Farmers' Risk Perceptions of Intensified Conservation Practices On-Farm

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Abstract

Risk plays an important role in agricultural production decisions. When installation of new or intensification of existing conservation practices are under consideration, each farmer will have a unique, subjective view of the associated risks. The individualistic nature of risk perceptions could have important implications for conservation adoption or intensification. Thus, a more complete understanding of the factors influencing farmer risk perceptions is needed to increase the effectiveness of education, extension, outreach and programmatic efforts. The purpose of this study is to examine farmers' risk perceptions regarding a bundle of in-field practices which could be used to intensify conservation efforts on farms in the Midwest. We present a conceptual model of perceived yield risk for four conservation practices: continuous no-till, conservation crop rotations, cover crops, and variable rate application of inputs. Bivariate probit models are estimated using survey response data from Kansas farmers.

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1.0 Introduction

Risk is an important component of agricultural production and plays an important role in farmers' production decisions, particularly the adoption of new or the intensification of existing conservation efforts on-farm (Aimin, 2010). In some cases, risk can have a larger effect than cost factors (Sattler & Nagel, 2010). The introduction and intensification of conservation practices on the farm introduces potential risks through impacts on cropping system dynamics, contract or practice limitations, and changes in production costs. These changes can result in shifts in net returns (due to changes in crop yields and/or costs) that may not be known a priori. Thus, risk is an important aspect in farmers' adoption decisions that needs consideration to help promote conservation adoption on-farm.

Many studies in the adoption literature utilize perceived risk as an explanatory factor in an adoption model (e.g. Kim et al., 2005 and Shapiro et al., 1992). Some studies have examined the perceived profitability or benefits of conservation practices to assess their impact on adoption patterns (e.g. Bergtold et al., 2012). Cary and Wilkinson (2008) found that perceived profitability was a highly significant factor in influencing the use of conservation practices. Reimer et al (2012) found risk characteristics to be the leading barrier for conservation tillage and also a barrier to the adoption of cover crops, grassed waterways, and filter strips among Indiana farmers.

Risk perceptions will be unique to individual farmers. Regardless of the statistical or objective risk for a given scenario, farmers will form their own perceptions. Some farmers will overestimate and others will underestimate the riskiness of a situation relative to the statistical risk. Thus, attempting to anticipate farmers' risk behaviors using an objective measure of risk is could yield misleading results. Additionally, risk perceptions may differ based on the decision context (Bontempo et al, 1997). That is, risk perceptions for the same farmer will be a function not only of characteristics specific to him, but also those specific to the conservation practice under consideration. Despite the complex and individual nature of their formation, few studies have examined risk perceptions of more intensive conservation practices on-farm. Understanding these perceptions and the factors that shape them are important if education, extension, outreach and programmatic efforts to promote conservation adoption are to be successful.

The purpose of this study is to examine farmers' risk perceptions regarding a bundle of in-field practices which could be used to intensify conservation efforts on farms in the Midwest. The specific conservation practices being examined are continuous no-till, conservation crop rotations, cover crops, and variable rate application of inputs. Selection of these practices was based on the assumption that their adoption represents an intensification of conservation efforts on-farm. For example, it is common in Kansas for farmers to utilize no-till practices for the production of soybean and corn, but switch to reduced tillage practices when producing wheat in rotation (Canales 2016). Understanding farmers' risk perceptions concerning these practices and the factors that shape them can help in the design of successful policies to promote on-farm conservation intensification.

2.0 Conceptual Model of Perceived Yield Risk

From a technical perspective, yield risk can be quantified in terms of means, variances, and other statistical measures. While statistical measures on yields may be obtained from a number of sources, such as government or academic institutions, there likely exists a disparity between the risk evaluations of researchers and the typical farmer (Kellstedt et al, 2008). This disparity makes the use of statistical measures as a proxy for farmer risk perceptions potentially problematic. For example, individuals opting for a risky option may be labelled as risk seeking by researchers, when in fact their behavior is based on their subjective perception of the risk and they are actually “perceived risk averse” (Bontempo et al, 1997). Thus, in many instances it may be valuable to have an approach which allows for risk perception heterogeneity.

Modelling individual risk perceptions is complex, largely due to the psychological uncertainties regarding how people formulate their perceptions. Risk perceptions are likely a function of cultural and environmental variables; an individual’s personal background and experiences; and contextual characteristics. Moreover, an individual’s perceptions may be fluid over time as they are reshaped by new knowledge or experiences. These complexities make the formulation of a conceptual model and subsequent selection of variables a non-trivial task.

Studies often assume risk perceptions can be explained along key dimensions. Sander van der Linden (2015), for example, notes that past research on climate change risk perceptions typically assume influence from four key dimensions: socio-demographic, cognitive, experiential, and socio-cultural. Hung et al (2011) proposed perceived risk from a nuclear plant as a function of compensation effects, social trust, socioeconomic characteristics, local context, and hybrid psychometric dimensions. Despite differing terms given to the individual subsets, or key dimensions, similarities exist in what they attempt to capture, such as knowledge about the topic, respondent demographics, and respondent world views. This study follows this “key dimension” approach. As seen in Figure 1, farmer perceptions of yield risk for a given conservation practice are assumed to be a function of five dimensions: *farmer characteristics*, *farm characteristics*, *environment variables*, *attitudes and beliefs*, and *experiential variables*.

