private market news services, extension) in making my marketing decisions.	**0.3536**	0.1338	-0.0172	0.1189
c. I do have adequate life insurance.	0.0721	**0.4704**	-0.0122	0.2224
d. I do have adequate health insurance.	0.1601	**0.7813**	0.1476	-0.1134
e. My farming operation does have adequate liability insurance.	0.2177	**0.5493**	0.0524	0.0635
f. I spread the sale of my commodities over the year.	0.2341	0.0093	-0.0910	-0.0065
g. Off-farm income is important for the survival of my family.	-0.1390	0.0073	**0.8226**	0.0953
h. Off-farm investments are important sources of income for my family.	0.1819	0.1389	**0.4251**	-0.1596
i. Maintaining a low debt-to-asset ratio is important to me.	0.1530	0.2184	-0.0951	0.2169
j. Most of my machinery is new and/or in good repair.	**0.4407**	0.2430	-0.0679	0.0984
k. I have fields in different locations to reduce yield risk.	**0.4620**	0.1247	0.1493	0.0235
l. In case of emergency, I have sufficient back-up management and labor.	**0.6487**	0.1007	0.0912	0.0275
m. I see myself as a person who plans ahead.	**0.6370**	0.2582	-0.0026	0.1315
n. I believe recent changes in government agricultural policy have substantially increased the risk of my farming operation.	-0.0210	0.0077	0.0698	**0.5181**
o. I consider myself to be a low cost producer.	0.0714	0.1377	-0.0900	0.2634
p. I am prone to making last minute decisions.	**-0.3284**	-0.0272	0.0424	0.1734
q. I use financial information in decision-making about my farm.	**0.3004**	0.1039	0.0025	0.1038
r. Passing my land onto my children is important to me.	**0.3257**	-0.0345	0.0335	0.2871
Eigenvalues	1.9621	1.4426	1.0058	0.6597
Variance explained (%)	38.698	28.453	19.838	13.011
Cumulative variance explained (%)	38.698	67.151	86.989	100.000

Factor loadings ≥ |0.30| are shown in bold. Survey questions with factor loadings < |0.30| are not included in the regression estimation. In addition, Factor 4, government risk, is not included in the multinomial regression because the factor does not explain a sufficient amount of variation (eigenvalue = 0.6597). The shaded areas indicate questions **NOT** included in the multinomial logit regression.

Table 3.7. Coefficients for multinomial logit model of conservation practice adoption.

VARIABLES	O	M	NV	NF	NM	NVM	NFM	CC
Self-Risk Assessment	0.0679 (0.4725)	1.6356** (0.5005)	-0.0559 (0.3427)	0.1894 (0.4506)	0.0713 (0.2799)	0.3998 (0.3873)	0.2035 (0.4217)	-0.2097 (0.3385)
Management Risk Factor	-0.2799* (0.1684)	0.2163 (0.1961)	-0.2280 (0.1883)	0.0486 (0.2054)	0.1448 (0.1226)	0.1489 (0.1714)	0.0091 (0.1827)	-0.1136 (0.1555)
Insurance Risk Factor	0.0746 (0.2073)	0.3379 (0.2614)	0.3656 (0.2658)	0.0367 (0.2444)	-0.1749 (0.1464)	-0.1639 (0.1888)	0.0864 (0.2347)	0.1721 (0.1975)
Off-farm income Risk Factor	0.5290** (0.1896)	-0.3954* (0.2219)	-0.0344 (0.1783)	-0.1124 (0.186)	0.0625 (0.1208)	-0.1777 (0.1767)	0.1169 (0.2006)	0.05 (0.1494)
Crop acres	-0.4841 (0.4188)	-0.4381 (0.4478)	0.2386 (0.2488)	-0.2044 (0.3377)	-0.0176 (0.2014)	-0.3879 (0.3624)	-0.4324 (0.4468)	0.3669* (0.2008)
CRP acres	-82.8193 (68.2189)	-121.7239 (106.4828)	-4.8232 (5.6089)	6.5119** (2.8291)	-7.3261* (3.9716)	0.0354 (4.632)	2.9247 (3.9477)	-1.4794 (3.0893)
Percent cash rent	-0.6813 (0.8667)	-0.9697 (1.0231)	1.0741 (0.8021)	-0.4576 (0.9556)	0.6995 (0.5533)	0.8974 (0.7654)	0.3179 (0.8282)	1.4467** (0.6751)
Livestock	-0.0751 (0.6343)	2.1161** (0.853)	0.5651 (0.6481)	0.4360 (0.6795)	2.1814*** (0.499)	1.4257** (0.6973)	2.1334** (0.8359)	0.7677 (0.5562)
First adopter	-0.2283 (0.2954)	-0.9402** (0.3691)	1.4468*** (0.4078)	0.3200 (0.3424)	0.1332 (0.2057)	0.4930 (0.3238)	-0.1758 (0.3221)	0.6756** (0.2747)
Conservation Priority	-0.6132* (0.3542)	0.8751 (0.6578)	-0.3023 (0.4721)	0.8336 (0.5861)	-0.3497 (0.2757)	-0.0830 (0.4534)	0.6569 (0.5061)	-0.0306 (0.3756)
Profit vs. Environment	0.2050 (0.2672)	0.6005* (0.3269)	0.2525 (0.2485)	-0.0663 (0.2807)	0.0366 (0.1816)	0.0951 (0.2699)	0.1522 (0.2683)	-0.4372* (0.2316)
Central KS	-0.1435 (0.791)	3.6282*** (1.3913)	1.2980* (0.7852)	3.5686*** (1.0904)	0.3121 (0.5207)	1.4614* (0.783)	2.4028** (0.9656)	1.9112*** (0.644)

Table 3.6 (continued)

Eastern KS	-0.1680 (0.7603)	2.7925* (1.4502)	1.0275 (0.854)	3.1833*** (1.2269)	-0.2699 (0.5733)	0.6437 (0.9192)	1.8669* (1.0314)	0.7997 (0.8199)
Soil Testing	-0.1080 (0.2477)	-0.1284 (0.3382)	-0.0327 (0.298)	-0.8708** (0.3555)	-0.1614 (0.1841)	-0.1157 (0.2896)	-0.3197 (0.2938)	-0.3683 (0.2547)
Constant	3.0444 (3.3152)	-17.4907*** (6.147)	-9.8843*** (3.7422)	-9.0194** (4.2238)	-0.56030 (2.3573)	-4.6221 (3.5814)	-9.2184** (4.0304)	-4.1908 (3.1058)
--*Model characteristics*--								
Observations	252							
Log likelihood	-377.76							
LR $\chi^2(105)$	259							
Prob > χ^2	0.0000							
Pseudo R^2	0.2553							

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Abbreviations are as follows: *O* = Non-adopter, *M* = use manure, *NV* = no-till and variable rate technology, *NF* = no-till and filter or buffer strips, *NM* = no-till and manure use, *NVM* = no-till, variable rate technology, and manure use, *NFM* = no-till, filter or buffer strips, and manure use, and *CC* = cover crops practice bundle.

Table 3.8. Marginal effects for multinomial logit model of conservation practice adoption.

VARIABLES	O	N	M	NV	NF	NM	NVM	NFM	CC
Self-Risk Assessment	0.0001 (0.0015)	-0.0179 (0.0547)	0.0005 (0.002)	-0.0046 (0.0133)	0.0054 (0.0152)	0.0071 (0.047)	0.0281 (0.0257)	0.009 (0.0209)	-0.0277 (0.0288)
Management risk factor	-0.0011 (0.0026)	-0.0116 (0.0239)	0.0001 (0.0002)	-0.0117 (0.0078)	0.0007 (0.0069)	0.0306 (0.0206)	0.0095 (0.0113)	-0.0011 (0.009)	-0.0155 (0.0136)
Insurance risk factor	0.0003 (0.001)	0.0069 (0.0284)	0.0001 (0.0005)	0.0175 (0.0116)	0.0020 (0.0084)	-0.0416* (0.0249)	-0.0116 (0.0125)	0.0058 (0.0119)	0.0206 (0.0177)
Off-farm risk factor	0.0018 (0.0044)	-0.0042 (0.0238)	-0.0001 (0.0005)	-0.0020 (0.0073)	-0.0046 (0.0063)	0.0137 (0.0205)	-0.0149 (0.0116)	0.0060 (0.0102)	0.0043 (0.0131)
Crop acres	-0.0016 (0.0041)	0.0074 (0.0383)	-0.0001 (0.0006)	0.0117 (0.0105)	-0.0069 (0.0118)	0.0001 (0.0351)	-0.0292 (0.0242)	-0.0233 (0.0214)	0.0420** (0.0177)
CRP acres	-0.2786 (0.4651)	0.9036 (0.6275)	-0.0392 (0.1224)	-0.1187 (0.2335)	0.3247** (0.156)	-1.3415* (0.7118)	0.1788 (0.3299)	0.2895 (0.2114)	0.0813 (0.2961)
Percent cash rent	-0.0039 (0.0098)	-0.1867* (0.1116)	-0.0005 (0.0018)	0.0281 (0.0334)	-0.0341 (0.0324)	0.0630 (0.0905)	0.0346 (0.0502)	-0.0080 (0.0403)	0.1076* (0.0572)
Livestock	-0.0033 (0.0083)	-0.3555*** (0.0796)	0.0004 (0.0014)	-0.0129 (0.0264)	-0.0152 (0.0235)	0.2970*** (0.0657)	0.0383 (0.0394)	0.0611* (0.0343)	-0.0100 (0.0459)
First adopter	-0.0015 (0.0038)	-0.0872** (0.0403)	-0.0004 (0.0015)	0.0563*** (0.0175)	0.0039 (0.0117)	-0.0214 (0.0359)	0.0220 (0.0214)	-0.0220 (0.0168)	0.0502** (0.0236)
Conservation Priority	-0.0019 (0.0049)	0.0201 (0.0596)	0.0003 (0.0012)	-0.0115 (0.0191)	0.0328 (0.0212)	-0.0789* (0.0452)	-0.0026 (0.0303)	0.0397 (0.026)	0.0021 (0.0322)
Profit vs. Environment	0.0008 (0.002)	0.0049 (0.0357)	0.0002 (0.0008)	0.0121 (0.0105)	-0.0020 (0.0094)	0.0128 (0.0307)	0.0085 (0.0181)	0.0092 (0.0135)	-0.0464** (0.0198)
Central KS	-0.003 (0.0077)	-0.3009*** (0.0848)	0.0015 (0.0058)	0.0170 (0.0314)	0.1597** (0.0793)	-0.1297* (0.0712)	0.0425 (0.0537)	0.0981 (0.0656)	0.1148* (0.0655)

Table 3.7 (continued)

Eastern KS	-0.0020 (0.0055)	-0.1901* (0.1004)	0.0014 (0.0053)	0.0215 (0.0412)	0.2155 (0.1348)	-0.1727** (0.0746)	0.0052 (0.0613)	0.0972 (0.0872)	0.0240 (0.0774)
Soil Testing	0.0001 (0.0009)	0.0585 (0.0376)	0.0000 (0.0001)	0.0051 (0.0125)	-0.0270** (0.0129)	-0.0046 (0.0311)	0.0022 (0.0196)	-0.0099 (0.0146)	-0.0245 (0.0221)

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Abbreviations are as follows: *O* = Non-adopter, *N* = no-till only, *M* = use manure, *NV* = no-till and variable rate technology, *NF* = no-till and filter or buffer strips, *NM* = no-till and manure use, *NVM* = no-till, variable rate technology, and manure use, *NFM* = no-till, filter or buffer strips, and manure use, and *CC* = cover crops practice bundle.

