COTTON PRODUCTION IN RELATION TO THE PROBABILITY OF PRECISION FARMING TECHNOLOGY ADOPTION IN TENNESSEE COUNTIES

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Abstract

Five logit regression models were used to estimate the probabilities of farmers in Tennessee counties adopting four precision farming technologies and at least one of the four technologies. The probabilities of farmers adopting at least one precision farming technology were greater than 50% in 21 of 22 counties where more than 1,000 acres of cotton were produced in 1999.

Introduction

Farmers who practice precision farming use information about the heterogeneous makeup of their farm fields to make management choices. Precision farming does not use a single technology to generate information for decision making but a whole set of information technologies (Swinton and Lowenber-DeBoer). These technologies include: (*a*) diagnostic and data management technologies which generate and organize data that describe field variability, (*b*) technologies capable of attaching spatial coordinates to the data, and (*c*) variable rate application equipment that allows farmers to apply inputs using the information about field variability (Nowak; Khanna, Epouhe, and Hornbaker). More precise placement of inputs with precision farming may increase farm profits and may reduce adverse environmental consequences of crop production (Kitchen et al.; Koo and Williams; Sawyer; Watkins, Lu, and Huang). However, the key to farmer adoption of site-specific farming is the profitability of the technology (Daberkow; Reetz, and Fixen; Roberts, English, and Mahajanashetti; Sawyer).

A March 1999 survey of Tennessee Agricultural Extension Agents identified 284 producers using some form of precision farming technology in 38 of Tennessee's 95 counties (English, Roberts, and Sleigh). Even though the number of farmers using precision farming technology in Tennessee was small, firms supplying these services expected the demand for precision farming services to grow rapidly over the next five years (Roberts, English, and Sleigh) and cotton farmers are interested in knowing whether these services will be made available to them. The objectives of this research were: 1) to identify factors influencing the geographic location of precision farming technology adoption in Tennessee, 2) to estimate the probabilities of precision farming technology adoption in Tennessee counties, and 3) to correlate those probabilities with where cotton is produced in the state.

Methods

The location of precision farming technology adoption can be analyzed in the same way as other technology investment decisions. A farmer's decision to investment in precision farming technology is related to maximization of expected net farm income over time, which depends on factors influencing costs and revenues in a geographic area. Based on this assumption, five logit models (Pindyck and Rubinfeld) were estimated, each with a binary dependent variable indicating whether a Tennessee county had at least one farmer using a yield monitor with GPS (YMW), a yield monitor without GPS (YMO), grid soil sampling (GSS), variable rate fertilizer and/or lime application (VRT), and any precision farming technology (APF). Data required to form the dependent variables were obtained from the aforementioned survey of Agricultural Extension Agents (English, Roberts, and Sleigh), while data for the explanatory variables were taken from the 1997 Census of Agriculture (U.S. Department of Agriculture).

Six explanatory variables were included in the logit models to capture differences in resource endowments among counties and, hence, the relative potential for farmers to earn higher net farm income from adopting precision farming technology (Table 1). The percentage of county land in farms (LANDP), which attempted to capture the general importance of agriculture within a county, was hypothesized to positively influence the likelihood of adoption. Total cropland (TCL) was hypothesized to be positively related to the odds of precision farming technologies being adopted in a county, while the value of sales of livestock, poultry, and their products (LSAL) was hypothesized to be negatively related to precision farming technology adoption. Cropland as a percentage of total land in farms (PCIF) was hypothesized to be positively related to precision farming technology adoption. The percentage of farmland in farms of 260 acres or more (PALF) was hypothesized to be positively related to adoption because larger farmers are more likely to have the resources to cost effectively use these technologies and are more likely to be in a position to bear the risk. Finally, the value of crop sales per harvested acre (CSPA) was hypothesized to positively influence adoption.