Variables included under *farmer characteristics* are meant to capture a farmer’s cultural background, such as age and education. Previous research implies an uncertainty regarding the impact of these variables on risk perceptions. Kellstedt et al (2008) state that past research indicates that higher socioeconomic status, including education, lead to lower levels of perceived climate change risk. Linden (2015) notes that there is some support for this view, but many studies find little to no correlation between age and education and risk perceptions on climate change. However, Linden (2015) warrants their inclusion as control variables to aid in assessing the net influence of other factors. Risk perception studies often find what is termed the "white male effect" which refers to the fact that women and racial minorities tend to exhibit heightened levels of perceived risk (Kellstedt et al, 2008). However, due to low variability in the data (99.2% white and 98.4% male), these variables were not included.

Variables included for *farm characteristics* intend to capture a farmer's level of exposure to yield risk. Two variables were used for this group: size of the operation (in hundreds of acres) and the percent of household income from cropping operations. It is uncertain in which direction farm size should influence risk perceptions. Farmers operating more acres may view yield risk in a "more to lose" manner leading to an increased perception of risk, or they may see more acres as way of spreading the risk. It is expected that higher percentages of household income from cropping will lead to increased levels of risk perception, *ceteris paribus.* The intuition is that as an increasing amount of a household's income comes from sources not subject to the risk, there should be less risk on the ability to maintain the current lifestyle.

Environment variables are meant to capture factors specific to a farmer's physical environment which may influence the risk associated with different practices. The first of these, climate, could include factors such as average annual precipitation, temperatures, soil characteristics, etc. The second, neighboring farms, represents the influence of practice adoption in the local area. When a farmer adopts a new conservation practice, the successes or failures should add to the knowledge base of his neighbors. Even if a farmer does not pay close attention to the successes or failures of others with a practice, if the farmer is aware of the increased usage, risk perceptions may still be impacted. In this case, increased usage may serve as a signal to non-adopters that yield risk is lower than they originally thought. Thus, as more farmers within a region adopt a given practice, there should be a corresponding effect on yield risk perceptions.

The *attitudes and beliefs* set includes variables on a farmers' reported levels of risk aversion; perceptions of practice impacts on soil erosion, soil fertility, weed pressure and/or insect pressure; and belief regarding the consequences of their cropping decisions on the local environment. It is expected that more risk averse individuals will assign higher risk to a given practice, perhaps based on emotion or dread. However, if farmers are completely objective in their assessment of risk, the level of risk aversion may not exert any influence. Farmers who hold "positive" practice perceptions are expected to exhibit lower levels of decreased yield risk. For example, it is believed that a farmer who expects soil fertility to increase or weed pressure to decrease under cover crops will attribute a lower level of yield risk to cover crops. There is no a priori expectation regarding the attitude towards impacts on the local environment. As with risk aversion, for a completely objective farmer this may have no impact. However, if a farmer's perceived yield risk is compounded (diminished) corresponding to negative (positive) local environmental impacts from the practice, a causal relationship may exist. The direction of this relationship is ambiguous, as it would depend on a farmer's belief regarding the impacts of the practice on the local environment, both sign and magnitude.

The final grouping, *experiential variables*, is included to capture both a farmer's own experience with a given practice, as well as knowledge which can be gleaned from other sources. For the latter, a variable indicating membership in an environmental organization has been included. Membership in an organization that focuses on the conservation practices examined here should have an obvious impact on yield risk perceptions. For other types of environmental organizations, those not directly concerned with agricultural conservation practices, the implied relationship is less clear. However, farmers involved with any environmental organization may be more inclined to seek information regarding conservation practices than their non-member counterparts and so a relationship may still hold. As for a farmer's own experience with a practice, an influence on perceived yield risk should again be obvious. In this case though, endogeneity exists: past adoption of a practice will impact current yield risk perceptions and yield risk perceptions influence adoption behaviors. The two-way relationship is indicated by the direct connection between past experience and yield risk perception in Figure 1. This could be modeled as a time-step process in which a farmer's decision to adopt or not along with other changes leads to an updated yield risk perception and then the process repeats. This is beyond the scope of the current study. Rather, it is acknowledged that endogeneity exists and is accounted for in the empirical model.

