ADOPTION AND NON-ADOPTION OF PRECISION FARMING TECHNOLOGIES BY COTTON FARMERS

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ABSTRACT

We used the 2009 Southern Cotton Precision Farming Survey data collected from farmers in twelve U.S. states (Alabama, Arkansas, Florida, Georgia, Louisiana, Missouri, Mississippi, North Carolina, South Carolina, Tennessee, Texas, and Virginia) to identify reasons on why some adopt and others do not adopt precision farming techniques. Those farmers who provided the cost as the reason for non-adoption are farmers characterized by lower education level and small farm size. Among farmers who provided profit as a reason for adopting precision farming, variables such as irrigation, education, computer, and university publication were significant.

Keywords: Precision agriculture, Cotton, logit, multinomial logit

INTRODUCTION

Precision farming (PF) is generally defined as a method capable of helping farmers to apply the right amounts of inputs, on right place, and at right time. Since its inception in mid 1980s, precision farming related technologies have been a common and growing occurrence in cereal and legume productions. However, in cotton production, as our 2009 survey of farmers in twelve cotton growing states revealed, the adoption rate was only around 34%. This finding is surprising because precision farming technologies are generally touted to have both increased profit and environmental quality benefits.

Precision farming technologies are used to obtain information about yield and soil characteristics at different points in a field. PF can potentially help farmers to establish a profitable crop management system and reduce environmental hazards by applying optimal inputs at different parts of the field (Bongiovanni and Lowenberg-DeBoer, 2004; Roberts, et al., 2004; Torbett, et al., 2007; Watson, et al., 2005). It can also help to decrease production cost and maximize profit (Swinton and Lowenberg-DeBoer, 1998). If farmers believe a new alternative technology can provide better returns than the ones they are adopting at the present they will adopt the technology. Use of site-specific technologies is profitable in many crops (Griffin, et al., 2004; Swinton and Lowenberg-DeBoer, 1998).

Precision farming is considered as an important technology since it can reduce environmental burdens (Auernhammer, 2001). Farmers who are environmentally conscious focus on the adoption of technologies that help to mitigate environmental hazards. For example, farmers who believe water quality is important are likely to adopt precision agriculture that helps to reduce water pollution. A desire to be at the forefront of agriculture technology could be a reason for practicing precision agriculture. Innovative farmers are likely to adopt PF at the beginning to take advantage of new technology (Lowenberg-DeBoer, 1996). Many studies have analyzed factors affecting the adoption of PF (Daberkow and McBride, 2003; Larkin, 2005; Roberts, et al., 2004).

Economic theory says that as long as an individual believes that benefits from adopting a technology exceed costs, the technology gets adopted. General understanding of perception of farmers reveal that farmers adopt a technology if it is in their best interest to adopt the technology. Farmers also have tendency to reject a technology at the time when the technology is first introduced, consistent with the typical technology adoption curve (only 2.5% farmers are innovative farmers). Yapa and Mayfield (1978) state that lack of sufficient information, lack of favorable attitude, lack of economic means to acquire technology and lack of physical availability of technology are the major cause behind non-adoption. Nowak (1992) provides the reasons for being unable or unwilling to adopt a conservation technology. He indicates that farmers unable to adopt conservation technology because of lack of information, complexity of the system, high labor requirements, planning horizon for the technology to be profitable seem too far in the future, availability and inadequate managerial skill, lack of accessibility of supporting resources. For the reasons behind unwilling to adopt, we can classified these reasons as cost, satisfaction with the existing technology, time, and other reasons. Behavioral characteristics of non-adopters could be very different than the characteristics of adopters. Knowing the answer to the question on why farmers adopt or do not adopt precision farming technologies can be helpful to formulate effective policies so that adoption rate can be increased. Results should be helpful for agricultural support personnel and policy makers to target cotton farmers to improve efficiency, increase profit and reduce negative environmental impacts.

