Assessing Conditional Probabilities of Adopting Conservation Practices of Kansas Farmers

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Introduction

Agricultural conservation systems consist of different conservation practices including conservation tillage, dynamic crop rotations, cover crops, use of legumes in rotation, use of manure, precision agriculture, integrated pest management, and conservation nutrient management practices. The applied economics literature has studied a large number of factors affecting the adoption of these conservation practices. Many studies have examined the adoption of single practices, while only a few others have examined the joint adoption of a set of conservation practices or bundles. A limited number of studies have examined the step-wise or sequential adoption of conservation practices .

Purpose and Objectives

The purpose of this study is to examine and analyze the adoption of conservation practices by farmers in Kansas from both a joint and conditional perspective. More specifically this study:

Examines farmers' joint and conditional decisions to adopt alternative conservation bundles and the socio-economic and farm factors affecting adoptions. Conservation practices considered will be the use of conservation tillage, cover crops and the use of manure (as a fertilizer source).

Data and Methodology

The Survey – A survey data was developed in 2011 to collect data examining Kansas farmers' land use decisions and collect additional data on farmers' goals in farming; participation in conservation programs; use of irrigation; willingness to grow biofuel crops; views related to price, yield and weather risk; usage of insurance and marketing options; and characteristics of the farming operations. Data utilized from the survey in this study is provided in Table 1.

A primary goal of the survey was to assess the effects of alternative conservation practices and crop choices on farmers' land-use decisions in Kansas. The survey targeted Kansas farmers with 50 or more acres of arable land and over $10,000 in gross farm annual income in 2010. A total of 2317 surveys with usable data were received out of the 10,000 sent, while 684 were returned as undeliverable or where non-applicable (e.g. farmer was deceased or retired), resulting in a response rate of approximately 25 percent. Survey data was supplemented with landscape characteristic and weather data.

Methods – Based on a random utility modeling framework, a multinomial model is developed to capture the adoption of different conservation plans, where

$$\pi_m = Pr(I = m) = \frac{exp(V_m(X_i; \beta_m))}{\sum_{s=1}^{M} exp(V_s(X_i; \beta_s))},$$

π_m is the probability of adopting the m^{th} conservation plan (which are given in Table 3), V_m is the index function observable component of utility, β_m is a set of parameters, and X_i is a vector of explanatory variables (given in Table 1).

The marginal probability of adopting a given practice is then given by:

$$P_s = \sum_{m \epsilon \{\delta_m: Y_s = 1\}} \pi_m,$$

where Y_s is an indicator variable equal to 1 when practice *s* is included in bundle *m*. From this, one can derive the marginal effect of a change in an explanatory variable on the probability of adopting a single practice, while taking into account the other practices adopted, as:

$$\frac{\partial P_s}{\partial x_k} = \sum_{m \epsilon \{\delta_m: Y_s = 1\}} \frac{\partial \pi_m}{\partial x_k}.$$

From the joint framework, the conditional probability of adopting a practice, given the adoption of other practices can be assessed, as well, via:

$$P_{s|r} = \frac{P_{sr}}{P_r} \text{ where } P_r = \sum_{m \epsilon \{\delta_m: Y_r = 1\}} \pi_m \text{ and } P_{sr} = \sum_{m \epsilon \{\delta_m: Y_s = 1, Y_r = 1\}} \pi_m.$$

The marginal effect of a change in an explanatory variable on the conditional probability of adopting a given conservation practice can be given by:

$$\frac{\partial P_{s|r}}{\partial x_k} = \frac{\frac{\partial P_{sr}}{\partial x_k} * P_r - P_{sr} * \frac{\partial P_r}{\partial x_k}}{P_r^2}.$$

The conditional probabilities and marginal effects may be useful tool to help determine what factors affect farmers' interest in intensifying conservation on-farm and what tools may be useful in promoting such activities.