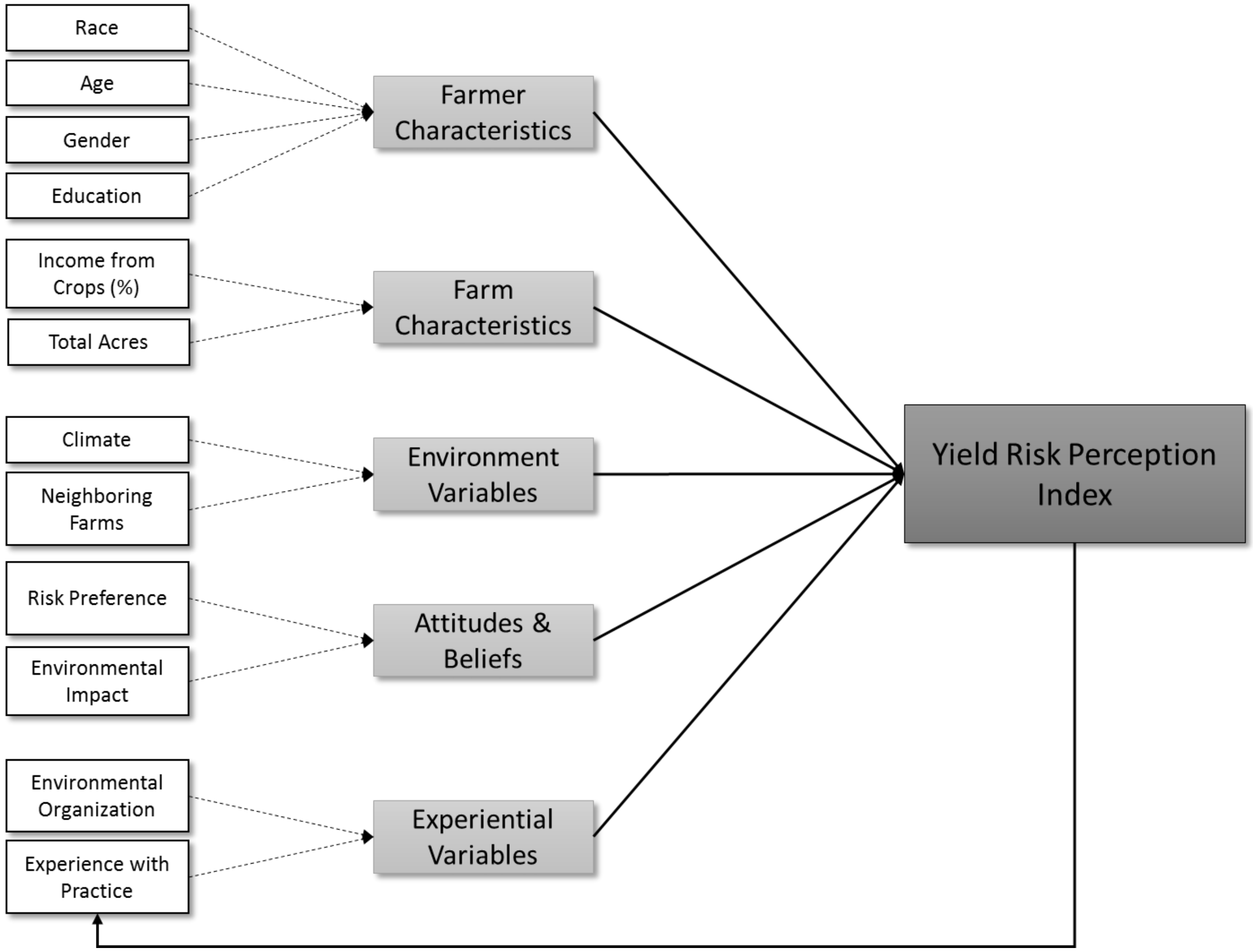

Figure 1. Perceived yield risk conceptual framework

3.0 Data

This study examines the perceived risk of alternative conservation practices by farmers in Kansas. A survey was administered during a series of workshops spanning ten locations across the state of Kansas from December 2013 to March 2014. Workshop locations were selected to capture differences in climate, landscape and farm make-up. Locations included: Salina, Great Bend, Colby, Dodge City, Wellington, Pratt, Hiawatha, Topeka, Manhattan, and Parsons, Kansas. Prior to administering the survey, it was field tested with three focus groups held in Manhattan, Salina and Wellington.

A sample of farms was obtained from the Kansas Farm Management Association

(KFMA). The KFMA has approximately 2,300 farms across Kansas in their database that produce crops and livestock. Approximately 76% of these farms are primarily crop producers and 16% identified as crop/livestock producers. Working with members of KFMA allowed for survey data to be matched with financial data from KFMA respondent farms. A total of 1,513 farmers from the KFMA were mailed letters inviting them to attend one of the workshop. Of the farmers contacted, 40 no longer farmed, were deceased or could not be located; and 432 responded to the letter. In total, 250 of the 432 farmers who responded attended the workshops. The remaining farmers who responded were interested, but could not attend the workshops on the dates these were held. This resulted in an adjusted response rate of approximately 30%, and an attendance rate of 17%. Workshop attendees were compensated for their time and travel expenses with a stipend of $125.