METHODOLOGY

A cotton producer's decision to adopt PF can be expressed in the framework of a discrete choice model. We are interested to analyze factors that affect adoption or non-adoption of PF component technologies. Since reasons for adoption or non-adoption have more than two categories, an appropriate model to analyze such type of data is multinomial logit model. Suppose a cotton producer's utility function for a given technology is given as

$$U = U\,(attitude,\ profit,\ willingness, z)$$

Here 'attitude' indicates cotton farmers' attitude toward precision farming technology, profit indicates perceived profit from adopting precision farming technology, `willingnes' indicates cotton farmer's willingness to adopt a technology and Z indicates vector of socio-demographic variables. Positive attitude about precision farming leadsType equation here. to its adoption which is a condition $U^{k+a} > U^{a}$. Here, U^{a} indicates utility associated with initial attitude about the technology. As a technology is favored U^{k+a} becomes greater than the utility obtained from the initial level of attitude toward a technology, with $k + a > a$. Similarly, from profit perspective, technology is adopted if $Profit|t = 1 > Profit|t = 0$. Here $t = 1$ means cotton farmers adopt a technology and $t = 0$ means farmers do not adopt a technology. Suppose we compare their behavior with the behavior of farmers in a base category. Similarly, cost and time constraints would reduce favorability of a new technology. Using a multinomial logit model, probability of choosing j (for adoption or non-adoption) by farmer i can be presented as:

$$Prob(Y_i = j) = \frac{e^{\beta_j x_j}}{\sum_{j=1}^{k} e^{\beta_j x_j}}$$

Where $k = 3$ for adoption reasons, $k = 4$ for non-adoption reasons, and $k = 7$ for all reasons. x is the vector of characteristics that explain decision regarding the adoption of PF. Generally, the decision to adopt PF typically depends on the cotton producer's education, farming experience, farm size, cost associated with precision farming and other characteristics that are relevant to PF. β are the parameters associated with these characteristics. Choices examined for non-adoption are 1. I do not adopt the technology for cost reason, 2. I do not adopt the technology because I am satisfied with the existing technology, 3. I do not adopt the technology because I do not have time to adopt the technology, 4. I do not adopt the technology for other reasons. Similarly, choices examined for adoption are 1. I adopt technology for profit, 2. I adopt PF for environmental benefit, 3. I adopt PF to be at forefront of technology. If we are only interested on choice of adopting or non-adoption decision, the response variable in this analysis is binary, indicating whether the individual (1) decides to adopt PF or (2) not to adopt PF. In this case, Y takes the value 1 if the cotton producer decides to adopt a PF, 0 otherwise. An appropriate model for this type of analysis is a probit/logit model.

DATA

We used recently collected data to identify the variables behind adoption and non-adoption of precision farming technologies in cotton production. The data were obtained from the 2009 Southern Cotton Precision Farming Survey conducted in twelve U.S. states (Alabama, Arkansas, Florida, Georgia, Louisiana, Missouri, Mississippi, North Carolina, South Carolina, Tennessee, Texas, and Virginia). Survey method suggested by Dillman (2000) was used to collect information about precision farming technologies adoption. Details about this survey are available in Mooney et al. (2010) .

Farmers have provided three reasons (profit, environmental benefit and the desire to be in the forefront of technology) for adopting and four reasons for nonadopting precision (i. Cost, ii. No time to adopt, iii. Satisfied with the current practice, and iv. Other) precision farming technologies. We found that 34% of farmers (478 farmers) have adopted and 66% farmers (924 farmers) have not adopted cotton precision farming technologies. Among adopter, 70% provided profit, 23% provided environmental benefit and 16% provided to be at the forefront of technology as reasons for adopting precision farming. Among the reasons provided for non-adoption, cost was given as a reason by 46% of nonadopters, no time to adopt as a reason by 3% of nonadopters, satisfied with the current practice as a reason by 41% nonadopters, and other unspecified reasons by 10% nonadopters.