Table 1. Definition of Explanatory Variables and Summary Statistics

	Variables	Mean	Standard Deviation	Definition
Landscape Attributes	kw_factor	0.30	0.10	Spatially weighted average K-W factor in counties farmers operate
	awc	0.16	0.06	Spatially weighted average of available water content in counties farmers operate
	sd_slope	3.78	1.58	Standard deviation of slope within counties farmers operate
Farm Characteristics	total acres	1150.41	6524.27	Total cropland acres operated in 2010
	rent_acres _Percent	0.41	0.37	Percentage of farm acres rented
	irrigation _percent	0.05	0.21	Percentage of crop land irrigated
	cattle_hogs	0.53	0.50	Cattle and/or hogs raised on farmers' operation in 2010 (1 = yes, 0 = no)
	eqip_csp	0.12	0.32	Farmer participates in EQIP and/or CSP in 2010 (1 = yes, 0 = no)
Farmer Demographics and Characteristics	experience	35.85	15.04	Number of years the operator has been farming
	risk_avoider	0.41	0.49	Farmer is described as a risk avoider (1 = yes, 0 = no)
	off_farm	0.53	0.50	Farmers or immediate families employed off the farm (1 = yes, 0 = no)
	crop _insurance	0.68	0.47	Farmers grow but do not insure the crop (1= yes, 0 = no)
	gender	0.95	0.23	Gender of farm operator (1 = male, 0 = female)
	college	0.34	0.47	Farm operator has earned a college degree (1 = yes, 0 = no)
Region	west	0.23	0.42	Agricultural reporting district 10, 20 or 30 (1 = west, 0 = others)
	east	0.32	0.47	Agricultural reporting district 70, 80 or 90 (1 = east, 0 = others)
Weather	avgPZ	0.52	0.11	Mean Palmer Z Drought over past 10 years
	stdPZ	2.04	0.13	Standard deviation of the Palmer Z Drought over past 10 years

Standard deviations are provided for continuous variables, but not for binary variables, as they are function of the mean. Thus, the standard deviation of all binary variables is calculated as: $\sqrt{p(1-p)}$, where *p* is the mean of the binary variable.

Table 3. Estimated Marginal Effects for the Unconditional and Conditional Adoption No-Till, Cover Crops and Manure

Variables	No-Till	Cover Crops	Manure	No-Till and Cover Crops	No-Till and Manure	Cover Crops Given No-Till Adopted	Manure Given No-Till Adopted
kw_factor	0.7281*	-1.5503*	0.4273*	-0.1405	-0.0441	-0.3501	-0.1787
	(0.4486)	(0.4505)	(0.2987)	(0.1965)	(0.1602)	(0.4271)	(0.2784)
awc	-1.4071*	3.0432*	-0.8998*	0.1846	0.1612	0.5046	0.4794*
	(0.8161)	(0.8198)	(0.5753)	(0.3476)	(0.2930)	(0.7516)	(0.5071)
sd_slope	-0.0045	-0.0058	0.0024	-0.0067*	-0.0025	-0.0126*	-0.0035
	(0.0076)	(0.0077)	(0.0044)	(0.0040)	(0.0031)	(0.0091)	(0.0053)
total acres	-0.0001*	0.0001*	0.0000	0.0000*	0.0000*	0.0000	0.0000*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
rent_acres percent	-0.1023*	0.0997*	-0.0117	-0.0148*	0.0215*	-0.0178	0.0543*
	(0.0326)	(0.0327)	(0.0234)	(0.0162)	(0.0081)	(0.0331)	(0.0159)
irrigation percent	-0.0280	0.1466*	-0.1841*	0.0152	-0.0472*	0.0315	-0.0781*
	(0.0901)	(0.0906)	(0.1229)	(0.0251)	(0.0426)	(0.0648)	(0.0707)
cattle hogs	0.0627*	-0.0338*	-0.0117*	0.0503*	-0.0018	0.0913*	-0.0136*
	(0.0224)	(0.0236)	(0.0126)	(0.0172)	(0.0078)	(0.0401)	(0.0142)
eqip_csp	-0.1153*	0.0591*	0.0407*	-0.0197*	0.0246*	-0.0254	0.0624*
	(0.0382)	(0.0373)	(0.0188)	(0.0211)	(0.0106)	(0.0426)	(0.0192)
experience	0.0016*	-0.0008*	-0.0002	-0.0001	0.0000	-0.0003	-0.0003
	(0.0008)	(0.0008)	(0.0004)	(0.0003)	(0.0003)	(0.0007)	(0.0005)
risk avoider	0.0074	0.0183	-0.0217*	0.0101*	-0.0148*	0.0189*	-0.0275*
	(0.0220)	(0.0218)	(0.0130)	(0.0094)	(0.0085)	(0.0199)	(0.0145)
off_farm	-0.0453*	0.0573*	-0.0065	-0.0036	0.0083*	-0.0021	0.0216*
	(0.0230)	(0.0228)	(0.0136)	(0.0096)	(0.0085)	(0.0194)	(0.0145)
crop insurance	-0.0199*	0.0420*	-0.0168*	-0.0035	-0.0032	-0.0047	-0.0028
	(0.0236)	(0.0236)	(0.0134)	(0.0092)	(0.0083)	(0.0198)	(0.0142)
gender	-0.1078*	0.1730*	-0.0426*	0.0149	-0.0243*	0.0409	-0.0268*
	(0.0518)	(0.0525)	(0.0231)	(0.0293)	(0.0147)	(0.0589)	(0.0260)
college	-0.0480*	0.0735*	-0.0156*	0.0161*	0.0019	0.0366*	0.0106
	(0.0237)	(0.0236)	(0.0148)	(0.0097)	(0.0078)	(0.0226)	(0.0138)
west	-0.0187	0.0033	-0.0213*	0.0024	-0.0097	0.0068	-0.0132
	(0.0325)	(0.0324)	(0.0184)	(0.0235)	(0.0118)	(0.0276)	(0.0204)
east	-0.0642*	0.0822*	-0.0638*	-0.0012	-0.0152*	0.0044	-0.0157*
	(0.0287)	(0.0291)	(0.0222)	(0.0118)	(0.0106)	(0.0270)	(0.0183)
avgPZ	0.2564*	-0.0904	-0.0944*	0.0647*	0.0310	0.0965	0.0114
	(0.1228)	(0.1240)	(0.0785)	(0.0169)	(0.0485)	(0.1353)	(0.0844)
stdPZ	-0.2046*	0.1531*	0.0108	-0.0504*	-0.0462*	-0.0751	-0.0479
	(0.1136)	(0.1144)	(0.0726)	(0.0468)	(0.0445)	(0.0975)	(0.0768)