The workshops consisted of an introductory presentation covering the basic aspects of the conservation practices under study, a time for farmers to answer a survey questionnaire, a set of stated choice experiments, and a focus group to discuss farmers' views on conservation. During the workshop, farmers were asked to complete a survey with questions to elicit their farming history, farm operation, and the conservation practices used on their farm.

Data from farmers with incomplete responses for needed variates were not considered, leaving a different number of farmers' data for analyses, depending on the conservation practice being analyzed. The four conservation practices of interest included continuous-no-till, dynamic crop rotations, cover crops, and variable rate application of inputs. The number of complete observations in the data for each practice was 204, 187, 164 and 153 for continuous-no-till, dynamic crop rotations, cover crops, and variable rate application of inputs, respectively.

Table 1 presents summary data for the dependent and independent variables used in the model. The dependent variables concerning perceived risk of the different conservation practices was assessed asking a question on a Likert Scale of 1 (Strongly Disagree) to 5 (Strongly Agree) if the respondent perceived that the conservation practice being examined reduced yield risk. Given limited variation across the different categories for the Likert Scale in many cases, each question was recoded as a binary variable with '1' representing Agree or Strongly Agree and '0' representing Neutral, Disagree, and Strongly Disagree. The four conservation practices examined include:

(i) *Continuous no-tillage*: No-tillage is a form of conservation tillage, where soil disturbance is limited to nutrient injection. Plant residue is left on the soil surface and only partial removal is allowed. Continuous no-till indicates that all the crops in the crop rotation are planted using a no-till drill/planter and no-till equipment is used year round (SSSA, 2012).

(ii) *Conservation crop rotations*: Conservation crop rotation consists of rotating different unrelated crops within the same field in a predetermined sequence, and include green manures, perennial grasses, heavy residue cash crops and reduction of fallow periods within the rotation (NRCS, 2015).

(iii) *Cover crops*: Cover crops are a conservation practice that consists of growing seasonal crop varieties between annual cash crops, with the purpose of providing protection of the soil surface from soil and water erosion (Snapp et al., 2005).

(iv) *Variable rate application of inputs*: Variable-rate application (VRA) of inputs consists of spatially varying input rates based on field requirements with the aid of computer-

controlled devices. The objective of the VRA of inputs is to maximize the economic efficiency of input application.

The remainder of the explanatory variables include a range of binary, ordinal and continuous dependent variables that are defined and summarized in Table 1. The inclusion of these variables is supported by the literature on perceived risk and conservation adoption studies (e.g. Greiner et al, 2009; Koundouri et al, 2006; Pannell et al, 2006).

Table 2 presents farmers demographics reported in the survey and compares them to the 2012 U.S. Census of Agriculture (NASS-USDA, 2013) and the demographics of KFMA members in 2013 (KFMA, 2014). The farmers surveyed were between 20 and 90 years of age, with a sample average of 57 years which could be considered representative of the average Kansas farmer (58 years – as reported in the U.S. Census of Agriculture). However, the average size (including CRP land) of farm operations in the sample (2,453 acres and gross sales value of $400,000 to $599,999) is larger than the average farm size of 747 acres and sales value of $298,845 in Kansas, as reported in the 2012 Census of Agriculture. It should be noted that small size farms, hobby/residential farms, or farms operated by retired operators (sales < $250,000) represent a significant share of the total U.S. farm population (Lambert et al., 2007). In the U.S. Census of Agriculture, farmers with sales lower than $99,999 represent roughly 74% of the total farms (NASS-USDA, 2013). This study focuses on medium to large farms, excluding small hobby farmers, retired farmers, and very large operations. Medium and large farmers were chosen as the study group as the goal was to examine farmers that produce a higher percentage of the overall crop production. In addition, this group was selected because farm size plays an important role for conservation practice adoption, particularly for practices that are management intensive as they require operators to be devoted to farming because of the additional learning, time, and financial investment needed (Lambert et al., 2007).

When comparing the farm demographics of the farmers who participated in the survey to those of all KFMA members, the sample is representative of the KFMA group. KFMA members are a good sample of farmers to study as they generally operate medium to large size farming operations, which is the main target of this study. Hence, results in this study should be interpreted as representing conservation practice adoption decisions by medium to large farm operators in Kansas.

4.0 Empirical Model

Assume that farmer *i*'s perceptions concerning yield risk for conservation practice *j* are represented by a latent continuous variable R_{ij}. Risk perceptions, R_{ij}, are a function of a set of explanatory variables as described in the conceptual framework and illustrated in Figure 1, i.e.:

$$R_{ij} = \boldsymbol{\beta}_j \boldsymbol{X}_i + \boldsymbol{\alpha}_j \boldsymbol{Z}_{ij} + \gamma_j E_{ij} + u_{ij}, \qquad (1)$$

where $(\boldsymbol{\beta}_{j,} \boldsymbol{\alpha}_{j,}\ \gamma_j)$ is a vector of parameters (including an intercept) to be estimated, $\boldsymbol{X}_i$ is a set of explanatory variables specific to farm/farmer *i* (e.g. farmer characteristics, farm characteristics, environment variables, attitudes, beliefs, and experiential variables), $\boldsymbol{Z}_{ij}$ is a set of farmer specific variables about the efficacy or impact of conservation practice *j* (e.g. soil erosion reduction, weed suppression, etc.), E_{ij} is the experience that farmer *i* has with conservation practice *j*, and u_{ij} is a mean zero IID error term.