The variables to explain the adoption/non-adoption pattern are based on human capital theory, farm and production characteristics, and other variables used in adoption literature. Education and farming experience are measures of human capital that reflect the ability to innovate ideas. We expect that human capital has positive influence in the decision to adopt a new technology. Previous studies (Paxton, et al., 2010; Roberts, et al., 2004; Velandia, et al., 2010; Walton, et al., 2010) have shown that age, income, farming experience are widely accepted human capital variable that affect adoption decisions. Most of these studies have shown that age has negative influence on technology adoption (Soule, et al., 2000). Farm characteristics are important variable for understanding a farmer's decision to adopt (Pandit, et al., 2011; Paudel, et al., 2011). We also use financial and location variables as reasons for precision agriculture technology adoption. University publications are helpful to cotton producer to obtain precision farming information. Extension services convey information about university research and publication that help farmers to make informed decision which can influence profitability (Hall, et al., 2003). Farmers with larger farms and higher than average county yield were more likely to adopt precision

Table 1. Definition of variables and summary statistics

Variables	Definition	Number	Mean	Std. Dev.
Adoption and non-adoption	All adoption and non-adoption categories	1167	3.904884	1.77423
Non-adoption reasons	Four non-adoption reasons categories*	912	3.142544	1.120348
Adoption reasons	Three adoption reasons categories**	259	1.57529	0.780781
Adoption dummy	=1 if PF is adopted, 0 otherwise	1167	.2219366	.4157269
Age	Age of farm operator (years)	1581	53.88299	12.66949
Farm Income	Percentage of farm income in total household income	1541	72.74822	29.01344
Livestock	=1 if farmers own livestock	1654	.3331318	.4714758
Education	Formal education of farm operators (years)	1516	14.18931	2.526515
Experience	Farming experience (years)	1566	31.5728	13.49541
Farm size	Farm size (000 acreas)	1653	1.064206	1.37814
Computer	=1 if farmers use computer for farm management	1586	0.539092	0.498627
Future Adoption	Plan to adopt precision farming in future (years)	1607	3.742999	1.555302
University Publication	Future plan of farming (years)	1558	0.348524	0.476656
Agricultural Easement	=1 if the farm currently have agricultural easement	978	0.133947	0.340769
Spatial yield Variability	Spatial yield variability	1152	37.32432	23.47281
Number of PF meeting	Number of attendance in precision farming meeting	1491	2.817572	6.011196
Delta	=1 if farm is located in Delta region (Louisiana, Arkansas, Mississippi), 0 otherwise	1664	0.154447	0.361486
Corn Belt	=1 if farm is located in Corn belt region (Missouri), 0 Otherwise	1664	0.020433	0.141518

Appalachia	= 1 if farm is located in Appalachia region (Tennessee, North Carolina, Virginia), 0 otherwise	1664	0.176082	0.381004
South East	=1 if farm is located in Southeast region (South Carolina, Alabama, Georgia, Florida), 0 otherwise	1664	0.203125	0.402446
South Plain	=1 if farm is located in Southeast reagion (Texas), 0 otherwise	1664	0.445914	0.497216

*Non-adoption reasons: Cost, No Time to Adopt (Time), Satisfied with current practice (Satisfied), and Other
** Adoption reasons: Profit, Environmental benefit (Environment), To be at forefront of technology (forefront)

technology (Banerjee, et al., 2008). Computer is essential to keep financial record and to find information about use of precision agriculture. It has been found that farmers who kept computerized financial records were more likely to be successful as measured in terms of an operator's labor and management income. (Mishra et al., 1999).

An agricultural easement is a legal agreement limiting the use of land to predominantly agricultural use, so landowners who sign for agricultural easement agree to use the land only for agricultural purposes and permanently releases the right to develop the land for non-agricultural activities (Brinkman, 2011). Hence, the main purpose of agricultural easement is to maintain agricultural areas by preserving good agricultural soils under intermediate development pressure. We expect that agricultural easement to have negative effects on technology adoption because landowner receives payment for the development value of the land, and they care more about environment than profit. Farmers owning irrigated land may benefit having precision farming technology. Knowledge of soil moisture variability in the field is helpful in reducing irrigation cost. McBratney et al. (2005) suggest beneficial role of precision farming in managing irrigation water. Paxton et al. (2010) studied the role of spatial yield variability on the number of precision farming technology adopted. They found that more within-field yield variability causes farmers to adopt precision farming technology.

Although these studies provide some reasons for the adoption and non-adoption of precision farming technologies, there could be other possible variables affecting farmers' decision making process. Many farmers are uncertain to use available technology due to environmental regulations, public concern, and economic gains from reduced inputs and improved managements, and hence these factors determine success of precision farming (Zhang, et al., 2002). Table 1 provides definitions and summary statistics for the variables used in empirical model.

