TIMING OF FARMER DECISIONS TO ADOPT FOUR COTTON PRECISION AGRICULTURE TECHNOLOGIES

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Introduction

Precision agriculture (PA) became available in the late 1980s. Since then many researchers have investigated the factors influencing PA technology adoption decisions that occurred before the specific date of a survey using probit or logit methods. Little research has evaluated the factors affecting the timing of the adoption decision once a new PA technology becomes available. The objective of this research was to determine the factors influencing the timing of southern cotton farmers' decisions to adopt yield monitoring (YMR), remote sensing (RMS), grid soil sampling (GSS) and management zone soil sampling (MSS) after they became commercially available using univariate and multivariate Tobit methods.

Methods

Data for this study were obtained from the Cotton Incorporated Southern Precision Farming Survey conducted in 12 southern states in 2009 for the 2008 crop. The numbers of years farmers reported using each PA technology were used as the dependent variables. Farm and farmer characteristics, adoption of other PA technologies, farmer perceptions, information sources used, and state characteristics were the independent variables. The relationship between the year t when farmer i adopted PA technology j and the number of years they used the technology is:

$$t_{ij} = t_s - YR^*_{ij},$$

where YR^*_{ij} is a latent variable (unobserved) for the number of years farmer i used PA technology j in the year t_s when the survey was conducted. YR_{ij} was the dependent variable for the four Tobit models (j = YMR, RMS, GSS, and MSS) (Maddala 1983):

$$YR_{ij} = YR^*_{ij} \text{ if } YR^*_{ij} > 0 \text{ and } YR_{ij} = 0 \text{ if } YR^*_{ij} \leq 0,$$
$$YR^*_{ij} = \beta x_{ij} + \varepsilon_{ij},$$

where β is a vector of unknown parameters, x_{ij} represents the factors affecting YR^*_{ij}, and ε_{ij} is an error vector. If $YR_{ij} > 0$, the farmer adopted technology j in year t; if $YR_{ij} = 0$, the farmer did not adopt technology j.

Results

Results indicated that the residuals of the four univariate Tobit regressions are correlated, suggesting correlation across error terms. Thus, the information presented below was developed from multivariate Tobit estimation of the four equations using methods that account for error correlation.

Younger cotton farmers who had larger farms, higher lint yields, household income greater than or equal to $100,000, adopted GSS or other PA technologies before or at the same time as YMR, thought PA would be profitable and important in the future, thought PA would improve environmental quality, and had farms in Louisiana adopted YMR earlier than other farmers, while farmers who used the Internet for PA information adopted YMR later than others.

Younger cotton farmers who adopted GSS, MSS, or other PA technologies before or at the same time as RMS, thought PA would improve environmental quality, used news/media for PA information, and had farms in Arkansas or Missouri adopted RMS earlier than other farmers. Farmers who used crop consultants adopted RMS later than other farmers.

Younger cotton farmers who used computers for farm management, adopted MSS or other PA technologies before or at the same time as GSS, thought PA would improve environmental quality, used crop consultants for PA information and had farms in all states except Virginia, adopted GSS earlier than other farmers. Farmers who rented a larger portion of the land they farmed, used a laptop in the field, adopted YMR before or at the same time as GSS, used the Internet or news/media for PA information adopted GSS later than other farmers.

Younger cotton farmers who adopted other PA technologies before or at the same time as MSS, used news/media for PA information and had farms in Missouri adopted MSS earlier than other farmers. Farmers who rented more of the land they farmed, used a computer for farm management, used a laptop in the field, adopted YMR before or at the same time as MSS, thought PA would be profitable, obtained PA information from other farmers or the Internet for PA information, and had farms in GA adopted MSS later than other farmers.

Conclusions

Different factors influence cotton farmers' timing of YMR, RMS, GSS and MSS adoption in the technology diffusion process. Results can be used to develop education programs targeting technology-specific information to meet the needs of specific groups of farmers. Agribusiness firms can use the results to aim promotional efforts toward farmers who are likely to benefits the most from early adoption of similar new technologies.

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Table 1. Summary of significant variables for yield monitoring, passive remote sensing, grid soil sampling and management zone soil sampling.