As mentioned in the conceptual framework, R_{ij} is conditional on a farmer's experience with conservation practice *j*, E_{ij}, which is an endogenous variable. To model this endogeneity, we assume that a farmer's experience with conservation practice *j*, is a function of a set of explanatory variables. Many of these variables will be similar to what influences the yield risk perception, but additional factors, such as farm management goals and behaviors, will impact adoption, as well (Caldas et al. 2014; Pannell et al., 2006). Thus, we model E_{ij} as:

$$E_{ij} = \boldsymbol{\delta}_j \boldsymbol{X}_i + \boldsymbol{\theta}_j \boldsymbol{Z}_{ij} + \boldsymbol{\tau}_{\boldsymbol{j}} \boldsymbol{Y}_{\boldsymbol{i}} + \varepsilon_{ij}, \qquad (2)$$

where $(\boldsymbol{\delta}_{j,} \boldsymbol{\theta}_{j,}\ \boldsymbol{\tau}_{\boldsymbol{j}})$ is a vector of parameters (including an intercept) to be estimated, $\boldsymbol{Y}_i$ is a set of explanatory variables specific to farm/farmer i measuring farm management and perceptions (e.g. first-time adopter, profit maximizer, etc.), and ε_{ij} is a mean zero IID error term.

As described in the data section, what is observed is whether a farmer perceives that conservation practice j reduces yield risk and if a farmer has used or is using conservation practice j. Thus, both R_{ij} and E_{ij} are binary variables. Assuming that $\begin{pmatrix} u_{ij} \\ \varepsilon_{ij} \end{pmatrix} | \boldsymbol{X}_i, \boldsymbol{Z}_{ij}, \boldsymbol{Y}_i \Big) \sim NIID \left[\begin{pmatrix} 0 \\ 0 \end{pmatrix} \begin{pmatrix} 1 & \rho \\ \rho & 1 \end{pmatrix} \right]$, equations (1) and (2) can be simultaneously estimated as a bivariate probit model (Greene, 2012). As indicated by Greene (2012), given that the bivariate probit model is estimated using full information maximum likelihood the simultaneity between R_{ij} and E_{ij} is explicitly captured in the estimation process and no additional model modifications are needed to account for the endogeneity. The parameter ρ measures the tetrachoric correlation between R_{ij} and E_{ij}, capturing the endogenous relationship between the two equations in the model. Estimation of the bivariate probit model is carried out using maximum likelihood estimation in LIMDEP 10 and is thoroughly outlined in Greene (2012).

5.0 Results

Results for each of the models can be found in Table 3. Of the four estimated, the continuous no-till model had the least explanatory power as indicated by a pseudo-R^2 of 0.3280. The highest pseudo-R^2 of 0.4406 was for the variable rate application model. Falling in between were the conservation crop rotation, pseudo-R^2 = 0.3599, and cover crops, pseudo-R^2 = 0.4059. The tetrachoric-correlation coefficient was positive and statistically significant across all four models, lending support to the assumption of endogeneity between perceived yield risk from a practice and experience with that practice.

Continuous No-Till. For the continuous no-till experience equation (*EXPNT*), statistically significant coefficients were estimated for five variables: whether the farmer is "cautious" (*RISK2*) or is willing to take risks after research (*RISK3*); if the farmer believes no-till reduces soil erosion (*NTEROS*) or increases soil fertility (*NTFERT*); and if the farmer tends to adopt new technology before his neighbors (*FRSTAPT*). Negative coefficients were estimated for both risk variables suggesting that risk averse individuals are less likely to have experience with continuous no-till. Positive coefficients were estimated for the soil erosion and fertility variables, indicating a belief that no-till decreases erosion or increases soil fertility will increase the probability of a farmer having experience with the practice. A positive coefficient was estimated for *FRSTAPT*, indicating these farmers are more likely to have experience with continuous no-till.

The estimated tetrachoric-correlation coefficient between the equations was $\hat{\rho}$ = 0.745 and was significant at the one-percent level, indicating a strong positive relationship between experience with continuous no-till and the belief that it reduces yield risk. In the yield risk perception equation (*NTR*), statistically significant impacts were found for membership in an environmental organization (*ENV_ORG*); *RISK2*; *RISK3*; operating in eastern Kansas (*EAST*), *NTEROS*, and *NTFERT*. The coefficient on *ENV_ORG* is negative, indicating that farmers who are members of an environmental organization are more likely ascribe yield risk to continuous no-till. Coefficients on *RISK2* and *RISK3* are also negative which implies risk averse farmers are more likely to see continuous no-till as a yield risk. *NTEROS* and *NTFERT* both had positive coefficients, and so a belief that continuous no-till reduces soil erosion or increases soil fertility will decrease the perceived risk to yields. Each of these conforms to prior expectations. The coefficient on *EAST* is negative, indicating that farmers in eastern Kansas see continuous no-till as riskier to yields than farmers in central Kansas (the omitted region). The impacts for *RISK2*, *RISK3*, *NTEROS*, and *NTFERT* are consistent with our prior expectations; there were no prior expectations on *ENV_ORG* or *EAST*.