Appendix A3 - Risk-Related Questions

For your farm/ranch management, how would your neighbors describe your risk taking behavior? (*Mark one*)

___ An extreme risk avoider
___ Cautious
___ Willing to take risks after adequate research
___ Not really concerned about risk
___ Enjoy taking risks in my business
___ A real gambler

Do you purchase federal or private crop insurance? ___ Yes ___ No

Do you purchase insurance to cover hail damage for your cash crops ___ Yes ___ No

Do you keep a line of credit open at your primary lender? ___ Yes ___ No

Please rank the degree to which you agree with each statement below.

Statement	**Rank from 1 to 6 where:** **1 = Strongly Disagree;** **2 = Disagree;** **3 = Somewhat Disagree;** **4 = Somewhat Agree;** **5 = Agree;** **6 = Strongly Agree**					
a. I have enough cash on hand or assets that can be easily converted to cash to pay all my bills.	1	2	3	4	5	6
b. I rely heavily on market information (for example: government reports, private market news services, extension) in making my marketing decisions.	1	2	3	4	5	6
c. I do have adequate life insurance.	1	2	3	4	5	6
d. I do have adequate health insurance.	1	2	3	4	5	6
e. My farming operation does have adequate liability insurance.	1	2	3	4	5	6
f. I spread the sale of my commodities over the year.	1	2	3	4	5	6
g. Off-farm income is important for the survival of my family.	1	2	3	4	5	6
h. Off-farm investments are important sources of income for my family.	1	2	3	4	5	6
i. Maintaining a low debt-to-asset ratio is important to me.	1	2	3	4	5	6
j. Most of my machinery is new and/or in good repair.	1	2	3	4	5	6
k. I have fields in different locations to reduce yield risk.	1	2	3	4	5	6
l. In case of emergency, I have sufficient back-up management and labor.	1	2	3	4	5	6
m. I see myself as a person who plans ahead.	1	2	3	4	5	6
n. I believe recent changes in government agricultural policy have substantially increased the risk of my farming operation.	1	2	3	4	5	6
o. I consider myself to be a low cost producer.	1	2	3	4	5	6
p. I am prone to making last minute decisions.	1	2	3	4	5	6
q. I use financial information in decision-making about my farm.	1	2	3	4	5	6
r. Passing my land onto my children is important to me.	1	2	3	4	5	6

For every $100 of farm assets you have, what percent is financed with debt? (*Mark one*)

___ 0% ___ 1% to 4% ___ 5% to 9% ___ 10% to 14%

___ 15% to 19% ___ 20% to 29% ___ 30% to 49% ___ 50% to 69%

___ 70% to 89% ___ greater than 90%

Appendix B3 - Conservation Practice Questions

Do you have a conservation plan for your farm? ___Yes ___ No

How do you agree with this statement: (*Please circle your response from 1 to 6*)

I usually adopt new technology (e.g. no-till, new seed varieties, GPS, etc.) before my neighbors.

Strongly Disagree 1 2 3 4 5 6 **Strongly Agree**

How do you agree with this statement: (*Please circle your response from 1 to 6*)

Conservation of soil and water resources is a top priority in the management of my farming operation.

Strongly Disagree 1 2 3 4 5 6 **Strongly Agree**

How do you agree with this statement: (*Please circle your response from 1 to 6*)

Maximizing farm profit is more important than environmental stewardship

Strongly Disagree 1 2 3 4 5 6 **Strongly Agree**

Indicate which in-field conservation practices listed below you use and whether you received cost-share, incentive payments, or income from using each practice from the USDA, Natural Resources Conservation Service (NRCS) or some other state agency. Then indicate the program in which you participated. See the codes below for a list of NRCS and state programs.

Conservation Practice	**Do you use this practice?**	**If Yes, do you receive cost-share, incentive payments, or income for using this practice?**	**If Yes, indicate what programs provided cost-share/incentive payments.** (*List all that apply from codes below or write in.*)
Conservation Tillage (No-till, Strip-till, Reduced-till, Ridge-till)	___ Yes ___ No	___ Yes ___ No	
Cover Crops	___ Yes ___ No	___ Yes ___ No	
Variable Rate Application/Field mapping	___ Yes ___ No	___ Yes ___ No	
Filter or Buffer Strips	___ Yes ___ No	___ Yes ___ No	
Use of Manure	___ Yes ___ No	___ Yes ___ No	
Other (*specify*)	___ Yes ___ No	___ Yes ___ No	
Other (*specify*)	___ Yes ___ No	___ Yes ___ No	

Program Codes:
1 – Environmental Quality Incentives Program (EQIP)
2 – Conservation Security/Stewardship Program (CSP)
3 – Conservation Technical Assistance (CTA)
4 – Wildlife Habitat Incentives Program (WHIP)
5 – Grasslands Reserves Program (GRP)
6 – Farm and Ranch Lands Protection Program (FRPP)
7 – Conservation Reserve Program (CRP)
8 – Wetlands Reserve Program (WRP)
9 – State of Kansas Conservation Programs
10– Other (*specify*):____

About how often do you have your soils tested? (*Mark one*)
___ Every Year ___ 2 years ___ 3 years ___ 4 or more years ___ Never

Chapter 4 - Farmers' Risk Perceptions in Stated Choice Experiments on Adoption of Alternative Cellulosic Biofuel Feedstocks

4.1 Introduction

A great deal of uncertainty surrounds development of a cellulosic bioenergy industry and markets. Production of cellulosic and other "second-generation" biofuels continues to lag behind U.S. federal government mandates requiring increased use of these advanced fuels. The Renewable Fuels Standard (RFS2) contained in the Energy Independence and Security Act of 2007 (EISA) mandated that 500 million gallons of cellulosic biofuels be produced in 2012. However, due to several production limitations, the Environmental Protection Agency reduced the amount to 10.45 million gallons based on actual production capabilities (U.S. Environmental Protection Agency, 2012). Due to production uncertainty of cellulosic biofuel production, farmers may be reluctant to participate in new enterprises to produce energy crops. Without established markets and prices, farmers will likely be reluctant to produce cellulosic biofuel feedstocks. In addition, farmer perceptions about biofuels and renewable energy in general will further influence their decisions whether to begin producing a bioenergy crop. Traditional crops and livestock have well-established futures and spot markets as well as crop insurance so farmers know their production has an outlet, understand production risks, and are able to forward contract their production and hedge market risk.

Underlying risk perceptions can affect an individual's decision-making behavior regarding whether to invest their retirement savings in stocks or bonds; whether to lead a healthy lifestyle; whether to purchase insurance; business's decisions about whether to invest in new technology; and farmers' decisions regarding using government programs to manage risk (Chavas, 2004; Robison & Barry, 1987). Much research has studied consumers' willingness to pay for products, tourism amenities, or improved environmental conditions by taking account of consumers' risk perceptions about food, product safety, environmental quality, etc. (Kamakura & Russell, 1989; Chintagunta, Jain, & Vilcassim, 1991; Boxall & Adamowicz, 2002; Dietz & Atkinson, 2010). In a similar way, perceptions about risk in growing non-traditional crops can play an important role in determining whether farmers are willing to produce bioenergy crops.

The purpose of this paper is to determine how risk or other unobserved factors affect farmers' choices in stated choice experiments about adopting alternative cellulosic biofuel enterprises on-farm under contract. This study uses a latent class regression model to determine if heterogeneity exists among survey respondents' risk perceptions in a stated choice framework. Latent class models have gained popularity in agricultural, natural resource, and environmental economic research to determine how consumers react to environmental policy changes, choose park amenities, or adopt agricultural practices. Latent class models find classes within data that answer "unasked" questions and when the questions' importance are unknown (Giordani, Schlag, & Zwart, 2010).

Three important crops for cellulosic biofuel production are corn stover, sweet sorghum, and switchgrass. Each of these crops has its own unique characteristics that farm managers will consider when evaluating adoption of these crops. Corn stover as a bioenergy feedstock can provide corn-producing farmers with added revenue in addition to the corn grain. Sweet sorghum provides farmers with a familiar crop that rotates well with traditional crops. Switchgrass may provide farmers with an opportunity to produce a high-value crop on marginal land, or replace land currently used to produce hay or enrolled in the Conservation Reserve Program (CRP). This study will examine farmers' willingness to grow these crops in a stated choice framework, subject to their perceptions about risks on their farms.

The next section is a brief literature review of research using latent class models to model preference heterogeneity among respondents in natural resource contexts. A description of data and methods are presented after the literature review. A discussion of results, conclusions, and implications follow.

4.2 Literature Review

Latent class models (LCM) have gained popularity as a way to model heterogeneity across individuals' responses to stated preference questions. Early work using LCMs can be found in marketing research studies assessing consumers' willingness to purchase products based on different brands or quality attributes (Chintagunta et al., 1991). Market segmentation studies also use latent class models. Kamakura and Russell (1989) found consumers can be segmented based on purchases when considering both price and quality differences. LCMs provide differences in demand elasticities for different types of consumers. For instance, Chintagunta et al. (1991) found consumers' intrinsic preferences for different brands of saltine crackers affected own-price and cross-elasticities depending on whether consumers were loyal to a specific brand or more motivated by prices.

Dietz and Atkinson (2010) used a LCM to assess citizens' willingness to pay for pollution control policies in the Southwark area of London, England. They determined that LCMs provided better estimates than a conditional or multinomial logit model. They utilized a 3-class latent model to determine citizens' views requiring that polluters or pollutees pay for air pollution due to automobile emissions in the city. They found that the LCM was able to specify a type of respondent who was more concerned with mitigating effects of taxation on lower income residents and shifting the burden to polluters. The LCM isolated respondents who are more interested in an equitable distribution of emissions taxes rather than taxing specific groups, but who may wish to minimize their own obligation. In other words, self-interest plays a role in a respondent's choice, but it is not always observable to researchers. A latent class modeling approach can help define these differences across survey respondents.

