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Precision Agriculture and Big Farm Data: Producer Adoption and Opinions

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Introduction

Using scarce resources to feed an ever-increasing world population in the climate of increasingly-volatile commodity prices has charged producers with the task of becoming more efficient. The answer to these problems may lie within technological advancements, through the usage of precision agriculture and the "big" data these technologies are capable of producing. These technologies are expected to have an enormous impact that could effectively allow farmers to produce more with less. As such, research regarding producer adoption and opinions of the technology are of great relevance. Furthermore, there is great debate over the data produced by these technologies; with the success of data analytics in other industries, many see it as the future of agriculture. However, the potential benefits of this data come with just as many challenges, from not knowing what to do with the data to concerns over ownership, privacy, and security. This study seeks to inform the debate by providing timely empirical results of producers' concerns on the topic.

Objectives

- Determine the factors influencing adoption of precision agriculture technologies in Nebraska.
- Determine the factors influencing adopters' propensity for sharing farm data.
- Determine the sequential adoption of precision agriculture technologies by Nebraska producers.
- Examine producer opinions regarding precision agriculture and the data it produces.

Methodology

The data used in this study were produced by distributing an in-depth survey to producers at various Nebraska Extension meetings across the state in 2014-2015. In total, 135 responses were received, but after removing out-of-state responses and missing data, 102 complete responses were able to be used in analysis. The first two objectives listed above were accomplished using a Poisson regression model to analyze the individual effects of multiple independent variables on one dependent variable composed of count data. Producer opinions on the topic were examined via frequency tables from questions in the aforementioned survey.

Average Respondent Characteristics (n=102)	
Average Age	47.42
Average Row Crop Acres in Operation	1334.87
Average Gross Farm Income	$971,813.73
Percentage Using Irrigation	63.73%
Percentage Using Cell Phone with Internet Access	79.41%
Average Number of Technologies Adopted	4.47

The number of technologies adopted by producer i or the number of entities with which producer i is comfortable sharing their farm data (Y_i) can be expressed generally as a function of multiple independent variables (X_i) as follows:

$$\ln(Y_i) = \propto + \beta_i X_i$$

Thus,

$$Y_i = e^{\propto + \beta_i X_i}$$

Where $\propto$ is the intercept and β_i are the respective parameter estimates for each variable produced in SAS by running the Poisson regression. To determine the marginal effect of each variable, the function must be differentiated with respect to X_i, yielding the following:

$$\text{Marginal Effect} = \frac{dY_i}{dX_i} = \beta_i e^{\propto + \beta_i X_i}$$

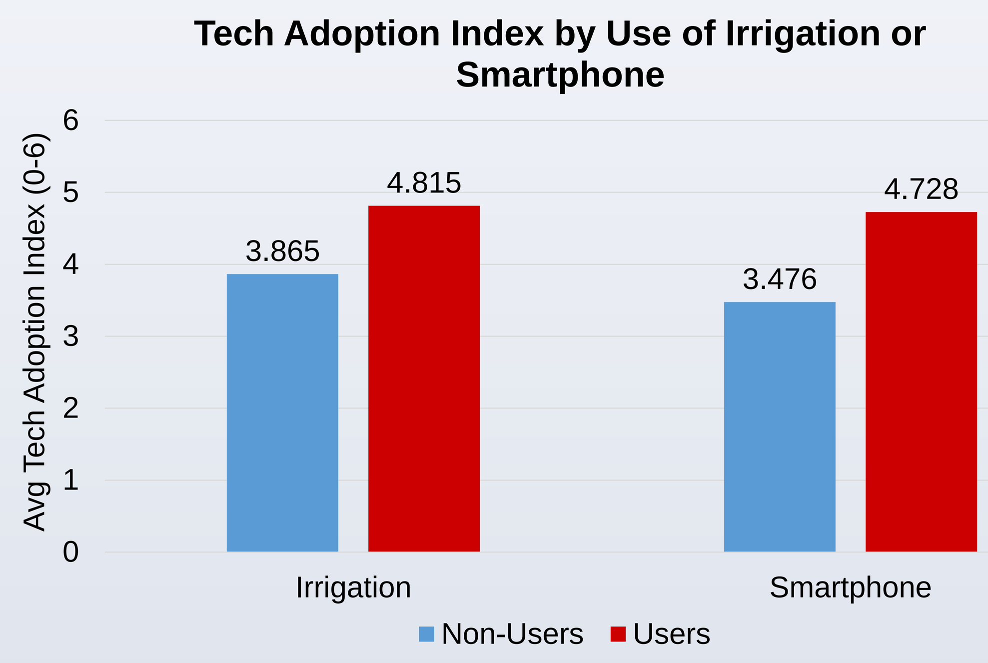
Thus, it can be seen that the sign of the parameter estimate, β_i, indicates the sign of the marginal effect of each respective variable.