RESULTS AND CONCLUSIONS

We used a logit model to identify variables that determine whether a farmer adopts or does not adopt PF in cotton production. After identifying variables impacting yes/no decision to adopt PF, we run a multinomial logit model to identify the factors that influence the choice of a particular reason for adoption/non-adoption of PF. We assumed that the response depends upon characteristics of individual cotton producer. Before running the multinomial logit model, we tested for the IIA assumption using the Hausman test (See Table 2). It was found that the IIA assumption holds for our data. Additionally, our analysis also indicated that multicollinearity is not a problem among the explanatory variables included in the model. We also did not find any explanatory variables to be endogenous as indicated by the Durbin-Wu-Hausman test statistics. We used non-adoption as the base category in choice of adoption regression model. In the multinomial logit model, we used profit as a base category since one of the important aspects of adopting PF is profitability.

Table 2. Housman tests of IIA assumption

Omitted	χ^2	d.f.	P-value	Evidence for
Combined (Non-adoption + Adoption)				
Cost	0	3	1	H0
Time	0	3	1	H0
Satisfied	0	6	1	H0
Other	0	6	1	H0
Environment	0	6	1	H0
Forefront	0	7	1	H0
Non-adoption				
Time	0	2	1	H0
Satisfied	0	5	1	H0
Other	0	5	1	H0
Adoption				
Environment	0.224	2	0.894	H0
Forefront	0	1	1	H0

Table 3. Parameters estimates of logit model (adoption vs. non-adoption)

Variables	Coeff	P-Value	Marg. Eff.	P-Value
Age	-0.051	0.055	-0.007	0.052
Farm Income	0.005	0.336	0.001	0.337
Livestock	0.749	0.008	0.104	0.008

Education	0.187	0.014	0.026	0.010
Experience	0.034	0.180	0.005	0.179
Farm size	0.444	0.009	0.061	0.004
Computer	1.288	0.000	0.183	0.000
Future adoption	0.064	0.503	0.009	0.503
University publication	0.865	0.001	0.127	0.001
Agricultural easement	0.577	0.168	0.082	0.174
Spatial yield variability	0.005	0.417	0.001	0.415
Number of PF meeting	0.036	0.020	0.005	0.020
Delta	2.388	0.000	0.361	0.000
Corn Belt	0.167	0.845	0.023	0.847
Appalachia	1.893	0.000	0.275	0.000
Southeast	1.213	0.002	0.171	0.001

In the multinomial logit non-adoption model, cost is chosen as a base category as many cotton producers do not adopt PF because of cost reason. Logit regression coefficients and marginal effects are presented in Table 2. Our results show that age has negative and significant effect on adoption of PF. This means that older cotton producers are less likely to adopt precision farming than younger. We found that a unit increase in variables livestock, education, farm size, computer, university publication, number of PF meeting increases the probability of adopting precision farming. Cotton producers who live in Delta, Appalachia and Southeast have higher probability of choosing PF than farmers located in the Corn Belt.

Multinomial logit coefficients are presented in Table 4 and Table 6. These coefficients are interpreted based on their comparison to the base category. A positive coefficient means that as the explanatory variable increases, a farmer is more likely to choose alternative *j* than the base category which is profit in our case. Marginal effects are generally chosen to interpret than the regression coefficients of the model. These marginal effects do not give the same sign as the regression coefficients. We obtain the average marginal effect on a choice of a change in explanatory variables. Marginal effects are presented in Table 5 and Table 7. Only significant coefficients are interpreted here.

A unit increase in variables livestock, education, farm and region being Delta, Appalachia, and Southeast decreases the probability of choosing cost as the reason for non-adoption than other choice categories. Region being Corn Belt increases the probability of choosing cost as the reason for non-adoption. A unit change in agricultural easement, region being Delta, Corn Belt, and Southeast decreases the probability of choosing no time to adopt as the reason for non-adoption than other choice categories, whereas education has opposite effect.

A unit increase in variables computer, region being Delta, Corn Belt decreases the probability of choosing satisfied with current practice as the reason for non-adoption than other categories. Marginal effect in variable future adoption is positive and significant which implies that a year increase in future plan to adopt PF increases the probability of cotton producer nonadopting PF for other reasons. Table 7 also implies that university publication has similar effects. In contrast, we found that farm income and cotton producers who are located in Corn Belt have opposite effects.