Glenk and Colombo (2011) used principal components analysis (PCA) to reduce the number of variables in a stated choice study and included the PCA results in a latent class model to differentiate among survey respondents' willingness to pay for climate change policies in Scotland. They found heterogeneity exists across survey respondents and that willingness to pay for climate change policies depends on respondents' class. Their analysis has policy implications for carbon sequestering policies directed at farmers because policy makers should consider private and public costs before instituting policy due to resistance from certain types of market participants.

Boxall and Adamowicz (2002) included factor analysis in a latent class regression model study to determine how recreational users value park amenities in five Canadian/U.S. parks. The factor analysis grouped park attendees by their desire to get away from their routine for quiet relaxation, those who want to get away for a quiet weekend, those who simply love being out in nature, and those who love being in the wilderness for many days at a time. They determined that heterogeneity among individuals' preferences changes welfare analysis for park attendees by including the four latent segments in a latent class logit model. They used results from the LCM to calculate compensating variation for individuals' indirect utility functions, which helped measure the dollar amount park attendees should be compensated to maintain his/her initial level of utility.

Bard and Barry (2000) analyzed farmers' self-reported risk perceptions and found responses to Likert-scale based risk perception questions were correlated positively with responses to scientific risk elicitation questions where farmers choose between different lotteries with different probabilities of occurring. The study shows that answering risk perception questions can approximate farmers' risk-taking behavior under a hypothetical lottery, but also found that using more than one tool to model risk is often more useful than only one method.

Individuals have varying perceptions of risk, just as they have differing perceptions of how they value park amenities or societal issues. This paper will contribute to literature using a latent class modeling framework to assess farmers' willingness to produce cellulosic biofuel feedstocks under varying risk perceptions.

4.3 Data and Methods

This section explains the data source, discusses the theoretical utility framework for farmers maximizing utility, and then presents the empirical model that analyzes farmers' willingness to adopt cellulosic biofuel crops subject to risk perceptions.

4.3.1 Data

A stated choice survey was designed to assess farmers' willingness to produce three types of crops for biofuels (corn stover, sweet sorghum, and switchgrass) for biofuel under contract with biorefineries or other biomass processors following Louviere, Hensher, and Swait (2000) and Roe, Sporleder, and Belleville (2004). The survey included questions about farmers' risk perceptions, conservation practice adoption, and general information about their operations. It was administered face-to-face by the Department of Agricultural Economics at Kansas State University and USDA National Agricultural Statistics Service (NASS), Kansas Field Office from November 2010 to January 2011. A total of 485 farmers in western, central, and northeastern Kansas with more than 260 crop acres and at least $50,000 in gross sales were contacted. The survey was tested on focus groups in August 2010, then with face-to-face interviews in October

2010. NASS enumerators were trained during a two-day training session and began interviewing farmers in early November. Interviews took 57 minutes (on average) to complete and farmers were compensated for their time with a $15 gift card. 290 surveys were completed and returned while 38 farmers were out of business or could not be reached, resulting in a 65% response rate (290/(485-38) = 0.65).

The two parts of the survey utilized for data in this study are the biofuel feedstock stated choice experiments and questions regarding farmers' risk perceptions. The next sections discuss each component of the survey in detail.

4.3.1.1 Stated Choice Experiment

Figure 4.1 shows an example of three stated preference questions farmers were presented with to determine which biofuel crop(s) contracts they would be willing to grow at different levels of returns, contract lengths, biorefinery harvest options, insurance availability, and nutrient replacement (in the case of corn stover), government incentive payments (in the case of sweet sorghum), and establishment cost share (in the case of switchgrass). Table 4.1 contains a description of the attributes and levels for each biofuel feedstock and Table 4.2 contains summary statistics for the stated choice experiments.

The survey provided a brief explanation of each type of biomass production and explained the contract attributes before requiring a response to the set of stated choice questions shown in Figure 4.1. Survey respondents were asked to consider five independent choice scenarios with options to choose between two contracts or an "opt out" option, as shown in Figure 4.1.

The choice scenarios contain two generically labeled contracts with attributed levels assigned randomly and an option to "opt out." Following Louviere et al. (2000) a $(1^4 \times 1^3 \times 2^2)^2$

fractional factorial design for corn stover, a $(1^4 \times 1^3 \times 3^2)^2$ fractional factorial design for sweet sorghum, and a $(3^2 \times 2^3)^2$ fractional factorial design for switchgrass were used to develop 90 random choice sets for each feedstock in order to identify all main effects and any potential interaction effects between attributes and levels. The choice sets were randomly assigned into 18 blocks (18 survey versions) and each respondent was presented with five choice scenarios for each biofuel feedstock (see Figure 4.1). The following is a brief discussion about contract options as shown in Table 4.1.

4.3.1.1.1 Corn Stover

Contract options were unlabelled and had four attributes for corn stover: (1) Net returns per acre, (2) Contract length, (3) Biorefinery harvest option, and (4) Nutrient replacement option.

Net returns is explained as the additional return on a dollar per acre basis for harvesting residue after costs are paid. The attribute has four levels: \$0, \$10, \$20, or \$30 per acre. Since farmers already harvest corn grain, harvesting residue becomes an additional value for them, so it is plausible that they would harvest residue just to remove it from the field if it causes a problem with planting the following crop, and they have no cost associated with it. Alternatively, farmers may wish to earn money to compensate them for their time.

Contract length had three levels: 2, 5, and 8 years. Because biorefineries likely want an ensured supply of product to produce biofuels after making a substantial investment in their plant, it may not make sense that they would offer year-by-year contracts. Therefore, the minimum contract length available was assumed to be two years, and up to eight years. The farmer would only have to supply the biomass if it was produced, and no tonnage requirement was assumed for the contract.

To add flexibility to the contract options, an effects coded (−1, +1) biorefinery harvest option is included as a binary choice that offers a custom harvest option at the biorefinery's expense, but does not require the farmer to allow the biorefinery on their land to harvest the biomass. Net returns was assumed to include the cost of biorefinery harvest. Effects coding helps capture the grand mean of a utility function without confusing a base level mean that can occur when assigning dummy codes or usual (i.e., 1, 0) binary coding (Hensher, Rose, & Greene, 2005). In addition, assigning a zero to the value would indicate the attribute is not included in the contract.

Finally, the nutrient replacement option is effects coded as a binary choice indicating the biorefinery would (yes) or would not (no) compensate the farmers for lost nutrients (e.g., nitrogen, phosphorus, and potassium) from biomass removal. It is difficult to know the exact dollar amount of the nutrients, so it was explained that the value would be negotiated annually depending on current fertilizer prices and the estimated quantity of each nutrient contained within the biomass.

4.3.1.1.2 Sweet Sorghum

For sweet sorghum, contract options were unlabelled and had five attributes: (1) Percentage net returns above corn or sorghum production, (2) Contract length, (3) Biorefinery harvest option, (4) Insurance availability, and (5) Government incentive provision.

Since sweet sorghum provides an annual bioenergy crop option to farmers and is a crop with which farmers are familiar, the net return value was presented as a percentage return above the next best alternative crop, which was assumed to be corn or sorghum. Farmers were asked to consider a "base" net return of $50 per acre and choose a percentage return above this value that may entice them to grow sweet sorghum as a biofuel feedstock. The attribute had four levels:

0%, 15%, 30%, and 45%. By using the percentage net returns above returns earned from traditional crop production practices, a market price for biomass can be determined using production costs and crop yields, without putting a precise monetary value on the biomass. In addition, using the percentage net return above corn or sorghum production will allow prices to "float" to levels that will entice farmers to adopt sweet sorghum. Farmers understand returns per acre, so asking them to indicate a desired return per acre is useful because many farmers are unwilling to make a decision to grow biomass without knowing production costs and actual dollar returns based on prices and yields. Then, a biomass price can be determined from price and yield combinations that produce the farmers' desired return per acre. Policy makers and the biofuel industry will benefit from the survey results because they will know whether farmers are willing to supply biomass, while realizing prices required for farmers to adopt. The method benefits biorefineries by helping them determine prices they can afford to pay for biomass by knowing how much farmers require to make it a worthwhile enterprise. The attribute is recoded from a percentage to a dollar amount for analysis purposes.

Contract length had three levels, the same as the contract length for corn stover. Since sweet sorghum production is similar to corn stover harvesting in that they take place on an annual basis, it is assumed contract lengths could be the same for both enterprises. Biorefinery harvest option was included as an effects coded variable, the same as in the corn stover experiment.

Insurance availability is another effects coded binary attribute (+1, −1) indicating whether a crop-insurance type instrument is available for farmers to purchase under the biomass contract. The farmer would not be required to purchase the insurance, it is just provided if the farmer prefers to use it in the event of a crop failure. The insurance instrument would function similar to crop insurance that farmers already use.

4.3.1.1.3 Switchgrass

The switchgrass experiment had five unlabelled attributes for each contract option: (1) Percentage net returns above CRP or hay production, (2) Contract length, (3) Biorefinery harvest option, (4) Insurance availability, and (5) Seed cost-share provision.

It was assumed that switchgrass would only be planted on marginal land (that may not be renewed in the Conservation Reserve Program (CRP)) or that is currently in hay production. Therefore, net returns above hay or CRP payments had three levels: 5%, 20%, and 35% and can be interpreted the same as the percentage returns in the sweet sorghum experiment.

Contract length had two levels: 7 years and 16 years. Since switchgrass is planted approximately once every ten years, a producer may wish to enter into a contract length of at least seven years. If they choose to continue producing switchgrass, it is likely they would enter into a contract for 16 (or more) years. However, 7- and 16-year contracts allow a producer to discontinue switchgrass production if they chose to transition their land back into regular crop or hay production, or CRP.

An effects coded (−1, +1) biorefinery harvest option is included as a binary choice that offers a custom harvest option at the biorefinery's expense, just as in the corn stover and sweet sorghum experiments. In addition, insurance availability is included as an effects coded variable just like that found in the sweet sorghum experiment. Finally, a seed-cost share attribute was included with three levels: 0%, 35%, and 70%. The high cost of establishing switchgrass may necessitate the biorefinery's sharing in seed costs. The three levels indicate a percentage of the seed cost the biorefinery would pay under each contract scenario.

