The Effects of Government Farm Support Programs on the Adoption of Farm Technology

Haden Comstock and Nathan DeLay

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Purdue University
Center for Commercial Agriculture

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Haden Comstock [1] Nathan DeLay [1]

[1]Department of Agricultural Economics, Purdue University

Introduction

Precision Agriculture Technologies (PATs) are a suite of technologies that use **field-level data** to better inform production practices and input use. These technologies have been linked to more efficient chemical use, environmental benefits, profit margin increases, and risk reduction [1].

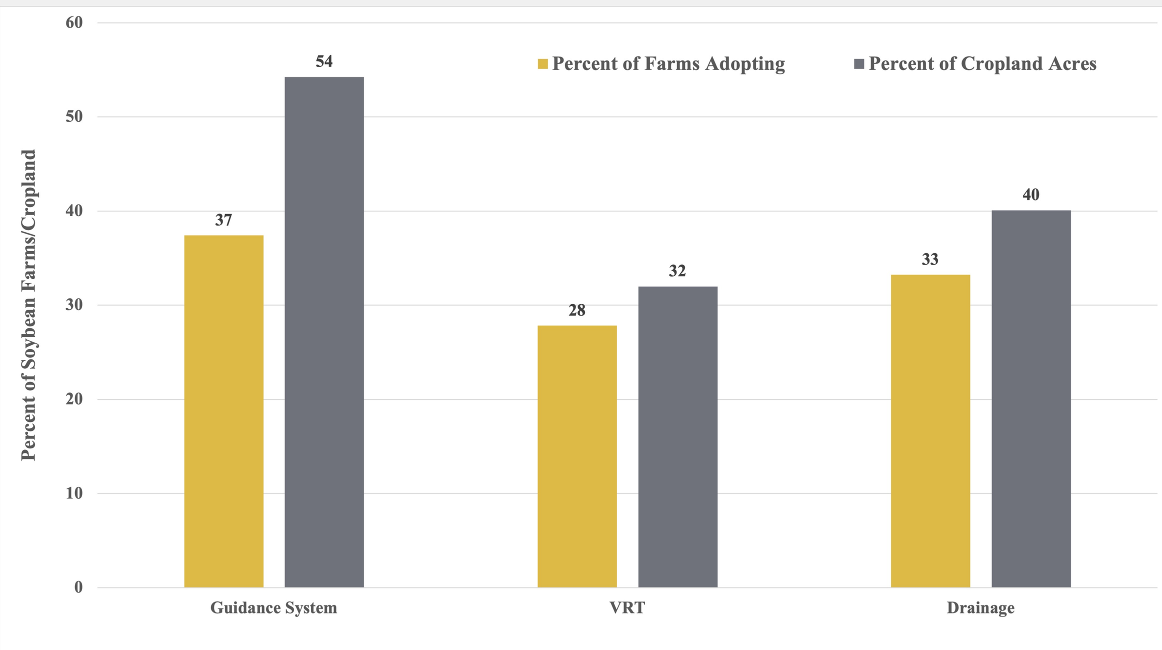

Figure 1. Technology Adoption on Soybean Farms/Cropland Acres, 2018.
Source: USDA, ERS, 2018 Agricultural Resource Management Survey, Phase II.

Figure 1. shows adoption patterns for three PATs on soybean farms/acres in 2018. VRT and Tile-Drainage adoption below 50% for both soybean farms and acres. Guidance adoption only above 50% for soybean acres.