Four tenure variables were hypothesized to influence the location of precision farming technology adoption (Table 1). Adoption of precision farming technologies was considered more likely on owned cropland than on rented cropland (Lee and Stewart). Therefore, the number of farmers harvesting crops who were full owners (FOCF) was hypothesized to positively influence precision farming technology adoption in a county, while the numbers of farmers who were part owners (POCF) and tenants (TCF) were hypothesized to negatively influence adoption. Lastly, the number of owned acres in part-owner farms minus the number of acres rented (LOMR) was hypothesized to be positively related to adoption.

The logit models were used to estimate the probabilities of precision farming technology adoption in 95 Tennessee counties. These probabilities were compared with the location of cotton production in the state.

Results

Logit regression results are presented in Table 2. All regressions had highly significant log likelihood scores and percentages of concordant predictions were all greater than 91%. The logit models had from two to six significant explanatory variables. Only one variable (CSPA) had significant coefficients with signs contrary to expectations. From a theoretical standpoint, the production of higher (lower) valued crops cannot be said to discourage (encourage) the adoption of precision farming technologies (Swinton and Lowenberg-DeBoer), but from a practical standpoint one can conclude that the production of higher (lower) valued crops in Tennessee counties was significantly associated with lower (higher) odds of precision farming technology adoption. Higher valued crops such as tobacco, nursery crops, fruits and vegetables are typically produced on small fields relative to row crops and/or in Tennessee counties where row crops are relatively unimportant. The technologies evaluated were not typically used on the smaller fields, nor in the counties where these higher valued crops are produced.

All technologies evaluated were more likely to be adopted in counties where part-owner farmers owned more land compared to the amount they rented (LOMR) and, except for yield monitors without GPS (YMO), where the percentage of cropland compared to total land in farms was higher (PCIF). In addition to those variables, several other variables significantly affected the adoption of individual technologies. Yield monitors with GPS (YMW) were more likely to be adopted in counties with more cropland,

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more full-owner farmers harvesting crops, and fewer part-owner farmers harvesting crops. Adoption of yield monitors without GPS (YMO) was more likely in counties with more acreage in large farms. Grid soil sampling (GSS) was more likely in counties with lower-valued crop production, more cropland, and fewer part-owner farmers harvesting crops. Variable rate fertilizer and/or lime application (VRT) was more likely to be adopted by farmers in counties with more acreage in large farms and more full-owner farmers harvesting crops. Finally, adoption of at least one precision farming technology (APF) was more likely in counties with more acreage in large farms, lower-valued crop production, more full-owner farmers harvesting crops, and fewer part-owner farmers harvesting crops.

In 1999, cotton production in 22 Tennessee counties was more than 1,000 acres (Tennessee Department of Agriculture). The estimated probability of having at least one farmer using a yield monitor with GPS (YMW) was greater than 50% in 16 of those counties. For yield monitors without GPS (YMO), grid soil sampling (GSS), and variable rate fertilizer and/or lime application (VRT), 18, 20, and 16 of the 22 counties had estimated adoption probabilities greater than 50%, respectively. Finally, for the adoption of any of the four precision farming technologies, 21 of the 22 cotton producing counties had estimated adoption probabilities greater than 50%.

Conclusions

Data from a March 1999 survey of County Agricultural Extension Agents and the 1997 Census of Agriculture were use to develop five logit regression models to estimate the probabilities of Tennessee counties having farmers adopting various precision farming technologies. Probabilities estimated from these models were compared with counties where cotton was produced in 1999. The vast majority of counties where cotton was produced in Tennessee also had high estimated probabilities of precision farming technology adoption (greater than 50%). Results suggest that most cotton farmers in Tennessee reside in counties with high probabilities that precision farming technologies will be adopted and where precision farming services are or will be available to farmers.