4.3.1.2 Farmers' Risk Perceptions

Respondents rated the degree to which they agreed or disagreed with certain statements designed to assess their perceptions about and reactions to risk on their farm regarding how they manage financial and personal risk related to their farm operation and family. The questions followed a format by Bard and Barry (2000) that elicited famers' risk perceptions by asking a number of questions in a Likert-scale method. These questions were developed to elicit risk preferences about how farmers view potential sources of risk for their farming operations or families rather than asking questions about how they would enter into a risky situation such as a lottery. Risk questions included statements on their habits with respect to purchasing medical and life insurance, maintaining a line of credit, marketing, and using information to make decisions. Risk perception questions were asked on a six-point Likert scale where 1 = strongly disagree and 6 = strongly agree. In addition, they were asked to answer questions regarding how they thought others viewed their aversion to or preference for risk, whether they used crop/hail insurance, kept an open credit line, and their debt-to-asset ratio. Appendix A4 contains the list of risk-related questions presented to each farmer. Table 4.3 contains summary statistics for the risk assessment questions.

4.3.2 Methods

A latent class model can be used to determine unobserved risk classes farmers may fit into when considering biofuel crop options. Using survey data and the approach following Boxall and Adamowicz (2002), a random utility model can be used to determine how risk perceptions affect farmers' decision without focusing solely on the choice attributes contained in the study. Heterogeneous perceptions of risk and biofuels or biofuel crops will likely impact farmers' decisions, and have important influence on the biofuel cropping options they choose.

Random utility theory considers a decision maker's unobserved characteristics such as how farmers perceive risk as it relates to their family, financial situation, and their overall operation, as well as those observed by a researcher such as demographics and types of crops already grown (Train, 2003). The model assigns weights to questions based on their importance within the data. Giordani et al. (2010) found that a latent class model can separate survey respondents by risk-taking behavior—that is, whether they are Bayesians (calculate probabilities of uncertain events and consider alternatives before accepting risk), risk neutral, or extreme risk avoiders.

A latent class conditional logit model (Train, 2003; Boxall & Adamowicz, 2002; Breffle, Morey, & Thacher, 2011) is used to determine how farmers incorporate risk attitudes into their decisions for entering into a contract to produce bioenergy feedstocks. This model separates respondents into unobservable segments, or classes, that can explain differences across types of respondents (Train, 2003). Greene and Hensher (2003) tested whether a mixed logit, multinomial logit, or latent class logit model was best to analyze data from a survey of prospective transportation consumers. The researchers determined that both the mixed logit and latent class model were better predictors than the multinomial logit in this instance, but that it is difficult to determine whether the latent class model was a better predictor than the mixed logit even when the LCM was, statistically, a better model. Mixed logit models require specific parameter distributions about individual respondents while latent class models are semiparametric and approximate discrete rather than continuous underlying distributions. Due to these differences, either model is well-suited to estimating discrete choice models and researchers need to pay particular attention to their research question to determine which model is best. It is useful to use a LCM to separate farmers based on risk perceptions when determining their willingness to adopt new enterprises such as cellulosic bioenergy feedstock production.

4.3.2.1 Theoretical Model

Risk in agriculture is often broken into production, marketing, and financial categories, but farmers' personal perceptions vary within each category (Bard & Barry, 2000). Other categories of risk include price risks (input and output), personal risks (i.e., death, health, or family relationships), and institutional risks (i.e., government policy) (Meuwissen, Hardaker, Huirne, & Dijkhuizen, 2001).

Following Roe et al. (2004), assume producers maximize expected discounted utility when they choose to enter into a bioenergy crop contract instead of producing a traditional enterprise. Then, producer *i*'s expected discounted utility for contract *j* will be:

(4.1) $$V_{i,j} = V\left(\mathbf{Z}_j, \lambda_i, L_{ki}\right) + \varepsilon_{i,j}$$

where $\mathbf{Z}_j$ is a vector of contract attributes such as the additional net return above traditional crop production over time, contract length in years, custom biomass harvest option, a nutrient replacement option, biomass crop insurance availability, government incentive payments, establishment cost-share depending on which crop is analyzed, and λ_i is farmer *i*'s risk perception factors. Due to variation in climate and growing conditions across Kansas, a fixed effects location parameter, L_{ki}, is included to account for farmers' location in the northeast, west, or central part of the state. Finally, the error term, $\varepsilon_{i,j}$, represents the nonsystematic (or random) part of expected utility that is unobserved by the researcher and is distributed Type I extreme value (Louviere et al., 2000; Train, 2003). Farmer *i* will choose the contract $j = 1, \ldots J$, that maximizes expected utility: i.e.,

(4.2)

$$\max_{\mathrm{j}} E\left(V_{i1}, \ldots V_{iJ}\right)$$

That is, the farmer will adopt the contract that provides the highest expected utility, such that

(4.3) $$\Delta V_{i,j,k} = V_{i,j} - V_{i,k} > 0 \quad \forall k.$$

The change in utility, $\Delta V_{i,j,k}$, from adopting j is greater than adopting any k for $k \neq j$.

4.3.2.2 Econometric Model

A LCM calculates the probability of respondent *I* from class q ($q = 1, 2, \ldots, Q$) choosing alternative (contract) j from alternatives $j = 1, 2, \ldots, J$ while individual *I* participates in choice situation, t ($t = 1, 2, \ldots, T$). The model estimates:

(4.4)
$$\text{Prob[individual } i \text{ choosing choice } j \text{ in situation } t \mid \text{class } q] = \exp(\mathbf{x}'_{it,j}\boldsymbol{\beta}_q) \Big/ \textstyle\sum_{j=1}^{J} \exp(\mathbf{x}'_{it,j}\boldsymbol{\beta}_q)$$

where $\mathbf{x}_i$ is a matrix of choice attributes chosen by individual *I* and $\boldsymbol{\beta}_q$ is a vector of coefficients for individuals in class q. Following Greene and Hensher (2003), this can be written as

(4.5) $$P_{it|q}(j) = \text{Prob}(y_{it} = j \mid \text{class } = q)$$

The probability that an individual, *I*, will fall into a certain class, q, in choice set t then becomes

(4.6) $$P_{i|q} = \textstyle\prod_{t=1}^{T} P_{it|q}$$

Latent class probabilities sum to one, so the model estimates $Q - 1$ latent class estimates. A form to estimate the class probability is a traditional multinomial logit form:

(4.7) $$M_{iq} = \exp(\boldsymbol{\alpha}'_i\boldsymbol{\theta}_q) \Big/ \textstyle\sum_{q=1}^{Q} \exp(\boldsymbol{\alpha}'_i\boldsymbol{\theta}_q), \; q = 1, \ldots, Q \text{ and } \theta_Q = 0.$$

Where M_{iq} is the latent class constant probability, $\boldsymbol{\alpha}_i$ is a vector of respondent *I*'s characteristics and $\boldsymbol{\theta}_q$ is the latent class parameter estimate (Greene & Hensher, 2003). Combining equations 6 and 7 provides the likelihood that an individual will fall into class q:

(4.8) $$P_{iq} = \textstyle\sum_{q=1}^{Q} M_{iq} P_{i|q}$$

This model allows both contract attributes and respondent characteristics to determine the choice probabilities (Boxall & Adamowicz, 2002).

4.3.2.3 Empirical Estimation

4.3.2.3.1 Factor Analysis for Risk Factors

Factor analysis is a useful tool for grouping respondents by risk attitudes because it reduces data dimensionality (Khattree & Naik, 2000). Some studies have used factor analysis (at least in part) to determine how farmers view risk in relation to production, marketing, conservation, and adoption (Greiner, Patterson, & Miller, 2009; Maybery, Crase, & Gullifer, 2005; Flaten, Lien, Koesling, Valle, & Ebbesvik, 2005; Bard & Barry, 2001; Bard & Barry, 2000; Akcaoz & Ozkan, 2005). Risk perceptions can be determined from a factor model. A basic factor analysis model can determine common factors that determine a relationship among a set of observations and reduce data to a manageable level. A basic factor model following Khattree and Naik (2000) is:

(4.9)
$$\mathbf{z} = \mathbf{Lf} + \boldsymbol{\varepsilon}$$

where **z** is a $p \times 1$ vector of observations, or risk perceptions, **f** is a $k \times 1$ vector with elements f_1, …, f_k which are common factors; **L** is a $p \times k$ matrix of unknown constants, or factor loadings; and **ε** is a vector of elements ε_1, …, ε_p known as specific factors. Assume that **f** and **ε** are uncorrelated. Then, measuring a given z_i is considered a linear combination of factor elements, $f_1, \ldots, f_k$ and a specific factor, ε_i as:

(4.10)
$$z_1 = l_{11}f_1 + \cdots + l_{1k}f_k + \varepsilon_1$$
$$z_2 = l_{21}f_1 + \cdots + l_{2k}f_k + \varepsilon_2$$
$$\vdots$$
$$z_p = l_{p1}f_1 + \cdots + l_{pk}f_k + \varepsilon_p$$

where l_{ij} is the $(i,j)^{th}$ element of **L** and becomes the factor loading, or coefficient, of z_i on the j^{th} common factor f_j. Then, $\mathbf{L}^{-1}$ is multiplied by the **z** vector of individual *i*'s risk perception responses to arrive at a $p \times 1$ vector of risk perceptions, **λ**.

Choosing eigenvalues greater than or equal to 1.0 is the most common method for determining the correct number of factors. Eigenvalues explain the amount of variance in the factors (Hayton, Allen, & Scarpello, 2004; Costello & Osborne, 2005; Khattree & Naik, 2000; Kaiser, 1960). Under this method, as long as the eigenvalues are greater than one, the factor explains a sufficient amount of the variance in factors to warrant its inclusion in the analysis. However, it is also important that the researcher be able to explain the factors and that the factors are reliable (Kaiser, 1960). Choosing reliable factors is left to the researcher's discretion to some degree. If the factors make intuitive sense in helping answer the research question but the eigenvalue is slightly less than 1.0, it may make sense to include them to draw conclusions (Kaiser, 1960).

Factor analysis separated the risk perception questions into four categories, or factors, as shown in Table 4.4. The first factor contains risk perceptions associated with *management* including production, technology, and marketing activities. Factor 2 includes using personal *insurance* as a risk response (insurance risk). The third factor included in the analysis is o*ff-farm income/investments* as important for family survival (financial risk). Factor 4, *government policy risk*, is included in Table 4.4 for completeness, but its significance is questionable because its eigenvalue is less than 1.0, indicating it does not explain much of the variance in the model.