Conservation Crop Rotations. In the conservation crop rotation experience model (*EXPCCR*) coefficients on the east and west regions and on the belief that conservation crop rotations increase soil fertility (*CCFERT*) were all statistically. Farmers in both eastern and western Kansas are less likely to have used or are using conservation crop rotations compared to farmers in central Kansas. The coefficient on CCRFERT was positive, suggesting that farmers who believe conservation crop rotations improve soil fertility are more likely to have experience with the practice.

The estimated tetrachoric-correlation coefficient was $\hat{\rho}$ = 0.324 and was significant at the five-percent level. In the conservation crop rotation risk-perception equation (*CCRR*), the coefficient on CCRFERT was positive and significant (5%) indicating that believing conservation crop rotations improve soil quality increases the probability a farmer sees this practice as reducing yield risk. This is consistent with the prior expectation. A positive and significant (5%) impact was also found in the risk equation for being a college graduate

(*COLLEGE*). This suggests that college graduates are more likely to believe conservation crop rotations reduce yield risk. Finally, a negative and significant (10%) effect was found for farmers who believe their cropping decisions impact the local environment (*ENV_IMP*). Thus, farmers who believe they can impact the local environment through their cropping decisions are less likely to see conservation crop rotations as reducing yield risk. There were no prior expectations on either *COLLEGE* or *ENV_IMP*.

Cover Crops. Statistically significant impacts were found in the cover crop experience (*EXPCC*) equation model for cautious farmers (*RISK2*) and those willing to take risks after doing research (*RISK3*), a belief that cover crops reduce weed pressure (*CCWEEDS*), and if a farmer generally adopts new technology before his neighbors (*FRSTAPT*). The *RISK2* and *RISK3* coefficients were both negative, again suggesting more risk averse individuals are less likely to have used or currently be using cover crops. *CCWEEDS* was found to have a positive impact on adoption, and so a farmer who believes cover crops reduce weed pressure are more likely to have experience with them. Farmers who tend to adopt new technology first (*FRSTAPT*) were also more likely to have experience with cover crops. The *CONSTANT* parameter was negative and statistically significant.

The estimated tetrachoric-correlation coefficient was $\hat{\rho} = 0.297$ and was statistically significant at the 10-percent level. In the cover-crop risk-perception equation (*CCR*), a positive and significant (10-percent level) impact was found for the belief that cover crops reduce weed pressures (*CCWEEDS*). In other words, farmers who believe cover crops reduce weed pressure view incorporating the practice as less of a yield risk. This finding is consistent with expectations. None of the remaining parameters were found to be statistically significant for this model. The lack of statistical significance for many variables could be due to the limited extent of adoption of cover crops in Kansas.

Variable Rate Application. Operation size (*HUNDAC*) was found to have a positive and statistically significant impact on the probability a farmer has experience with variable rate applications (*EXPVRA*). This implies that as the number of acres being operated increases, so too does the probability that a farmer has experience with variable rate application techniques. A statistically-significant negative impact was found for farmers who require research prior to accepting risk (*RISK3*) and also for farmers living in western Kansas (*WEST*). Thus, being risk averse (to some degree) and operating in western Kansas both decrease the probability that a farmer has experience with variable rate applications. This finding could be a result of limited access to VRA services and equipment in this region. Being a first adopter of technology (*FRSTAPT*) has a positive and statistically significant effect on the probability of having experience with variable rate applications.

The tetrachoric-correlation coefficient for this model was $\hat{\rho} = 0.596$ and was statistically significant at the one-percent level. In the variable rate application risk-perception equation (*VRAR*), the only statistically significant impact found was on the belief that variable rate applications improve soil fertility (*VRAFERT*). The coefficient on *VRAFERT* was positive, so a farmer who perceives an increase in soil fertility from variable rate application is more likely to see the practice as yield risk reducing. This is consistent with prior expectations. Again, the lack of statistical significance for many variables could be due to the limited extent of adoption and experience with VRA of inputs in Kansas. This is highlighted by the fact that the only significant factor was perceived impacts on-farm from adoption of the practice.

Conclusions

This study examined farmers' yield risk perceptions regarding four in-field conservation practices: continuous no-till, conservation crop rotations, cover crops, and variable rate application. Using survey data from Kansas farmers, separate bivariate probit models were estimated to examine the factors impacting the yield risk perceptions and past or current experience with each practice. Variables included in the empirical models were selected to capture the dimensions proposed as key influencers of yield risk perceptions: farmer characteristics; farm characteristics; environment; attitudes and beliefs; and experience.