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Table 1. Variable Definitions, Hypothesized Signs, and Means

Var.	Definition	Sign	Mean
YMW	1 if at least one farmer in county used yield monitor with GPS; 0 otherwise		0.22
YMO	1 if at least one farmer in county used yield monitor without GPS; 0 otherwise		0.25
GSS	1 if at least one farmer in county used grid soil sampling; 0 otherwise		0.29
VRT	1 if at least one farmer in county used variable rate fertilizer or lime; 0 otherwise		0.19
APF	1 if at least one farmer in county used any precision farming technology; 0 otherwise		0.39
LANP	Land in farms as a percentage of countyland area (%)	●	42.57
TCL	Total cropland (1000 acres)	●	74.42
LSAL	Sales of livestock, poultry, and their products ($1,000,000)	●	10.71
PCIF	Cropland as a percentage of total land in farms (%)	●	60.04
PALF	Land in farms of more than 259 acres as a percentage of total land in farms (%)	●	49.72
CSPA	Value of crop sales per harvested acre ($100)	●	2.52
FOCF	Number of farmers harvesting cropland who are full owners (farmers)	●	382.18
POCF	Number of farmers harvesting cropland who are part owners (farmers)	●	173.46
TCF	Number of farmers harvesting cropland who are tenants (farmers)	●	34.00
LOMR	Acres in part-owner farms that are owned minus acres rented (1000 acres)	●	1.73

Table 2. Logit Regressions for the Location of Precision Farming Technology Adoption in Tennessee.

Explanatory Variable[a]	Dependant Variable[a]		
	YMW	YMO	GSS
Intercept	-16.025[b]	-21.443[b]	-17.738[b]
	(0.00)[c]	(0.00)	(0.00)
LANP	-0.037	-0.015	-0.052
	(0.26)	(0.67)	(0.15)
TCL	0.042[b]	-0.001	0.069[b]
	(0.03)	(0.95)	(0.00)
LSAL	-0.010	0.011	-0.056
	(0.75)	(0.74)	(0.14)
PCIF	0.221[b]	0.072	0.248[b]
	(0.00)	(0.33)	(0.00)
PALF	0.036	0.286[b]	0.058
	(0.46)	(0.00)	(0.30)
CSPA	-0.102	-0.842	-0.419[b]
	(0.61)	(0.15)	(0.09)
FOCF	0.019[b]	0.006	0.009
	(0.02)	(0.43)	(0.22)
POCF	-0.049[b]	0.002	-0.032[b]
	(0.01)	(0.90)	(0.06)
TCF	-0.023	0.017	0.004
	(0.45)	(0.62)	(0.92)
LOMR	0.082[b]	0.127[b]	0.156[b]
	(0.06)	(0.02)	(0.01)
Likelihood Ratio	42.087[b]	52.953[b]	64.021[b]
	(0.00)	(0.00)	(0.00)
Concordant (%)	91.4	92.8	94.8
Discordant (%)	8.6	7.2	5.0
Tied (%)	0.0	0.0	0.2

[a] Variables are defined in Table 1.
[b] Significantly different from zero ($\alpha = 10\%$).
[c] Probability of Chi Square greater than estimated Chi Square.

Table 2. (Continued). Logit Regressions for the Location of Precision Farming Technology Adoption in Tennessee.

Explanatory Variable[a]	Dependant Variable[a]	
	VRT	APF
Intercept	-21.991[b]	-19.207[b]
	(0.00)	(0.00)
LANP	0.046	-0.051
	(0.20)	(0.14)
TCL	0.004	0.020
	(0.85)	(0.39)
LSAL	-0.064	-0.035
	(0.20)	(0.27)
PCIF	0.162[b]	0.187[b]
	(0.03)	(0.01)
PALF	0.185[b]	0.179[b]
	(0.01)	(0.01)
CSPA	-0.454	-0.602[b]
	(0.14)	(0.05)
FOCF	0.013[b]	0.016[b]
	(0.10)	(0.02)
POCF	-0.029	-0.030[b]
	(0.11)	(0.05)
TCF	0.017	0.010
	(0.62)	(0.79)
LOMR	0.137[b]	0.114[b]
	(0.01)	(0.03)
Likelihood Ratio	38.562[b]	64.299[b]
	(0.00)	(0.00)
Concordant (%)	91.2	92.7
Discordant (%)	8.7	7.2
Tied (%)	0.1	0.1

[a] Variables are defined in Table 1.

[b] Significantly different from zero ($\alpha = 10\%$).

[c] Probability of Chi Square greater than estimated Chi Square.