Eigenvalues for the first three factors are greater than or equal to one and explain 87% of the variance in the risk perception data across respondents. Larger correlations (in absolute value) determine where each risk statement should be grouped within the factors. If farmers are concerned about production, marketing, and financial risk, the factors should group questions related to each type of risk (Bard & Barry, 2000). Meuwissen et al. (2001) found factors relating to farm family health, farm finances, legislation, production, and changes in farming situation to be significant sources of risk. Akcaoz and Ozkan (2005) found similar results with respect to risk factors associated with farm family health, finances, production, and government policy. The three factors listed above are similar in that they relate to production, marketing, and finances (*management* and *off-farm income/investments*), family health (*insurance*), and family financial well-being (*insurance* and *off-farm income/investments*). The fourth factor, *government risk*, has an eigenvalue of only 0.66, so it does not explain much of the variance in the data. However, as found in Meuwissen et al. (2001) and Akcaoz and Ozkan (2005), government policy is an important source of risk for farmers. Since the fourth factor only has one question ("I believe recent changes in government agricultural policy have substantially increased the risk of my farming operation.") with a factor loading higher than 0.30. Therefore, while it could be considered a government policy risk factor, it does not make sense to include the factor in the multinomial regression because it does not add significant information and a factor should have more than one element if it is to have explanatory power as defined by its relation with other variables.

Factor loadings explain the variation each risk statement has on the factors and farmers' decisions to adopt conservation. No specific criterion determines how high a factor loading should be to warrant inclusion in the analysis. If the factor loadings are too low, it may indicate they do not fit well with any factor, and have no effect on farmers' decisions. Alternatively, if they are highly correlated with more than one factor, it becomes difficult to determine in which factor they fit better. For this analysis, factor loadings greater than or equal to 0.30 (in absolute value) are used to make inference about farmers' risk perception effects on biofuel contract adoption. Survey questions with factor loadings less than 0.30 (in absolute value) were dropped when calculating the risk factor variable for the latent class model regression (Greiner et al., 2009). All the factor loadings are reported in Table 4.4 for comparisons. The dropped questions are: 1."I have enough cash on hand or assets that can be easily converted to cash to pay all my bills.", 6."I spread the sale of my commodities over the year.", 9. "Maintaining a low debt-to-asset ratio is important to me." And 15." I consider myself to be a low cost producer."

Factor 1, *management risk*, includes questions 2, 10, 11, 12, 13, 16, 17, and 18. These indicate farmers see using market information, maintaining machinery, spreading their operations geographically, having adequate backup labor/management, planning ahead, and using financial information in decision-making as risk-reducing. Each factor loading has a positive coefficient except Question 16. This indicates that farmers value these statements as contributing positively as a way to lower risk associated with unexpected problems on their farm operations that may cause lower productivity or unnecessary harm to family members or other laborers. The negative correlation of -0.328 indicates that being prone to making last minute decisions has an adverse effect on what might be called "good" management. Question 18, which asks about passing land onto the next generation, indicates the farmer is concerned about the longevity of his/her operation and likely takes care to maintain property, land, and machinery while ensuring a financially sound operation.

Factor 2, *insurance risk*, includes questions 3, 4, and 5 relating to life, medical, and liability insurance, respectively, relate to a farmer's personal or family life rather than to the farm operation. In each case, the factor loadings are positive and indicate the questions are highly correlated with the factor, as expected. In this case, the insurance factor shows farmers view life, health, and liability insurance as important risk-reducing strategies. The three components of the insurance factor are related to reducing personal or family financial responsibilities should a catastrophe occur on the farm such as death, dismemberment, or disease for a family member or other laborer employed on the farm.

Factor 3, *off-farm income risk*, includes questions 7 and 8. This factor is important for farmers who depend on off-farm income to supply basic household needs. Signs on significant factor loadings are positive, indicating they positively contribute to the factor and relate to each other strongly. In some cases, these may be small farms, while in others, it may indicate poor management if the farm is unable to provide a living for the farm family.

4.3.2.3.2 Latent Class Empirical Model

This study's primary interest is assessing how farmers' risk perceptions impact willingness to accept a contract. To accomplish this, the focus becomes the reduced-form representation of expected utility. A main effects model (Greene, 2007; Louviere et al., 2000) for producer *i* and contract *j* of the farm is:

(4.11)

$$V_{i,j} = \beta_0 + \sum_{k=1}^{K} \beta_k Z_j + \beta_\lambda \lambda_i + \varepsilon_{i,j}$$

for each biofuel feedstock was used, where *k* represents the index of contract attributes: returns per acre, contract length in years, a biorefinery harvest option, a nutrient replacement option for corn stover, an insurance option for sweet sorghum and switchgrass, a government incentive payment for sweet sorghum, a cost-share attribute for switchgrass, and location parameters for farmers in the three areas of Kansas. λ_i is farmer *i*'s risk perceptions and $\varepsilon_{i,j}$ is a Type I extreme value distributed error term.

Latent classes are determined by the three risk factors: management issues, insurance, off-farm income, and a binary variable where farmers were asked to indicate whether they have enough information to grow biofuel crops. A latent class model (LCM) captures correlations among choice alternatives in the model, which allows for relaxing the independent and irrelevant alternatives (IIA) assumption found in traditional conditional logistic regressions but does impose IIA within classes (Greene, 2007).

Equation (4.11) is modeled using a LCM regression in *NLOGIT 4.0*. The model uses simulated maximum likelihood with Halton draws using the Newton algorithm (Train, 2003). Predicted probabilities and farmers' willingness to pay for alternative contractual features are calculated in a spreadsheet. Standard errors for all statistics using model results are calculated using the delta method following Greene (2008).

The LCM is estimated with the contract attributes and farmer risk perceptions to determine how farmers make decisions amid unobserved classes. Risk factors ($\boldsymbol{\alpha}_i$) for the LCM are shown in Table 4.4. Using these variables to determine the latent classes will explain how farmers' risk perceptions affect their willingness to adopt a biofuel crop contract.

Contract choices A and B represent the randomly assigned, unlabeled contract choices for each scenario, while Option C is the "opt out" option. As seen in Figure 4.1, Option C does not contain any attributes, so $\beta_1 = \cdots = \beta_5 = 0$ and $V_{C,i} = \beta_6 Cent_i + \beta_7 East_i + \varepsilon_{i,j}$. This allows the model to control for unobserved individual effects associated with "opting out."

Assuming farmers are profit maximizers, the sign for *returns* is expected to be positive since higher net returns contribute to increased profit. Farmers likely prefer short-term contracts if they produce sweet sorghum or corn stover, but may prefer slightly longer contracts if they choose to grow switchgrass due to the long-term nature of perennial crops. Therefore, the sign of *contract length* should be negative for corn stover and sweet sorghum, but may be positive or negative for switchgrass. The coefficient's sign for *biorefinery harvest* may be either positive or negative depending on farmers' views about biorefinery harvest being a cost-saving option, or if farmers are reluctant to allow custom operators on their property and location. The signs for *nutrient replacement, insurance, government incentives, and cost-share* options are expected to be positive since farmers will likely prefer a nutrient replacement option in the case of corn stover and insurance availability as a tool to manage risk, especially on "experimental" crops in the sweet sorghum and switchgrass cases. For the sweet sorghum and switchgrass experiments, farmers are more likely to prefer some type of government incentive payment or cost share for establishing a switchgrass stand.

4.4 Results

4.4.1 Latent Class Models

As noted in Table 4.2, the largest percentage of farmers willing to adopt any of the cellulosic biofuel feedstocks were in the Central part of Kansas (69%, 75%, and 58% for corn stover, sweet sorghum, and switchgrass, respectively), while those in Western Kansas were least willing to adopt (41%, 49%, and 35% for corn stover, sweet sorghum, and switchgrass, respectively). Part of the reason for this may be because Western Kansas has more irrigated land, which is better suited to growing high-profit crops such as corn. In addition, the drier climate in Western Kansas may cause farmers to be less willing to remove residue because it can reduce moisture retention in the soil. In Northeastern Kansas, farmers are less willing to produce biofuel feedstocks since they are profitable producing corn and soybeans. Only 52%, 57%, and 34% for corn stover, sweet sorghum, and switchgrass, respectively, of these farmers were willing to adopt. Central Kansas farmers may be more willing to adopt switchgrass since they have less irrigation than farmers in Western Kansas have, and are more likely to produce less profitable wheat and sorghum than farmers in Northeastern Kansas are. Sweet sorghum was the most popular bioenergy feedstock crop across Kansas with 60% indicating they were willing to adopt while switchgrass was the least likely to be chosen with only 42% indicating they would produce it. Just over half (53%) of Kansas farmers indicated they would be willing to supply corn stover as a cellulosic bioenergy feedstock.

The corn stover, sweet sorghum, and switchgrass experiments have different numbers of latent classes but some overlap occurs in class meanings. Table 4.5 reports the results for the latent class estimation for each cellulosic bioenergy feedstock. The Akaike information criterion (AIC) and the Bayesian information criterion (BIC) were used to determine the number of classes to include in each model (Greene & Hensher, 2003; Breffle et al., 2011; Colombo, Hanley, & Louviere, 2009). However, the classes must also make sense with respect to respondent characteristics and estimated parameters (Greene, 2008; Dietz & Atkinson, 2010; Glenk & Colombo, 2011). In addition, too many classes can cause extremely large standard errors, which produce unreliable estimates (Greene, 2007). In all three experiments, the AIC falls when adding classes, but the BIC increases. A likelihood ratio test indicates additional classes are useful in all three experiments, but some degree of subjectivity still goes into class number selection, as noted above. The corn stover experiment has three latent classes while the sweet sorghum and switchgrass experiments have two classes. In the case of sweet sorghum and switchgrass, increasing the number of classes above two causes the standard errors of the utility parameters to increase to very high levels, indicating estimates may not be accurate. The number of risk factors included in the latent class estimation was varied to try to improve model fit. In the case of corn stover and switchgrass, all three factors and the biofuel information question were included, but only one of the risk factors is included in the sweet sorghum experiment. Results for each experiment are explained in the next sections. Table 4.5 contains parameter estimates from the latent class estimation.

4.4.1.1 Corn Stover

The corn stover experiment has three classes. The AIC is slightly lower when estimating four classes, but the more restrictive BIC is lower when estimating three classes (Kamakura & Russell, 1989; Boxall & Adamowicz, 2002). In addition, class probabilities become very small (i.e., about 0.10) with more than three classes. This may lead to difficulties when explaining the classes, as very few farmers fit into each category.

It is important to interpret latent classes against the base class, which is class number three in the corn stover experiment. None of the risk factors is significant for latent classes one or two. Given this result, it may make sense to estimate a conditional logit model, but this model may not account for unobserved heterogeneity among respondents. In addition, results from a conditional logit model may be similar to a latent class model (Greene & Hensher, 2003; Dietz & Atkinson, 2010; Boxall & Adamowicz, 2002) while a LCM may provide additional information. An important implication from this analysis is that farmers' risk perceptions do not have a statistically significant effect on whether they will enter into a contract to produce corn stover as a bioenergy feedstock. It is possible that since farmers are very familiar with corn production and baling stover, risk has little or no effect on their willingness to adopt a corn stover enterprise.