Our results suggest that a unit increase in variables education, farm size, computer, university publication and region being Delta and Appalachia increases the probability of choosing profit as the reason for adopting precision farming than other categories. On the other hand, cotton producer who participate in agricultural easement has less probability than who do not participate in the program as reason for adopting PF than other reasons. We found that a unit increase in farm size increases the probability of choosing environmental benefit as a reason for adopting precision farming. Positive and significant marginal effect of computer and agricultural easement implies that cotton producer who use computer for their farm management or participate in agricultural easement program has higher probability for adopting precision farming for environmental benefit as a reason for adopting PF. Cotton producers who are located at Corn

Table 4. Parameter estimates (combined adoption and non-adoption reasoning)

Variables	Non-adoption								Adoption			
	Cost		Time		Satisfied		Other		Environment		Forefront	
	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value
Age	0.032	0.303	0.002	0.980	0.042	0.198	0.066	0.095	0.000	0.993	-0.118	0.081
Farm Income	-0.004	0.480	-0.004	0.844	0.002	0.727	-0.013	0.122	0.005	0.594	0.007	0.533
Livestock	-0.714	0.054	-0.452	0.667	-0.484	0.197	-0.526	0.335	0.297	0.552	0.714	0.196
Education	-0.236	0.009	0.307	0.194	-0.193	0.039	-0.109	0.420	-0.018	0.884	-0.037	0.802
Experience	-0.024	0.409	-0.054	0.423	-0.007	0.826	-0.044	0.242	0.031	0.543	0.077	0.251
Farm size	-0.585	0.000	-1.225	0.128	-0.285	0.042	-0.387	0.133	0.029	0.792	0.047	0.731
Computer	-1.016	0.011	-1.154	0.293	-1.504	0.000	-1.169	0.035	0.470	0.492	-0.484	0.493
Future adoption	-0.025	0.821	-0.172	0.599	-0.079	0.494	0.275	0.128	0.207	0.250	0.017	0.933
University publication	-0.992	0.003	0.514	0.631	-0.974	0.006	-0.178	0.737	-0.224	0.630	0.336	0.548
Agricultural easement	0.197	0.728	-13.573	0.988	0.583	0.310	-0.116	0.897	1.915	0.002	1.667	0.011
Spatial yield variability	-0.003	0.640	0.004	0.843	-0.010	0.198	-0.010	0.366	-0.009	0.412	0.004	0.639
Number of PF meeting	-	0.159	-0.042	0.703	-0.035	0.204	-0.077	0.224	0.007	0.795	-	0.835

	0.031										0.008	
Delta	-2.517	0.000	-16.235	0.985	-2.169	0.000	-1.830	0.010	0.300	0.662	-0.195	0.822
Corn Belt	0.755	0.535	-15.393	0.997	-14.403	0.991	-14.830	0.996	-14.450	0.995	1.619	0.311
Appalachia	-1.754	0.000	-2.540	0.072	-1.444	0.004	-1.931	0.016	0.279	0.695	0.869	0.259
Southeast	-1.377	0.004	-15.667	0.981	-0.905	0.063	-0.591	0.359	0.324	0.651	-0.082	0.920
Constant	6.972	0.000	-1.591	0.774	4.682	0.019	1.295	0.643	-3.624	0.205	1.337	0.676

Note: Profit as the reason for adoption is used as the base.

Table 5. Marginal effects (combined adoption and non-adoption reasoning).