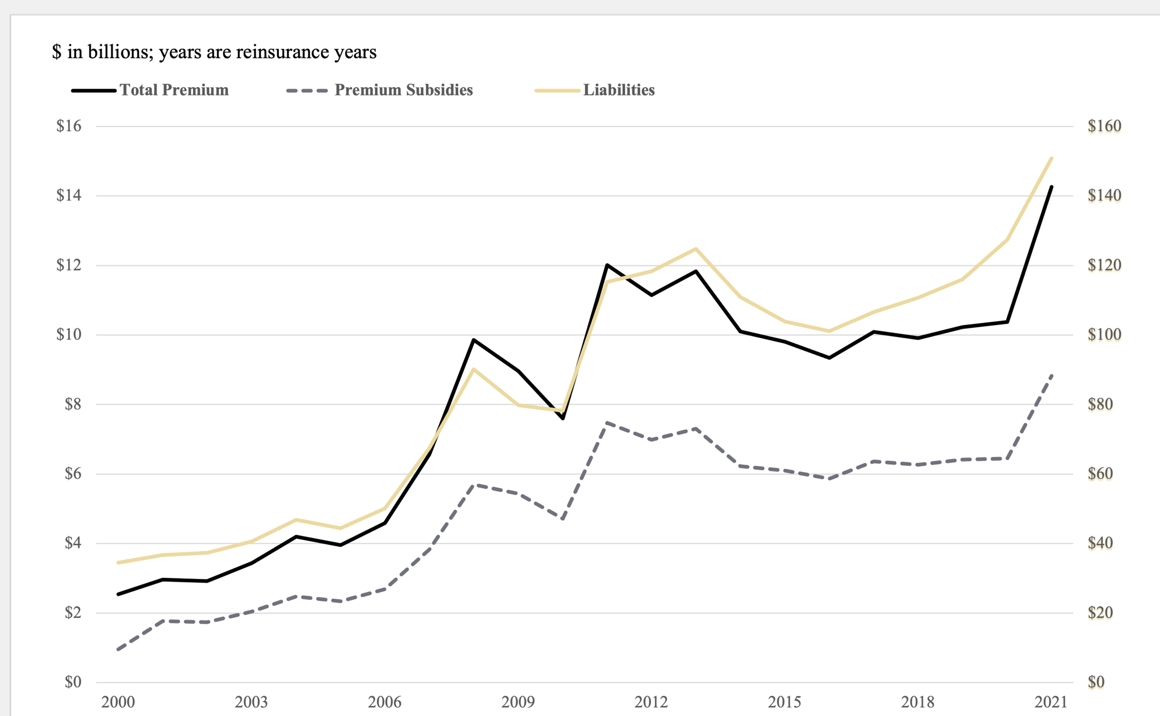

Figure 2. Annual FCIP Total Premium, Premium Subsidies, and Liabilities, 2000 - 2021.
Source: USDA, RMA, Summary of Business, 2000 - 2021.

Figure 2. shows the increase of the FCIP from 2000 - 2021. As participation has increased, the scope of the FCIP has continued to grow.

Objectives

- **Identify** the factors that influence technology adoption decisions for soybean operations in the U.S.
- **Explore** the relationship between the FCIP and technology adoption.
- **Determine** whether FCIP participation disincentivizes technology adoption.

Data

Data was obtained through the **Agricultural Resource and Management Survey (ARMS)**. ARMS is administered through the USDA Economic Research Service (ERS) and the National Agricultural Statistical Service (NASS). ARMS is a multi-phase survey that uses survey weights to be nationally representative, and covers production practices, producer characteristics, and farm financial information.

Methods and Empirical Estimation

A Poisson model with sample selection possesses the following main equation:

$$E(y_i|x_i', \epsilon_i) = \lambda_i = exp(x_i' + \sigma\epsilon_i)$$

Where y_i is the observed dependent variable, x_i is a vector of covariates, $_i$ is a vector of coefficients, and ϵ_i is an error term. However, whether or not y_i is observed depends on a latent-variable model, s_i:

$$s_i = \begin{cases} 1, & if\ z_i'\gamma + u_i > 0 \\ 0, & otherwise \end{cases}$$

$$corr(\epsilon_i, u_i) = \rho$$

Where γ is a vector of coefficients, z_i' is a vector of covariates, and u_i is an error term. If technology has been adopted by 2018, then s_i is equal to one and y_i is observed. This functional form will account for the sample selection bias.