Signs for the utility parameters are as expected. Net returns, biorefinery harvest, and nutrient replacement all have positive signs indicating farmers in each class are more likely to enter into contracts with higher returns, a biorefinery harvest option, and a nutrient replacement option. Contract length has a negative sign, indicating farmers are less likely to adopt a longer-term contract to supply corn stover to a biorefinery. (See Table 4.1 for a description of the contract attributes). Farmers in classes two and three are less likely to adopt a contract if they are in Eastern Kansas. Farmers in Central Kansas are neither more nor less likely to adopt a corn stover contract than those in other parts of the state.

4.4.1.2 Sweet Sorghum

The sweet sorghum model only has one risk factor, *management*, included in the estimation. Running the model with more risk factors or more than two latent classes produced large standard errors for most attributes. This may indicate the model should be run as having only one class (Glenk & Colombo, 2011; Dietz & Atkinson, 2010). However, decreasing the number of risk factors included in the latent class estimation provided more accurate utility parameter estimates. The AIC fell for each estimation with fewer risk factors until only the management factor remained.

Farmers in latent class one are more likely to view management issues with respect to unknown problems on their day-to-day operations as important but do not necessarily handle them well. The negative sign on the management risk factor indicates farmers in this class are "not as good" at managing their operations relative to class two. An important finding here may be that farmers in latent class two are better farm managers, and more willing to adopt alternative cropping practices, as indicated by the significance of the utility parameters in class two.

In latent class one, only contract length has a statistically significant negative coefficient. Not quite half, 42.4% of the respondents fall in this class. However, all utility parameters are significant in latent class two. Farmers in this class are less likely to adopt a contract if they are from the central or eastern part of Kansas. The negative sign on the central variable is somewhat unexpected since farmers in that part of the state plant more sorghum. Regardless of the area of

Kansas the farmer is from, they prefer contracts with higher net returns, shorter contract lengths, a biorefinery harvest option, some kind of insurance product availability, and a government incentive program.

4.4.1.3 Switchgrass

Two latent classes were estimated for the switchgrass experiment. Risk factor coefficients for the latent class segmentations are not statistically significant. Coefficients for the management, insurance, and off-farm risk factors are close to zero, making it difficult to determine the meanings of the classes. This may indicate that, in general, these risk perceptions do not play a role in farmers' decisions about whether to adopt a switchgrass enterprise. It may be that uncertainty and unfamiliarity with switchgrass production negates any effect of the risk perceptions if farmers are simply unwilling to grow switchgrass as a bioenergy feedstock. As noted in Table 4.2, switchgrass had the lowest number of farmers indicating willingness to adopt at only 42% compared with 53% for corn stover and 60% for sweet sorghum.

Being from the central part of Kansas increases the likelihood farmers in latent class one of the switchgrass experiment will adopt switchgrass while those in Eastern Kansas are less likely to adopt switchgrass. Nearly 70% of respondents fall in this category. In class two, farmers in Eastern Kansas are less likely to adopt a switchgrass producing contract. Farmers in both classes prefer higher net returns, a biorefinery harvest option, and a cost-share arrangement, as indicated by positive signs on the coefficients. Contract length has a negative sign, indicating farmers may be less willing to produce switchgrass as the contract length gets longer. The insurance attribute was not significant for farmers in class one, but those in class two are more likely to adopt a switchgrass contract if some kind of insurance is available. It is possible that overall, farmers in class two are more likely to be adopters while those in class one are non-adopters of a switchgrass contract.

4.4.1.4 Marginal Willingness to Pay

Farmers' marginal willingness to pay (MWTP) for contract attributes under risk perceptions is of interest to this study to determine whether risk plays a role in farmers' willingness to pay for incremental changes in the contract attributes. Table 4.6 reports the MWTP under each latent class for the three bioenergy crops.

For corn stover, the MWTP estimates are not statistically significant in latent class one. Latent class two respondents require $5.30 per acre per additional contract year to adopt a corn stover contract. These farmers are also willing to pay up to $7.81 per acre to have the biorefinery (or other custom operator) harvest their corn stover and up to $10.54 per acre to have a contract with a nutrient replacement option. Farmers in latent class three require about $1.01 per acre per contract year to enter into a corn stover contract. They are also willing to pay $5.25 per acre to have someone else harvest and $3.53 for a nutrient replacement option.

MWTP estimates for latent class one in the sweet sorghum experiment are not statistically significant, and as noted above, the sweet sorghum experiment was run with only one risk factor. However, for farmers in latent class two, the contract length attribute MWTP indicates farmers will only adopt a contract if they are compensated $2.14 per acre per year of additional contract length. Similar to the corn stover experiment, farmers are willing to pay $3.67 per acre for a biorefinery harvest option and about $0.25 per acre per percent of government incentive payments.

Potential switchgrass producers in latent class one who are likely neutral with respect to how they view their risk-mitigating strategy, will require $9.01 per acre per additional year of contract length before adopting a contract. This is in contrast to farmers in latent class two who only require \$0.72 per acre per additional year of contract length to adopt a switchgrass contract. Given the long-term nature of switchgrass production and the options offered farmers in the contract scenarios, it is possible farmers in latent class two are risk-taking. The low value they require for entering into longer-term contracts to produce cellulosic biofuel feedstocks without an established market may indicate they are willing to try new enterprises under uncertainty. MWTP for the biorefinery harvest option is also very different between the two classes with farmers in latent class one willing to pay \$11.35 per acre for a biorefinery harvest while those in latent class two are only willing to pay \$1.33 per acre. Finally, farmers in latent class two are willing to pay \$0.15 per acre for each percentage of seed and establishment costs the biorefinery is willing to share.

4.5 Conclusions

This study determines how farmers' risk perceptions affect their decisions to adopt three cellulosic bioenergy feedstocks using a stated choice framework. The bioenergy feedstocks analyzed were corn stover, sweet sorghum, and switchgrass because of their availability and suitability for production in Kansas. Cellulosic biofuel mandates require increasing production to reduce greenhouse gas emissions and dependence on petrochemical energy sources, but farmers may be reluctant to produce these crops with much uncertainty surrounding production and marketing. Farmers answered questions asking them to choose among alternative contract types with varying net returns, contract lengths, harvesting options, and other options specific to the types of crops grown. In addition, farmers answered questions eliciting their perceptions about certain operation or personal risk issues. These risk issues were incorporated in the analysis to segment farmers and determine if risk perceptions affect their decisions to adopt bioenergy crops.

A latent class model was estimated to account for heterogeneity among individuals' preferences for risk. Results indicate that farmers fall into different classes with respect to how they manage potential operational risk, depend on insurance or off-farm income and investments, and consider costs and government policy as contributing to risk on their farms. The class into which farmers fall can change the amount they are willing to pay for contract attributes. In general, farmers require compensation to enter into long-term contracts, but they are willing to pay from $1.33 to $11.35 per acre for a biorefinery harvest option, depending on the crop, and other options that might make bioenergy crop production less risky such as insurance, government incentives, and a seed cost share.

Overall, risk perceptions had relatively no significant impact on whether Kansas farmers will adopt a cellulosic biofuel feedstock enterprise. For farmers considering a corn stover enterprise, risk perceptions do not affect decisions, likely because a corn stover enterprise is familiar to farmers and risk is not an issue for them when producing this feedstock. For the sweet sorghum enterprise, only the management risk factor was statistically significant and had a negative sign, indicating farmers may view this type of crop as an important cellulosic biofuel feedstock enterprise, and may be more willing to adopt this type of enterprise due to their familiarity with sorghum production. In other words, any type of manager would be able to incorporate a sweet sorghum enterprise into their farming operation. However, for the switchgrass enterprise, farmers' unfamiliarity with the enterprise may cause their personal risk perceptions to be insignificant because they are simply reluctant to produce switchgrass as a bioenergy feedstock.

Much work remains to determine how risk affects decision-makers' choices when answering questions in stated choice experiments. While latent class models provide a reasonable framework to determine how individual heterogeneity affects decisions, other methods may also provide useful information to help researchers offer insight to producers, biorefineries, and policy makers. Results from this study indicate that biorefineries should understand that not all farmers will be willing to enter into a contract to produce biofuel crops depending on their goals for their operations. In addition, it is important for biorefineries to understand that farmers' risk perceptions do not play an important role in their decisions whether to adopt. Farmers may be willing to adopt cellulosic biofuel feedstock production as long as they know their production has a market. Farmers should understand that they have room to negotiate on different contract attributes. The hypothetical situations presented here are not the only combinations of contracts available. Nascent markets will necessitate flexibility on the part of all participants.

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Table 4.1. 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

Table 4.1 (continued)

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 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 4.2. Number and percentage of respondents adopting or not adopting a contract for a cellulosic bioenergy crop by region of Kansas.

	Corn Stover (*N = 288*)		Sweet Sorghum (*N = 285*)		Switchgrass (*N = 284*)	
Region	Adopt	Do Not Adopt	Adopt	Do Not Adopt	Adopt	Do Not Adopt
West	41	60	48	51	34	64
Central	63	29	69	23	53	38
Northeast	49	46	54	40	32	63
Total	153	135	171	114	119	165
West[a]	40.6%	59.4%	48.5%	51.5%	34.7%	65.3%
Central	68.5%	31.5%	75.0%	25.0%	58.2%	41.8%
Northeast	51.6%	48.4%	57.4%	42.6%	33.7%	66.3%
Total	53.1%	46.9%	60.0%	40.0%	41.9%	58.1%

[a] Regional percentages are calculated as number adopting or not adopting in that region divided by total for each crop in that region (e.g., "Adopt Corn Stover in West" would be calculated as: [41/(41+60)]*100 = 40.6%). Total is calculated as the number adopting or not adopting divided by the total number (*N*) for all three regions for each crop (e.g., "Adopt Corn Stover for Total" is calculated as [153/(153+135)]*100 = 53.1%).

Table 4.3. Summary of risk-related questions. (See Appendix A3 for questions and types of answers required.)