Variables	Non-adoption								Adoption					
	Cost		Time		Satisfied		Other		Profit		Environment		Forefront	
	Marg. Eff.	P-Value	Marg. Eff.	P-Value	Marg. Eff.	P-Value	Marg. Eff.	P-Value	Marg. Eff.	P-Value	Marg. Eff.	P-Value	Marg. Eff.	P-Value
Age	0.002	0.634	0.000	0.759	0.004	0.283	0.002	0.156	-0.002	0.663	0.000	0.950	-0.006	0.040
Farm Income	-0.001	0.249	0.000	0.912	0.001	0.210	-0.001	0.079	0.000	0.966	0.000	0.541	0.000	0.488
Livestock	-0.085	0.055	-0.001	0.965	-0.014	0.742	-0.008	0.752	0.031	0.458	0.029	0.321	0.047	0.097
Education	-0.024	0.031	0.006	0.070	-0.008	0.445	0.002	0.724	0.018	0.066	0.005	0.479	0.002	0.678
Experience	-0.004	0.240	-0.001	0.486	0.001	0.719	-0.002	0.223	0.000	0.979	0.002	0.522	0.004	0.212
Farm size	-0.069	0.010	-0.011	0.277	0.018	0.413	-0.003	0.820	0.039	0.001	0.014	0.032	0.012	0.047
Computer	-0.010	0.841	-0.003	0.824	-0.148	0.002	-0.017	0.549	0.111	0.005	0.061	0.014	0.005	0.860
Future adoption	-0.005	0.726	-0.002	0.590	-0.018	0.169	0.016	0.066	-0.004	0.756	0.013	0.206	0.000	0.964
University publication	-0.099	0.038	0.017	0.331	-0.074	0.106	0.031	0.321	0.080	0.035	0.010	0.687	0.035	0.112
Agricultural easement	-0.073	0.239	-0.016	0.008	0.030	0.772	-0.028	0.321	-0.105	0.021	0.126	0.015	0.066	0.093
Spatial yield variability	0.001	0.482	0.000	0.645	-0.001	0.225	0.000	0.573	0.001	0.334	0.000	0.553	0.000	0.314
Number of PF meeting	-0.001	0.892	0.000	0.889	-0.002	0.730	-0.003	0.392	0.003	0.132	0.002	0.315	0.000	0.824
Delta	-0.207	0.578	-0.021	0.020	-0.114	0.019	-0.016	0.617	0.224	0.002	0.102	0.092	0.031	0.528
Corn Belt	0.309	0.022	-0.015	0.009	-0.273	0.000	-0.063	0.000	-0.021	0.995	-0.072	0.000	0.135	0.660
Appalachia	-0.153	0.001	-0.015	0.195	-0.063	0.201	-0.039	0.104	0.119	0.070	0.062	0.250	0.089	0.082
Southeast	-0.141	0.004	-0.024	0.026	-0.015	0.776	0.013	0.670	0.094	0.930	0.056	0.269	0.016	0.667

Table 6. Parameter estimates (separate analysis of adoption reasonings and non-adoption reasoning).

Variables	Non-adoption						Adoption			
	Time		Satisfied		Other		Environment		Forefront	
	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value
Age	-0.093	0.080	0.007	0.742	0.041	0.194	0.005	0.950	-0.137	0.025
Farm Income	-0.002	0.927	0.007	0.132	-0.008	0.299	0.004	0.654	0.010	0.494
Livestock	0.269	0.784	0.190	0.507	0.124	0.803	0.321	0.544	0.752	0.210
Education	1.082	0.006	0.043	0.575	0.143	0.218	-0.010	0.933	-0.018	0.871
Experience	-0.006	0.925	0.020	0.307	-0.021	0.459	0.022	0.754	0.081	0.148
Farm size	-1.409	0.075	0.168	0.245	0.108	0.650	0.040	0.747	0.089	0.441
Computer	-1.315	0.442	-0.440	0.131	-0.074	0.870	0.370	0.576	-0.492	0.508
Future adoption	-0.096	0.705	-0.036	0.683	0.354	0.029	0.216	0.218	-0.092	0.644
University publication	1.438	0.302	0.042	0.901	1.102	0.041	-0.343	0.467	0.568	0.314
Agricultural easement	-16.383	0.000	0.323	0.480	-0.516	0.489	1.969	0.002	1.753	0.014
Spatial yield variability	0.015	0.196	-0.007	0.176	-0.007	0.512	-0.005	0.618	0.005	0.491
Number of PF meeting	0.178	0.117	-0.002	0.958	-0.079	0.132	0.004	0.841	-0.010	0.758
Delta	-15.728	0.000	0.309	0.499	0.851	0.169	0.592	0.403	0.289	0.728
Corn Belt	-19.207	0.000	-16.960	0.000	-17.067	0.000	-14.252	0.000	1.373	0.491
Appalachia	0.213	0.868	0.249	0.519	-0.001	0.998	0.450	0.518	1.406	0.070
Southeast	-19.480	0.000	0.545	0.128	1.011	0.075	0.324	0.639	0.184	0.833
Constant	-	0.029	-2.229	0.136	-6.638	0.002	-3.803	0.200	1.445	0.623

14.535

Note: Profit as the reason for adoption is used as the base for adoption and cost as the reason for non-adoption is used as the base for non-adoption.