Empirical estimation yielded strong support for the endogeneity assumption between lower perceived yield risk and personal experience with a given practice. The estimated tetrachoric-correlation coefficient was positive and statistically significant for all four models. In general, farmer and farm characteristics such as age, education, farm size, and income from crops, had no statistically significant impact on the risk perception or experience variables. This was not necessarily a surprising result, as similar findings have been reported in the literature (Linden, 2015). Consistent with expectations, farmers who identified as cautious or only willing to take risks after conducting research tended to be less likely to have experience with the conservation practices or believe they reduce yield risk. Also as expected, farmers who claim to be early adopters were more likely to have had experience with or be currently using the practices. Finally, and perhaps most interesting, were the impacts associated with practice perceptions. In general, if farmers believe a practice will improve soil fertility, reduce soil erosion, or reduce weed pressures, they are more likely to have experience with a practice and view them as reducing yield risk.

The results regarding the practice perceptions have potential implications for future outreach and extension efforts. Previous research has shown that risk is an important barrier to the adoption or intensification of on-farm conservation. Results from this study suggest that farmer perceptions as to a conservation practice's impacts on soil fertility, soil erosion, or weed pressures has an impact on both experience with a practice and the perceived yield risk from a practice. That is, these perceptions can have both an indirect, through risk, and direct effect on conservation practice adoption. Thus, it would be wise to focus some extension and outreach efforts on increasing farmer knowledge on positive soil erosion, soil fertility, or weed pressure benefits.

A second key implication comes from the positive correlation between experience with a practice and the perception that it reduces yield risk. This suggests that on-farm trialability would be an important component to successful conservation programs and intensification. Given the opportunity to conduct small-scale trials on their farms, farmers may experience changes in their yield risk perceptions which could induce large-scale adoption, perhaps throughout the entire operation.

Ultimately, how an individual farmer forms and later changes his risk perceptions is a complex psychological question. However, this study shows that advancing the knowledge of this process can have important consequences for conservation-oriented outreach and extension efforts. With the help of richer datasets, future research should seek to expand upon this study to further the understanding of farmer risk perceptions.

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Table 1. Summary data for dependent and independent variables

Variable	Description	*N*[a]	Average (std dev)
	Dependent Variable		
NTR	Equal to 1 if respondent "strongly agrees" or "agrees" that continuous no-till will reduce yield risk.	242	0.58 (0.49)
CCRR	Equal to 1 if respondent "strongly agrees" or "agrees" that conservation crop rotation will reduce yield risk.	242	0.64 (0.48)
CCR	Equal to 1 if respondent "strongly agrees" or "agrees" that cover crops will reduce yield risk.	242	0.28 (0.45)
VRAR	Equal to 1 if respondent "strongly agrees" or "agrees" that variable rate application will reduce yield risk.	240	0.41 (0.49)
	Explanatory Variables		
	Farmer Characteristics		
COLLEGE	Equal to 1 if respondent is a college graduate.	248	0.50 (0.50)
AGE	Age of respondent in years.	248	57.1 (13.2)
	Farm Characteristics		
HUNDAC	Number of acres in crops, hay, pasture, or CRP in hundreds of acres.	247	24.33 (20.02)
HHICROP	Percentage of household income which comes from cropping.	230	0.54 (0.32)
	Environment Variables		
EAST	Equal to 1 if respondent's operation is in "East" region of Kansas.	248	0.38 (0.49)
WEST	Equal to 1 if respondent's operation is in "West" region of Kansas.	248	0.21 (0.41)
	Attitudes & Beliefs		
RISK2	Equal to 1 if respondent is "cautious."	241	0.16 (0.37)
RISK3	Equal to 1 if respondent is "willing to take risks after adequate research."	241	0.60 (0.49)
ENVIMP	Equal to 1 if respondent "agrees" or "strongly agrees" that he can improve or harm the local environment through cropping choices.	247	0.90 (0.30)
NTEROS	Equal to 1 if respondent believes erosion will be lower under continuous no-till.	229	0.92 (0.27)
CCREROS	Equal to 1 if respondent believes erosion will be lower under conservation crop rotation.	208	0.75 (0.44)
CCWEEDS	Equal to 1 if respondent believes weed pressure will be lower under cover crops.	182	0.68 (0.47)
VRAWEEDS	Equal to 1 if respondent believes weed pressure will be lower under variable rate application.	169	0.23 (0.42)
NTFERT	Equal to 1 if respondent believes soil fertility will be higher under continuous no-till.	227	0.50 (0.50)
CCRFERT	Equal to 1 if respondent believes soil fertility will be higher under conservation crop rotation.	206	0.51 (0.50)
CCFERT	Equal to 1 if respondent believes soil fertility will be higher under cover crops.	180	0.62 (0.49)
VRAFERT	Equal to 1 if respondent believes soil fertility will be higher under variable rate application.	169	0.67 (0.47)
FRSTAPT	Equal to 1 if respondent "strongly agrees" or "agrees" that he usually adopts new technology before neighbors.	247	0.49 (0.50)
	Experiential Variables		
ENV_ORG	Equal to 1 if respondent is a member of an environmental organization.	248	0.10 (0.30)

[a] Number of observations changes across variables due to incomplete survey responses.