Question	N	Average	St. Dev	Median	Mode	Max	Min
1. Do you purchase federal or private crop insurance?[a]	287	270			1		
2. Do you purchase insurance to cover hail damage to your crops?[a]	286	153			1		
3. Do you keep a line of credit open at your primary lender?[a]	254	215			1		
4. I have enough cash on hand or assets that can be easily converted to cash to pay all my bills.	279	4.65	1.49	5	6	6	1
5. I rely heavily on market information (for example: government reports, private market news services, extension) in making my marketing decisions.	281	4.37	1.21	4	5	6	1
6. I do have adequate life insurance.	278	4.34	1.63	5	5	6	1
7. I do have adequate health insurance.	280	5.10	0.99	5	5	6	1
8. My farming operation does have adequate liability insurance.	279	5.25	0.80	5	5	6	1
9. I spread the sale of my commodities over the year.	277	4.69	1.09	5	5	6	1
10. Off-farm income is important for the survival of my family.	279	3.53	1.81	4	5	6	1
11. Off-farm investments are important sources of income for my family.	277	2.81	1.52	2	2	6	1
12. Maintaining a low debt-to-asset ratio is important to me.	279	5.03	0.93	5	5	6	1
13. Most of my machinery is new and/or in good repair.	279	4.46	1.19	5	5	6	1
14. I have fields in different locations to reduce yield risk.	282	4.28	1.35	5	5	6	1
15. In case of emergency, I have sufficient back-up management and labor.	278	4.03	1.39	4	5	6	1
16. I see myself as a person who plans ahead.	281	4.73	0.87	5	5	6	2
17. I believe recent changes in government agricultural policy have substantially increased the risk of my farming operation.	279	4.23	1.23	4	5	6	1
18. I consider myself to be a low cost producer.	280	4.36	1.04	5	5	6	1
19. I am prone to making last minute decisions.	279	3.38	1.23	3	4	6	1
20. I use financial information in decision-making about my farm.	280	4.71	0.95	5	5	6	1
21. Passing my land onto my children is important to me.	280	5.10	1.16	5	6	6	1
22. D/A ratio categories[b]	273	4.69	2.37	5	6	9	1

[a]Indicates a binary response. Only “yes” responses are included.

[b]A total of 10 options ranged from “0%” to “over 90%”. The most common response was “20 to 29%”, and no one chose “over 90%”. See Appendix A3. Questions are asked on a Likert-scale from 1=”Strongly Disagree” to 6=”Strongly Agree”.

Table 4.4. Factor Loadings for Risk Categories.

	Factor 1 *Management*	Factor 2 *Insurance*	Factor 3 *Off-farm*	Factor 4 *Govt. Risk*
1. I have enough cash on hand or assets that can be easily converted to cash to pay all my bills.	0.2903	0.2027	-0.2346	-0.0905
2. I rely heavily on market information (for example: government reports, private market news services, extension) in making my marketing decisions.	**0.3536**	0.1338	-0.0172	0.1189
3. I do have adequate life insurance.	0.0721	**0.4704**	-0.0122	0.2224
4. I do have adequate health insurance.	0.1601	**0.7813**	0.1476	-0.1134
5. My farming operation does have adequate liability insurance.	0.2177	**0.5493**	0.0524	0.0635
6. I spread the sale of my commodities over the year.	0.2341	0.0093	-0.0910	-0.0065
7. Off-farm income is important for the survival of my family.	-0.1390	0.0073	**0.8226**	0.0953
8. Off-farm investments are important sources of income for my family.	0.1819	0.1389	**0.4251**	-0.1596
9. Maintaining a low debt-to-asset ratio is important to me.	0.1530	0.2184	-0.0951	0.2169
10. Most of my machinery is new and/or in good repair.	**0.4407**	0.2430	-0.0679	0.0984
11. I have fields in different locations to reduce yield risk.	**0.4620**	0.1247	0.1493	0.0235
12. In case of emergency, I have sufficient back-up management and labor.	**0.6487**	0.1007	0.0912	0.0275
13. I see myself as a person who plans ahead.	**0.6370**	0.2582	-0.0026	0.1315
14. I believe recent changes in government agricultural policy have substantially increased the risk of my farming operation.	-0.0210	0.0077	0.0698	**0.5181**
15. I consider myself to be a low cost producer.	0.0714	0.1377	-0.0900	0.2634
16. I am prone to making last minute decisions.	**-0.3284**	-0.0272	0.0424	0.1734
17. I use financial information in decision-making about my farm.	**0.3004**	0.1039	0.0025	0.1038
18. Passing my land onto my children is important to me.	**0.3257**	-0.0345	0.0335	0.2871
Eigenvalues	1.9621	1.4426	1.0058	0.6597
Variance explained (%)	38.698	28.453	19.838	13.011
Cumulative variance explained (%)	38.698	67.151	86.989	100.000

Factor loadings ≥ |0.30| are shown in bold. Survey questions with factor loadings < |0.30| are not included in the regression estimation. In addition, Factor 4, government risk, is not included in the multinomial regression because the factor does not explain a sufficient amount of variation (eigenvalue = 0.6597). The shaded areas indicate questions **NOT** included in the multinomial logit regression.

Table 4.5. Latent class model coefficients. Standard errors are in parentheses.

	Corn Stover			Sweet Sorghum		Switchgrass	
	LC 1	LC 2	LC 3	LC 1	LC 2	LC 1	LC 2
Central	1.3504	-0.2711	0.1171	1.2215	-0.5081***	0.6323*	0.1385
	(1.238)	(0.2015)	(0.2595)	(1.3927)	(0.1099)	(0.3874)	(0.1751)
East	1.0694	-1.2261***	-0.5498*	0.7822	-0.9987***	-0.8547	-1.2769***
	(1.2967)	(0.2128)	(0.2823)	(1.2496)	(0.1206)	(0.531)	(0.1744)
Returns	0.2255*	0.0883***	0.1188***	-0.0128	0.1299***	0.0728**	0.1583***
	(0.1385)	(0.0072)	(0.0084)	(0.0666)	(0.0055)	(0.0363)	(0.0121)
Contract Length	-5.5991	-0.4752***	-0.1197***	-3.0472***	-0.2778***	-0.6563***	-0.1138***
	(2.4119)	(0.0326)	(0.0316)	(0.8098)	(0.0152)	(0.0818)	(0.0113)
Harvest	1.5348	0.7145***	0.6219***	-0.227	0.4754***	0.8266***	0.2106***
	(1.5623)	(0.083)	(0.0761)	(0.5746)	(0.0465)	(0.227)	(0.059)
Nutrient	0.8429	0.9303***	0.4366***				
Replacement	(0.819)	(0.0892)	(0.0699)				
Insurance				1.1456	0.3179***	-0.0582	0.2569***
				(1.0119)	(0.0465)	(0.1729)	(0.0619)
Govt. Incentive				0.0587	0.0331***		
				(0.0425)	(0.0037)		
Cost Share						0.0155**	0.0232***
						(0.0063)	(0.0022)
---------------*Latent class (θ_i) coefficients*---------------							
Constant	0.5532	1.3606*	-----	-0.3193***	-----	0.9884**	-----
	(0.6185)	(0.71)		(0.1258)		(0.4662)	
Biofuel info	-0.4600	-0.4638	-----			-0.3077	-----
	(0.3483)	(0.4306)				(0.2817)	
Management	0.0608	-0.0755	-----	-0.0020*	-----	-0.0101	-----
	(0.0869)	(0.1057)		(0.0011)		(0.0669)	
Insurance	-0.0136	-0.0142	-----			0.0072	-----
	(0.1136)	(0.1333)				(0.0879)	
Off-farm	-0.0533	0.0862	-----			-0.0021	-----
Income	(0.0743)	(0.0882)				(0.0582)	

Table 4.5 (continued)

Class probabilities	0.486	0.306	0.208	0.424	0.576	0.697	0.303
------------*Model Statistics*------------							
Number of Observations		1435		1425		1420	
AIC		1.088		1.255		1.004	
McFadden Pseudo-R^2		0.5228		0.4391		0.5553	
Log-likelihood		-752.333		-875.035		-693.726	

***, **, and * indicate statistical significance at the 0.01, 0.05, and 0.10 levels, respectively.

Table 4.6. Willingness to pay for contract attributes within the latent classes. Standard errors are in parentheses.

	Corn Stover			Sweet Sorghum		Switchgrass	
	LC 1	LC 2	LC 3	LC 1	LC 2	LC 1	LC 2
Contract Length	-27.25	-5.30***	-1.01***	238.20	-2.14***	-9.01***	-0.72***
	(19.95)	(0.35)	(0.25)	(1254.28)	(0.11)	(3.85)	(0.06)
Harvest	10.82	7.81***	5.25***	17.74	3.66***	11.35*	1.33***
	(36.27)	(1.00)	(0.58)	(101.06)	(0.35)	(6.10)	(0.37)
Nutrient Replacement	3.83	10.54***	3.53***				
	(3.45)	(1.15)	(0.64)				
Insurance				-89.55	0.41	-0.80	0.62
				(481.13)	(0.36)	(2.44)	(0.39)
Govt. Incentive				-4.59	0.25***		
				(23.87)	(0.03)		
Cost Share						0.21	0.15***
						(0.13)	(0.01)

***, **, and * indicate statistical significance at the 0.01, 0.05, and 0.10 levels, respectively.

Corn Stover Scenario		**Contract A**	**Contract B**	**Option C**
Contract Features	**Net Returns**	$20/acre/year	$30/acre/year	Do Not Adopt
	Contract Length	2 years	8 years	
	Biorefinery Harvest	Yes	Yes	
	Nutrient Replacement	No	Yes	
	Your Ranking (1-3)			

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	No	Yes	
	Insurance Availability	Yes	No	
	Gov. Incentive Payment	None	None	
	Your Ranking (1-3)			

Switchgrass Scenario		**Contract A**	**Contract B**	**Option C**
Contract Features	**Net Return Above Hay Production/CRP Rental Rates (Base: $40/ac)**	5% Higher/year	20% Higher/year	Do Not Adopt
	Contract Length	7 Years	16 Years	
	Biorefinery Harvest	No	Yes	
	Insurance Available	Yes	Yes	
	Seed/Establishment Cost-Share	35%	None	
	Your Ranking (1-3)			

Figure 4.1. Stated choice scenarios for corn stover, sweet sorghum, and switchgrass.

Appendix A4 - Risk-Related Questions

For your farm/ranch management, how would your neighbors describe your risk taking behavior? (*Mark one*)

___ An extreme risk avoider
___ Cautious
___ Willing to take risks after adequate research
___ Not really concerned about risk
___ Enjoy taking risks in my business
___ A real gambler

Do you purchase federal or private crop insurance? ___ Yes ___ No

Do you purchase insurance to cover hail damage for your cash crops ___ Yes ___ No

Do you keep a line of credit open at your primary lender? ___ Yes ___ No

Please rank the degree to which you agree with each statement below.

