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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 increasing 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, the 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 technologies 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 used to be analyzed in this study. The two first 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.

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

\[ \ln(Y_i) = \beta_0 + \beta_1 X_1 + \ldots + \beta_k X_k \]

Thus,

\[ Y_i = e^{\beta_0 + \beta_1 X_1 + \ldots + \beta_k X_k} \]

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

\[ \frac{dY_i}{dX_i} = e^{\beta_0 + \beta_1 X_1 + \ldots + \beta_k X_k} \beta_i \]

Marginal Effect \[ \frac{dY_i}{dX_i} = \beta_i e^{\beta_0 + \beta_1 X_1 + \ldots + \beta_k X_k} \]

Thus, it can be seen that the sign of the parameter estimate, \( \beta_i \), indicates the sign of the marginal effect of each respective variable.

Technology Adoption Results

<table>
<thead>
<tr>
<th>Factors Influencing Adoption Regression Results</th>
<th>Tech Adoption by Use of Irrigation or Smartphone</th>
<th>Technology Adoption by Size of Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td>Poisson Model Parameter Estimate</td>
<td>Standard Error</td>
</tr>
<tr>
<td>Intercept</td>
<td>1.5323**</td>
<td>0.1736</td>
</tr>
<tr>
<td>Operator Age</td>
<td>-0.0015</td>
<td>0.0002</td>
</tr>
<tr>
<td>Row Crop Acres</td>
<td>0.0091</td>
<td>0.0000</td>
</tr>
<tr>
<td>Gross Farm Income</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>Non-Irrigators</td>
<td>-0.1585**</td>
<td>0.1045</td>
</tr>
<tr>
<td>Smartphone Non-User</td>
<td>-0.2387**</td>
<td>0.1523</td>
</tr>
</tbody>
</table>

Notes:
- **Significance at the 0.01, 0.05, and 0.10 level are indicated by two, one, and three asterisks, respectively.
- p-value for irrigation was 0.129 only close to statistical significance at the 0.05 level.
- Using Irrigation, Precision Agriculture, and Big Farm Data: Producer Adoption and Opinions

Producer Opinion Results

Factors Influencing Data Sharing Regression Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Poisson Model Parameter Estimate</th>
<th>Standard Error</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1.1510***</td>
<td>0.3478</td>
<td>0.0000***</td>
</tr>
<tr>
<td>Age</td>
<td>-0.0230**</td>
<td>0.0011</td>
<td>0.0004***</td>
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<tr>
<td>Row Crop Acres</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.5857</td>
</tr>
<tr>
<td>Technology Adoption Index (including smartphone)</td>
<td>-0.0598</td>
<td>0.0468</td>
<td>0.2031</td>
</tr>
<tr>
<td>Non-Irrigators</td>
<td>-0.3615**</td>
<td>0.1831</td>
<td>0.0484**</td>
</tr>
</tbody>
</table>

Notes:
- **Significance at the 0.01, 0.05, and 0.10 level are indicated by two, one, and three asterisks, respectively.
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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 being significant, because those that irrigators are more likely to adopt a higher number of technologies; most likely due to the increased irrigation 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 or irrigation status. 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 research is needed to determine what they were not comfortable sharing their farm data with anyone than with equipment dealers, manufacturers, and neighbors. The number one reason reported for not 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 using precision ag was increased returns and improved profit. Regarding the future of the industry, the most common response for the biggest issue regarding technological advancements was affordability and cost of the technologies, and the biggest issue concerning farm-level data was issues with sharing the data and interpreting the results.

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

References

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Acknowledgements

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