1. Standard errors are presented in parentheses; 2. (*) indicates statistical significance at 10% level or higher

Table 2. Conservation Plans Adopting Crops Using No-Till, Cover Crops and Manure

Management Plan	In-Field Conservation Practices: No-Till (N)	Cover Crops (C)	Manure (M)	Percent of Respondents Using Plan
N	X		–	52.27
C	–	X	–	1.68
M	–	–	X	1.90
NC	X	X	–	4.19
NM	X	–	X	5.48
CM	–	X	X	*0.09*
NCM	X	X	X	*0.99*
NONE	–	–	–	33.41

The possible conservation bundles are outlined in Table 2. With the limited number of observation for conservation management plan bundles CM and NCM, it is assumed that *P (I = CM)* = 0, and *P (I = NCM)* = 0 (i.e. the probability of adopting these bundles is equal to zero), such that they will have no direct effect on model estimation.

Results and Implications

Most studies focus on adoption of a single practice. They are interesting, but ignore potential complementarities or substitutability (i.e. dependencies) between practices. The joint framework implicitly takes account of this. The unconditional probability of adopting a practice was 59% for no-tillage; 8.1% for cover crops; and 9.2% for use of manure.

- Land characteristics like susceptibility to soil erosion increase adoption of no-tillage and use of manure, but lower the likelihood of adopting cover crops.
- Interestingly, having crop insurance increases the probability of adopting cover crops by 4.2%, but lowers the probability of adoptions of no-tillage and use of manure by 2.0% and 1.7%, respectively.
- Participation in EQIP & CSP programs positively affects the adoption of cover crops and use of manure, but reduces the likelihood of adopting no-tillage. This may be due to current programmatic focus.

The joint adoption framework allows one to examine the simultaneous adoption of bundles of practices, which can help assess factors that affect the intensity of adoption on-farm. But this does not pick up the potential sequential nature of adoption of piece-meal approach.

- Farmers that are risk-avoiders, have a college education, raise livestock and/or live in areas more prone to drought are more likely to adopt no-tillage and cover crops.
- Farmers that have more land, rent more acres, and/or participate in EQIP and CSP programs are more likely to adopt no-tillage and usage of manure.

Conditional probabilities of adopting practices may help find out what it would take to get people to increase the size of bundles of practices or adopt additional practices, based on complementarities with other practices. We examined two specific probabilities: $C|N$ = 6.4% and $M|N$ = 11.1%.

- It is of interest to see what can be pulled out of cross-sectional adoption studies, given time series information on the adoption of conservation practices is not usually readily available.
- Farmers who have already adopted no-tillage are more likely to adopt cover crops if they are risk avoider, have a college education, and/or raise livestock.
- Farmers who have already adopted no-tillage are more likely to adopt usage of manure if they participate in EQIP/CSP; but less likely if they are a risk avoider, use irrigation or reside in Eastern KS.

The different types of marginal effects can provide valuable information for researchers, extension agents and conservation personnel. That is, these marginal effects can help guide outreach efforts identifying factors or barriers to the adoption of conservation practices for intensification of conservation on-farm.

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