Statement	**Rank from 1 to 6 where: 1 = Strongly Disagree; 2 = Disagree; 3 = Somewhat Disagree; 4 = Somewhat Agree; 5 = Agree; 6 = Strongly Agree**					
a. I have enough cash on hand or assets that can be easily converted to cash to pay all my bills.	1	2	3	4	5	6
b. I rely heavily on market information (for example: government reports, private market news services, extension) in making my marketing decisions.	1	2	3	4	5	6
c. I do have adequate life insurance.	1	2	3	4	5	6
d. I do have adequate health insurance.	1	2	3	4	5	6
e. My farming operation does have adequate liability insurance.	1	2	3	4	5	6
f. I spread the sale of my commodities over the year.	1	2	3	4	5	6
g. Off-farm income is important for the survival of my family.	1	2	3	4	5	6
h. Off-farm investments are important sources of income for my family.	1	2	3	4	5	6
i. Maintaining a low debt-to-asset ratio is important to me.	1	2	3	4	5	6
j. Most of my machinery is new and/or in good repair.	1	2	3	4	5	6
k. I have fields in different locations to reduce yield risk.	1	2	3	4	5	6
l. In case of emergency, I have sufficient back-up management and labor.	1	2	3	4	5	6
m. I see myself as a person who plans ahead.	1	2	3	4	5	6
n. I believe recent changes in government agricultural policy have substantially increased the risk of my farming operation.	1	2	3	4	5	6
o. I consider myself to be a low cost producer.	1	2	3	4	5	6
p. I am prone to making last minute decisions.	1	2	3	4	5	6
q. I use financial information in decision-making about my farm.	1	2	3	4	5	6
r. Passing my land onto my children is important to me.	1	2	3	4	5	6

For every $100 of farm assets you have, what percent is financed with debt? (*Mark one*)

___ 0%	___ 1% to 4%	___ 5% to 9%	___ 10% to 14%
___ 15% to 19%	___ 20% to 29%	___ 30% to 49%	___ 50% to 69%
___ 70% to 89%	___ greater than 90%		

Chapter 5 - Conclusions and Implications for Further Research

This dissertation contains three essays on Kansas farmers' willingness to adopt cellulosic biofuel feedstocks and conservation practices. Production of advanced and lignocellulosic biofuel feedstocks will become important as the United States attempts to become more energy independent while reducing greenhouse gas (GHG) emissions. Farm land across Kansas provides a good source of cellulosic biomass for bioenergy in the forms of corn stover, wheat straw, sweet or forage sorghum, hay, alfalfa, or biomass from conservation reserve program (CRP) acres. This dissertation had three purposes. First, it attempted to determine whether farmers in Kansas would be willing to produce switchgrass as cellulosic biofuel feedstocks under contract. Second, it attempted to determine how farmers' risk perceptions influence their decisions to adopt conservation practices on their farms. Third, it attempted to determine whether farmers would supply three types of biomass, corn stover, sweet sorghum, and switchgrass, under contract subject to their risk perceptions.

Data for the dissertation consist of results from a stated preference study administered by the Department of Agricultural Economics at Kansas State University and the National Agricultural Statistics Service Kansas Field Office. The survey gathered information from 290 farmers across Kansas including the number of acres in each farmer's operation; the amount of rented land they farm; the types of crops and livestock they produce along with yields and crop rotation patterns; a stated choice section asking their willingness to produce bioenergy feedstocks; their perceptions about biofuels from production and policy perspectives; the conservation practices they use on their farms; their perceptions about and how they manage potential sources of risk for their farm operations and families, and personal demographic characteristics.

Essay 1, "Farmers' Willingness to Grow Switchgrass as a Cellulosic Bioenergy Crop: A Stated Choice Approach," used stated preference data from the survey and a latent class model, which is a special case of a multinomial logistic regression, to determine farmers' willingness to produce switchgrass as a cellulosic biofuel feedstock under contract. Two latent classes were found in the data determining that heterogeneity across respondents exists for non-adopters and adopters. Results show that contract attributes positively affecting farmers' decisions. These attributes include net returns, biorefinery harvest options, insurance availability, and seed cost-share assistance. Contract length negatively affects farmers' decisions on which contract to choose, indicating they prefer shorter-term contracts. However, adopters are more likely to enter into a switchgrass contract than non-adopters and are more willing to pay more for a biorefinery harvest option, but require more compensation to enter into long-term contracts.

Marginal willingness to pay (MWTP) estimates show that contract length is an important attribute (maybe the most important attribute) in determining whether a farmer will produce switchgrass for bioenergy for each latent class. In each class, farmers require some payment ranging from $9.33 (for adopters) to $0.72 (for non-adopters) per acre per additional year of contract length to produce switchgrass for bioenergy. In addition, farmers see a seed-cost share arrangement as beneficial to entering into a switchgrass producing contract and non-adopters are willing to pay about $0.15 per acre per percentage point increase in the share of establishment costs paid by the biorefinery.

While switchgrass has great potential to help reduce the nation's dependence on nonrenewable sources of energy, much uncertainty exists as to its viability in Kansas. A primary area of further research is to determine how bioenergy crop characteristics, storage, and transportation issues affect farmers' decisions to grow a bioenergy crops. Risk aversion is also important when assessing farmers' willingness to adopt new technology or practices and could affect their decisions. The latent class logit model presented here attempts to control for these, but it does not help explain how farmers base their decisions because of these characteristics specifically.

Essay 2, "Farmer Risk Perceptions and Conservation Practice Adoption," used factor analysis to reduce data on farmers' risk perceptions to a reasonable size. Factor analysis found three important risk factors relating to farm operation management, insurance as a risk reducing strategy, and off-farm income as a risk reducing strategy for farmers' families. The risk factors were included in a multinomial logistic regression as independent variables along with farm characteristics to determine how farmers adopted conservation practice bundles.

Most Kansas farmers already practice some form of conservation tillage, indicating they recognize the need to conserve soil and moisture. Farmers who indicated they see themselves as a first adopter are more likely to use practices involving variable rate technology and cover crops, which is not unexpected since technology adoption is probably something first adopters will adopt and cover crops are not widely used in Kansas. Farmers who have livestock naturally practice conservation related to manure management. Central Kansas farmers are likely to adopt conservation practices possibly due to less irrigation use than Western Kansas farmers, and less rainfall than Eastern Kansas farmers receive.

Results show that, while risk factors were not significant in determining why farmers choose conservation practices on their farms, other variables do play a role in farmers' decisions whether to adopt. The risk perception related to insurance was the only statistically significant risk perception for farmers adopting a no-till/manure use conservation practice bundle. The insignificance of risk perceptions on conservation practice use is somewhat puzzling since it would seem that if conservation can ensure the longevity on their farm's productivity, farmers would adopt. However, if farmers are profit maximizers in the short run, they may be less willing to adopt conservation if the monetary costs are high, regardless of the short-term environmental costs. Since these risk perceptions have essentially no effect on conservation practice adoption, it seems that farmers do not consider the types of risk examined here when adopting conservation and consider other factors in their decisions. While not used in this study, it is possible that monetary incentives play a larger role in conservation adoption than an individual's risk perception.

More work remains in the area of farmers' risk perceptions and the effects on conservation practice adoption. This study attempted to relate risk perceptions to conservation practice adoption and found no relationship. It is possible that the risk questions were asked in a way such that they do not extract farmers' true risk aversion. Eliciting risk aversion through a different method may provide researchers with a better understanding of how farmers' risk perceptions and risk management strategies affect conservation adoption.

Essay 3, "Farmers' Risk Perceptions in Stated Choice Experiments on Adoption of Alternative Cellulosic Biofuel Feedstocks," used the three risk factors (management risk, insurance risk, and off-farm income risk) from Essay 2 to determine how farmers' risk perceptions affect their decisions to adopt three cellulosic bioenergy feedstocks under contract using a stated choice framework. The study incorporated the risk factors into a latent class model, similar to Essay 1 to assess heterogeneity across survey respondents based on their risk perceptions.

The bioenergy feedstocks analyzed were corn stover, sweet sorghum, and switchgrass because of their availability and suitability for production in Kansas. Results indicate that farmers fall into different classes with respect to how they manage potential operational risk, depend on insurance or off-farm income and investments, and consider costs and government policy as contributing to risk on their farms. The class into which farmers fall can change the amount they are willing to pay for contract attributes. In general, farmers require compensation to enter into long-term contracts, but they are willing to pay from $1.33 to $11.35 per acre for a biorefinery harvest option, depending on the crop, and other options that might make bioenergy crop production less risky such as insurance, government incentives, and a seed cost share.

Overall, risk perceptions had no significant impact on whether Kansas farmers will adopt a cellulosic biofuel feedstock enterprise, similar to the results from Essay 2. For farmers considering a corn stover enterprise, risk perceptions do not affect decisions, likely because a corn stover enterprise is familiar to farmers and risk is not an issue for them should they choos to produce this feedstock. For the sweet sorghum enterprise, only the management risk factor was statistically significant and had a negative sign, indicating farmers may view this type of crop as an important cellulosic biofuel feedstock enterprise, and may be more willing to adopt this type of enterprise due to their familiarity with sorghum production. In other words, any type of manager would be able to incorporate a sweet sorghum enterprise into their farming operation. However, for the switchgrass enterprise, farmers' unfamiliarity with the enterprise may cause their personal risk perceptions to be irrelevant because they are simply too reluctant to produce switchgrass as a bioenergy feedstock.

Much work remains to determine how risk affects decision-makers' choices when answering questions in stated choice experiments. While latent class models provide a reasonable framework to determine how individual heterogeneity affects decisions, other methods such as random parameters models may provide useful information to help researchers offer insight to producers, biorefineries, and policy makers about the potential costs and gains of a cellulosic biofuel feedstock industry. Results from this study indicate that biorefineries should understand that not all farmers would be willing to enter into a contract to produce biofuel crops depending on their goals for their operations. In addition, it is important for biorefineries to understand that farmers' risk perceptions as asked here do not play an important role in their decisions whether to adopt. Farmers may be willing to adopt cellulosic biofuel feedstock production as long as they know their production has a market. Farmers should understand that they have room to negotiate different contract attributes. The hypothetical situations presented here are not the only combinations of contracts available. Nascent markets will necessitate flexibility on the part of all participants.

Overall results from this dissertation indicate that farmers' decision-making characteristics bear further study. While risk enters into farmers' decisions, results from this study indicate their perceptions about risk are relatively unimportant with respect to adopting cellulosic biofuel feedstocks or conservation practices. One reason for this may be that crop farmers are relatively "comfortable" growing corn, soybeans, wheat, and sorghum when profits for these crops are high. Another reason may be that farmers have more risk management tools available to reduce yield and price risk, so they are less concerned with potential risks presented in this study.

Further research includes asking farmers risk perception questions along with risk elicitation questions to attempt to trace out a risk aversion frontier. Having a more complete understanding of farmers' risk aversion may help determine how risk enters into decisions about adopting new crop or livestock enterprises, new technology, or new crop insurance instruments.