Log-likelihood function

Combine the joint probabilities for the $s_i = 1$ and $s_i = 0$ cases:

$$ln(L(\theta)) = \sum_{i=1}^{N}[s_i * ln\{Prob(y_i, s_i = 1)|x_i, z_i, \theta\}] + (1 - s_i) * ln\{Prob(s_i = 0|z_i, \theta)\}]. \quad (1)$$

Where θ represents (β, γ, ρ, and σ) for notational simplicity. This function is then maximized using Gauss-Hermite quadrature.

Results

Table 1. Results from a Poisson Model with Sample Selection on Guidance Auto-Steering.

Variable Name	Intensity Equation Coefficient	Selection Equation Coefficient
Multi-Peril Adoption (Years)	0.007**	-0.002
	(0.003)	(0.003)
ERS REGION		
Northern Great Plains	-0.107	0.790***
	(0.110)	(0.112)
Eastern Uplands	0.027	-0.571***
	(0.199)	(0.196)
Southern Seaboard	0.168	-0.436***
	(0.141)	(0.116)
Loss Cost Ratio	-1.424	-5.687**
	(2.775)	(2.695)
Total Acres Operated (in 100,000's)	-0.323*	1.224***
	(0.188)	(0.188)
Percentage of Rented Acres	-0.102	0.724***
	(0.127)	(0.134)
Farm Assets (in $10 millions)	-0.196**	1.220***
	(0.089)	(0.103)
Constant	2.978***	-1.197***
	(0.460)	(0.377)
Prob > χ^2	0.0006***	
Wald test of indep. eqns. (ρ = 0): χ^2(1) = 116.93; Prob > χ^2 = 0.0000***		

Note: Significance at the 0.01, 0.05, and 0.10 levels are represented by ***, **, and * respectively.

Results

Table 2. Results from a Poisson Model with Sample Selection on VRT.

Variable	Intensity Model Coefficient	Selection Model Coefficient
Multi-Peril Adoption (Years)	0.029**	0.011
	(0.012)	(0.009)
Age	-0.005	-0.011*
	(0.007)	(0.006)
Coverage Level	0.014	0.018*
	(0.013)	(0.009)
Data Tools	0.736**	1.009***
	(0.333)	(0.167)
Years Operating	-0.012	-0.016**
	-0.01	(0.007)
Constant	-0.379	-1.610
	(1.343)	(0.998)
Prob > χ^2	0.0929*	
Wald test of indep. eqns. (ρ = 0): χ^2(1) = 3.54; Prob > χ^2 = 0.0600***		

Table 3. Results from a Poisson Model with Sample Selection on Tile-Drainage.

Variable	Intensity Equation Coefficient	Selection Equation Coefficient
Multi-Peril Adoption (Years)	0.014***	-0.005
	(0.002)	(0.008)
Southern Seaboard	0.549***	-1.718***
	(0.203)	(0.347)
Mississippi Portal	0.737***	-2.013***
	(0.206)	(0.301)
Chemical Expense (in $1 millions)	-0.822***	0.426
	(0.332)	(0.495)
Years Operated	-0.005***	0.016***
	(0.002)	(0.006)
Poor Drainage Concerns	(ommitted)	0.295*
		(0.154)
Constant	3.395***	-2.353**
	(0.421)	(1.011)
Prob > χ^2	0.000***	
Wald test of indep. eqns. (ρ = 0): χ^2(1) = 13.52; Prob > χ^2 = 0.0002***		

Conclusions

- This study found that enrollment in the current FCIP may be correlated with an increase in the average time of adoption for GPS based tractor guidance systems, variable rate technology (VRT), and subsurface tile-drainage.
- The FCIP may be viewed as a risk management tool to be used in conjuncture with other risk-reducing practices and technologies.
- Subsurface tile-drainage is a fundamentally different technology than guidance or VRT, as tile-drainage is meant to fix a specific problem (field drainage). This could explain why this model was able to solve with a higher degree of confidence.

References

[1] David Schimmelpfennig.
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