Table 2. Average farmer characteristics

Variable	Survey data: *N*	Mean	Std. dev.	Min.	Max	Mean 2012 Census of Agriculture[a]	Mean 2013 KFMA
Age (yrs.)	248	57	13.2	20	90	58	----
Acres	245	2,453	1,998	40	14,875	747	2,196
Sales	242	\$400,000 - \$599,000[b]		< \$0	> \$1 Million	\$ 298,845	\$618,416

[a] Source: National Agricultural Statistics Service, USDA (2013)

[b] Mean sales of 6.20 corresponds to the sales category of \$400,000 to \$599,999

Table 3. Estimated Bivariate Probit Model Coefficients

	Models							
	Continuous No-Till		Conservation Crop Rotation		Cover Crops		Variable Rate Application	
Variable	Yield Risk (*NTR*)	Adoption (*EXPNT*)	Yield Risk (*CCRR*)	Adoption (*EXPCCR*)	Yield Risk (*CCR*)	Adoption (*EXPCC*)	Yield Risk (*VRAR*)	Adoption (*EXPVRA*)
CONST	-1.514	-2.747**	0.557	-0.181	-1.250	-1.788*	0.151	-0.871
	(1.018)	(1.273)	(0.855)	(0.860)	(1.071)	(1.006)	(0.716)	(0.852)
AGE	0.011	0.017	0.000	0.009	0.005	0.013	-0.008	-0.001
	(0.010)	(0.011)	(0.010)	(0.011)	(0.012)	(0.011)	(0.010)	(0.011)
COLLEGE	0.203	-0.013	0.467**	-0.283	-0.150	0.157	-0.150	-0.137
	(0.238)	(0.249)	(0.267)	(0.267)	(0.254)	(0.261)	(0.247)	(0.298)
ENV_ORG	-0.870**	-0.019	0.283	0.419	-0.120	-0.492	--	--
	(0.398)	(0.401)	(0.378)	(0.443)	(0.388)	(0.472)		
HUNDAC	-0.002	0.003	-0.006	0.007	0.002	0.009	0.006	0.011**
	(0.006)	(0.006)	(0.006)	(0.008)	(0.006)	(0.008)	(0.005)	(0.005)
HHICROP	0.260	-0.539	0.194	-0.091	-0.569	0.447	-0.105	0.402
	(0.399)	(0.422)	(0.357)	(0.402)	(0.375)	(0.416)	(0.381)	(0.428)
RISK2	-0.992**	-0.712*	0.673	0.115	0.056	-1.021**	-0.489	-0.537
	(0.391)	(0.427)	(0.468)	(0.396)	(0.500)	(0.472)	(0.499)	(0.545)
RISK3	-0.664**	-0.658**	0.123	-0.019	0.105	-0.945***	-0.390	-0.520*
	(0.296)	(0.334)	(0.285)	(0.298)	(0.284)	(0.286)	(0.279)	(0.312)
ENVIMP	0.393	0.469	-0.842*	0.469	0.190	0.432	--	--
	(0.382)	(0.349)	(0.501)	(0.389)	(0.603)	(0.479)		
EAST	-0.549**	-0.416	-0.204	-0.646**	-0.009	-0.003	0.063	0.219
	(0.263)	(0.271)	(0.257)	(0.282)	(0.280)	(0.280)	(0.273)	(0.308)
WEST	-0.240	0.009	-0.294	-0.770**	-0.335	-0.434	-0.359	-1.051*
	(0.288)	(0.339)	(0.330)	(0.310)	(0.338)	(0.348)	(0.351)	(0.577)
EROS	1.336**	2.035**	0.270	-0.177	--	--	--	--
	(0.539)	(0.802)	(0.257)	(0.295)				
WEEDS	--	--	--	--	-0.606*	0.511*	0.216	-0.351
					(0.316)	(0.306)	(0.294)	(0.320)
FERT	0.504**	0.523**	0.607**	0.529**	0.213	0.155	0.534**	0.159
	(0.213)	(0.230)	(0.245)	(0.244)	(0.280)	(0.274)	(0.269)	(0.291)
FRSTAPT	--	0.543**	--	0.391	--	0.715***	--	0.870***
		(0.233)		(0.251)		(0.253)		(0.289)
RHO	0.745***		0.324**		0.297*		0.596***	
	(0.084)		(0.157)		(0.174)		(0.124)	
Fit Statistics								
Log Likelihood	-195.32		-195.75		-177.55		-167.25	
AIC	450.6		447.5		411.1		382.5	
Pseudo R^2	0.3280		0.3599		0.4059		0.4406	
N	204		187		164		153	