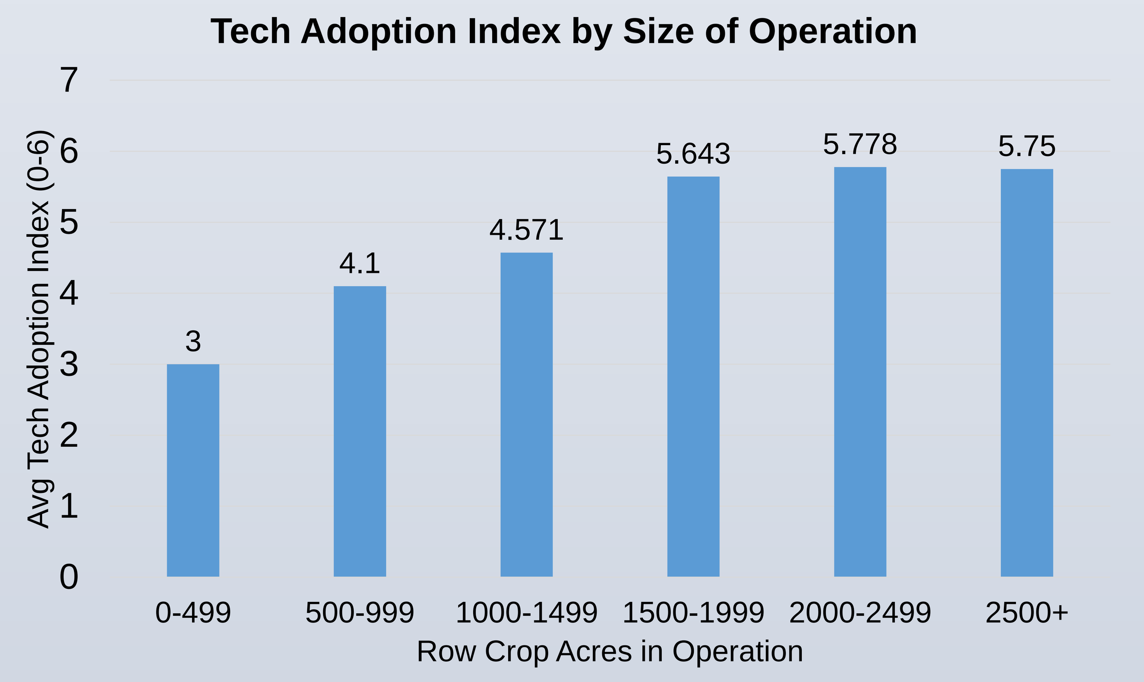
Technology Adoption Results

Factors Influencing Adoption Regression Results

Variable	Poisson Model Parameter Estimate[1]	Standard Error	P-Value[1]
Intercept	1.5323***	0.1736	0.0000***
Operator Age	-0.0015	0.0032	0.6346
Row Crop Acres	0.0001*	0.0000	0.0531*
Gross Farm Income	0.0000	0.0000	0.9213
Non-Irrigator	-0.1585[2]	0.1045	0.1294[2]
Smartphone Non-User	-0.2387*	0.1323	0.0711*

[1]Significance at the 10%, 5%, and 1% level are indicated by one, two, and three asterisks, respectively.
[2]The p-value for irrigation was 0.1294—very close to statistical significance at the α=10% level.