Table 7. Marginal effects (separate adoption/non adoption decision analysis).

Variables	Non-Adoption								Adoption					
	Cost		Time		Satisfied		Other		Profit		Environment		Forefront	
	Marg. Eff.	P-Value	Marg. Eff.	P-Value	Marg. Eff.	P-Value	Marg. Eff.	P-Value	Marg. Eff.	P-Value	Marg. Eff.	P-Value	Marg. Eff.	P-Value
Age	-0.002	0.632	-0.002	0.043	0.001	0.880	0.003	0.183	0.011	0.300	0.006	0.616	-0.016	0.032
Farm Income	-0.001	0.333	0.000	0.854	0.002	0.061	-0.001	0.125	-0.001	0.452	0.000	0.821	0.001	0.539
Livestock	-0.042	0.497	0.003	0.843	0.037	0.552	0.003	0.943	-0.103	0.271	0.022	0.782	0.081	0.285
Education	-0.023	0.137	0.016	0.033	-0.001	0.964	0.008	0.351	0.003	0.886	-0.001	0.960	-0.002	0.887
Experience	-0.003	0.513	0.000	0.866	0.005	0.207	-0.002	0.262	-0.009	0.354	0.001	0.959	0.009	0.198
Farm size	-0.023	0.483	-0.023	0.062	0.040	0.167	0.005	0.771	-0.012	0.547	0.003	0.866	0.009	0.479
Computer	0.095	0.133	-0.019	0.478	-0.088	0.153	0.011	0.731	0.006	0.960	0.070	0.386	-0.075	0.443
Future adoption	-0.007	0.694	-0.002	0.605	-0.019	0.295	0.028	0.026	-0.018	0.520	0.037	0.173	-0.018	0.418
University publication	-0.074	0.287	0.022	0.367	-0.042	0.556	0.094	0.099	-0.001	0.991	-0.073	0.327	0.074	0.198
Agricultural easement	-0.031	0.760	-0.025	0.001	0.096	0.337	-0.041	0.283	-0.417	0.000	0.281	0.013	0.136	0.153
Spatial yield variability	0.001	0.197	0.000	0.257	-0.001	0.217	0.000	0.686	0.000	0.875	-0.001	0.535	0.001	0.371
Number of PF meeting	0.002	0.785	0.003	0.110	0.001	0.866	-0.006	0.126	0.000	0.926	0.001	0.754	-0.001	0.731
Delta	-0.083	0.379	-0.024	0.001	0.039	0.677	0.068	0.266	-0.094	0.411	0.083	0.468	0.011	0.910
Corn Belt	0.521	0.000	-0.023	0.004	-0.405	0.000	-0.093	0.000	-0.055	0.883	-0.221	0.000	0.275	0.459
Appalachia	-0.047	0.569	0.002	0.921	0.054	0.515	-0.009	0.862	-0.182	0.124	0.012	0.913	0.171	0.123
Southeast	-0.116	0.112	-0.049	0.002	0.092	0.228	0.073	0.187	-0.055	0.667	0.045	0.680	0.010	0.922

Belt have less probability of adopting precision farming for environmental benefit. In contrast, region being delta has an opposite effect.

We found that a unit increase in age implies that the probability of adopting precision farming to be at the forefront of technology decreases as a reason of practicing PF, but a unit increase in farm size, livestock, agricultural easement and region being Appalachia increases the probability of adopting PF to be at forefront of technology.

If a policy is needed to be formulated so that cotton farmers adopt precision farming technologies, then perhaps we should target those farmers who have large farm size, those who are participating in agricultural easement program and those who use university publication in farm-decision-making process. Of course, these are preliminary results which need to be carefully evaluated before developing a definitive policy to increase adoption rate of precision farming technologies in cotton production.

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