Significant Variables	Definition
FARMSIZE[1]	Acres of cotton farmed in 2007 or 2008 (year of largest acreage)
YIELD[1]	Lint yield (lbs/acre) in 2007 or 2008 (year of largest acreage)
TENURE[3,4]	Ratio of rented to total land farmed in 2007 or 2008 (year of largest acreage)
AGE[1,2,3,4]	Age when farmer *i* adopted technology *j* (age in 2009 – *YRij*; j = YMR, RMS, GSS, MSS)
COMPUTER[3,4]	Farmer used computer for farm management (yes=1; else=0)
LAPTOP[3,4]	Farmer used laptop and/or handheld PDA in the field (yes=1; else=0)
MEDINCOME[1]	Taxable household income between $100,000 and $199,999 in 2007 (yes=1; else=0)
HIGHINCOME[1]	Taxable household income of $200,000 or greater in 2007 (yes=1; else=0)
$YR_{GSS} \geq YR_{YMR}$[1]	Number of years farmer used GSS was greater than or equal to number of years farmer used YMR (yes=1; else=0)
$YR_{OTHERS} \geq YR_{YMR}$[1]	Number of years farmer used other PA technologies was greater than or equal to number of years farmer used YMR (yes=1; else=0)
$YR_{GSS} \geq YR_{RMS}$[2]	Number of years farmer used GSS was greater than or equal to number of years farmer used RMS (yes=1; else=0)
$YR_{MSS} \geq YR_{RMS}$[2]	Number of years farmer used MSS was greater than or equal to number of years farmer used RMS (yes=1; else=0)
$YR_{OTHERS} \geq YR_{RMS}$[2]	Number of years farmer used other PA technologies was greater than or equal to number of years farmer used RMS (yes=1; else=0)
$YR_{MSS} \geq YR_{GSS}$[3]	Number of years farmer used MSS was greater than or equal to number of years farmer used GSS (yes=1; else=0)
$YR_{OTHERS} \geq YR_{GSS}$[3]	Number of years farmer used other PA technologies was greater than or equal to number of years farmer used GSS (yes=1; else=0)
$YR_{YMR} \geq YR_{MSS}$[4]	Number of years farmer used YMR was greater than or equal to number of years farmer used MSS (yes=1; else=0)
$YR_{OTHERS} \geq YR_{MSS}$[4]	Number of years farmer used other PA technologies was greater than or equal to number of years farmer used MSS (yes=1; else=0)
ENVIQUALITY[1,2,3]	Farmer thought PA would improve environmental quality (yes=1; else=0)
CONSULTANT[2,3]	Farmer used crop consultants for PA information (yes=1; else=0)
FARMER[4]	Farmer used other farmers for PA information (yes=1; else=0)
INTERNET[1,3,4]	Farmer used the Internet for PA information (yes=1; else=0)
NEWS[2,3,4]	Farmer used news/media for PA information (yes=1; else=0)
ALFL[3]	Farm located in Alabama or Florida (yes=1; else=0)
AR[2,3]	Farm located in Arkansas (yes=1; else=0)
GA[3,4]	Farm located in Georgia (yes=1; else=0)
LA[1,3]	Farm located in Louisiana (yes=1; else=0)
MO[2,3,4]	Farm located in Missouri (yes=1; else=0)
MS[3]	Farm located in Mississippi (yes=1; else=0)

Table 1. Continued.

Significant Variables	Definition
NC[3]	Farm located in North Carolina (yes=1; else=0)
SC[3]	Farm located in South Carolina (yes=1; else=0)
TN[3]	Farm located in Tennessee (yes=1; else=0)

1 = significant at 10% levels in YMR Tobit model.

2 = significant at 10% levels in RMS Tobit model.

3 = significant at 10% levels in GSS Tobit model.

4 = significant at 10% levels in MSS Tobit model.

Taxable household income less than $100,000 was the reference category.

Texas is the reference location.

Table 2. The correlation among the error terms of YMR, RMS, GSS, and MSS

Correlation between the error terms of:	Coefficient
YMR and RMS (rho12)	0.014
YMR and GSS (rho13)	0.465
YMR and MSS (rho14)	0.460
RMS and GSS (rho23)	−0.022
RMS and MSS (rho24)	0.141
GSS and MSS (rho34)	0.636

Likelihood ratio test of rho12 = rho13 = rho14 = rho23 = rho24 = rho34 = 0, Chi2(6) = 143.962 and Prob > chi2 = 0.0000.