Sequential Adoption Correlation Matrix*

		use								
		GPS	AS	VRT	ASC	SAT/ AER	CHL/ GRN	SOIL SMP	YLD MON	PRESC. MAP
users	GPS	*	83%	75%	78%	32%	8%	98%	92%	75%
	AS	100%	*	81%	88%	35%	10%	100%	94%	81%
	VRT	93%	83%	*	83%	36%	10%	99%	94%	86%
	ASC	96%	89%	82%	*	34%	8%	100%	96%	80%
	SAT/AER	93%	83%	83%	80%	*	20%	100%	97%	67%
	CHL/GRN	100%	100%	100%	86%	86%	*	100%	100%	100%
	SOIL SMP	85%	72%	69%	71%	30%	7%	*	85%	69%
	YLD MON	92%	78%	76%	78%	33%	8%	98%	*	75%
	PRESC. MAP	94%	84%	87%	83%	29%	10%	100%	94%	*
	Rank	**2**	**4**	**5**	**6**	**8**	**9**	**1**	**3**	**7**

*Among users of the technology listed in the first column, the table indicates the percentage of producers using the technology in the subsequent columns.

Producer Opinion Results

Factors Influencing Data Sharing Regression Results

Variable	Poisson Model Parameter Estimate[1]	Standard Error	P-Value[1]
Intercept	1.7518***	0.3754	0.0000***
Age	-0.0158***	0.0055	0.0042***
Row Crop Acres	0.0000	0.0001	0.5857
Tech Adoption Index (including smartphone)	-0.0598	0.0468	0.2013
Non-Irrigator	-0.3615**	0.1831	0.0484**

Fully Understand the Term "Big Data"?

Understanding Level	Observations	Percentage of Respondents
Strongly Disagree	11	12.1%
Somewhat Disagree	22	24.2%
Somewhat Agree	43	47.3%
Strongly Agree	15	16.5%
Average Understanding Index	2.68	

With Whom do you Feel Comfortable Sharing your Farm Data?

Choice	Observations	Percentage of Respondents
University Researchers or Educators	39	43.82%
Local Co-op	38	42.70%
Relatives	33	37.08%
No one	20	22.47%
Equipment Dealers	18	20.22%
Company who Manufactured Equipment	17	19.10%
Neighbors	12	13.48%
Average Sharing Index (Scale of 0-6)	1.76	

Biggest Issue Regarding Farm-Level Data?

Response	Observations	Percentage of Respondents
Understanding How to Use/Interpret Data	23	43.40%
Data Security/Confidentiality/ Who has Access to it	14	26.42%
Ownership of Data	5	9.43%
Accuracy of Data	4	7.55%
Return on Investment	3	5.66%
Glitches/Missing Data/Technical Problems	2	3.77%
Compatibility Issues	2	3.77%
Cost of Equipment & Software	1	1.89%

Conclusions

The results indicate that larger operations and those using a smartphone are more likely to adopt a higher number of precision agriculture technologies, while operator age and gross farm income were non-influential factors and the use of irrigation was close, but not quite a conclusive influential factor. Larger farmers are more likely to be able to afford the investment in the technology and also have an increased need for efficiency in covering larger areas, so this conclusion is intuitive. The usage of a smartphone being an influential factor is also intuitive, as the use of a smartphone is a potential indicator of technological competency, which may then lead to the adoption of further technologies. Irrigation practice was also very close to statistical significance, meaning that irrigators are more likely to adopt a higher number of technologies; most likely due to the increased intensity of production that comes with the use of irrigation.

For factors influencing the propensity to share farm data, two of the four factors studied were found to be statistically significant: operator age and irrigation use. Thus, we are able to conclude that older producers have a lower propensity to share their data than do younger producers, most likely due to the older generation being more skeptical of and less familiar with these new technologies. Producers not using irrigation in their operation were found to have a lower propensity to share their data, which could be due to their lower intensity of production and thus lesser reliance on data for efficiency. Although not statistically significant, it is of interest that a higher tech adoption index (i.e. more tech-savvy producers) resulted in a lower propensity to share farm data, potentially due to a greater understanding of the issue.

The majority of precision ag users believe their profits have increased due to use. Producer understanding of "big data" and its implications is lacking, with only a small amount fully understanding the term. Overall, producers are obviously leery of sharing their farm data; more respondents reported that they were not comfortable sharing their farm data with anyone than with equipment dealers, manufacturers, and neighbors. The number one reason reported for using precision ag was to increase efficiency, while the number one reason for not using was the cost of the investment. The most common number one benefit of use was reduced inputs and input cost. Regarding the future of the industry, the most common response for the biggest issue regarding advancements in agricultural production technology was affordability and cost of the technologies, and the biggest issue concerning farm-level data was understanding how to use and interpret the data.

The results of this study have implications for producers, precision ag equipment dealers and manufacturers, large agribusiness firms interested in the use of farm data, Extension personnel, and agricultural policy makers.

References

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