Market analysis and value perception of agronomic services

by

Jarod R. DeTurk

B.S., University of Nebraska, 2013

A THESIS

Submitted in partial fulfillment of the requirements

for the degree

MASTER OF AGRIBUSINESS

Department of Agricultural Economics

College of Agriculture

KANSAS STATE UNIVERSITY

Manhattan, Kansas

2022

Approved by:

Major Professor
Allen Featherstone

ABSTRACT

There has been a push towards producing food more sustainably. This is a global trend and is important for every industry. Agronomic principals have a unique place in agriculture. There are sustainable practices that farmers can implement, that equipment producers can develop for farmers, but agronomy can bring together multiple parts of production. Agronomy focuses on soil health, fertility, pesticide applications, and other facets of production so it is in a position to align technical goals of multiple parts of production to satisfy ever changing global needs.

Though it appears that the importance of agronomy in production agriculture is increasing, there is little research on the producer value of agronomic services, and what makes a producer employ a specialized agronomist in their operation. This research focuses on those issues. The study is conducted through a questionnaire to producers that asks questions ranging from demographic information to operation information, and finally focusing on whether a producer employs an agronomist in some capacity and what benefits that producer receives from that decision. The results of the questionnaire are used to estimate a logit regression to determine factors that influence a producer's decision to employ an agronomist, and descriptive statistics on producer's value perceptions of how much value they receive from employing an agronomist. These results are beneficial both to the agronomic industry in terms of tailoring what is offered in agronomic services, and are valuable to producers interested in seeing a more quantitative approach to what influences their peers' decisions.

The results show that if a producer has a higher percentage of crops as their primary income stream, they are less likely to hire an agronomist. Inversely, if a producer is spread between producing multiple agricultural products or has off-farm income they are more likely to employ an agronomist. It was originally thought that as an operation increased in size, hiring a specialized agronomist would be more likely, but the results are counter to this hypothesis.

Over 50% of producers who completed the questionnaire employed an agronomist. Demographics such as education level and age had less effect on whether they employed a crop consultant than other independent variables that are particular to their operation. The value that producers employing an agronomist saw in those services came primarily from weed and other pest management, fertility, and input cost savings. Producers saw less value for an outside opinion or expertise, adverse conditions reporting such as poor weather, and other.

TABLE OF CONTENTS

List of Figures v
List of Tables vi
Acknowledgments vii
Chapter I: Introduction 1
1.1 Research Question and Sub-Objectives 1
1.2 Thesis Outline 2
Chapter II: Literature Review 4
2.1 Importance of Agronomy in Production Agriculture 4
2.2 Regressions for Marketing Analysis 5
2.3 Snowball Sampling Method 6
2.4 Relationship marketing and customer loyalty 7
Chapter III: Theory and Methods 8
3.1 Economic and Business Theory 8
3.2 Data Collection and Examination Methods 9
3.3 Predicted Versus Actual Model 11
Chapter IV: Analysis 12
4.1 Descriptive Statistics 12
4.2 Regression Estimation Expected Signs 19
4.3 Correlation Matrix for Independent Variables 20
4.4 Regression Estimation Results 22
4.5 Change in Probability as the Independent Variables Change 25
Chapter V: Summary and Conclusions 31
5.1 Summary 31
5.2 Conclusions and Suggestions for Further Research 32
References 35
Appendix A 36

LIST OF FIGURES

Figure 4.1 Percent of Total Producers Employing an Agronomist 13

Figure 4.2 Producers Employing Agronomist Sorted by Education (N=37) 14

Figure 4.3 Percentage of Education Demographics Employing an Agronomist 15

Figure 4.4 Percentage of Producers with Agronomist; Nebraska vs. Out of State 17

Figure 4.5 Weighted Average of Perceived Value in Agronomic Services 18

Figure 4.6 Average Cost and Return per Acre for Agronomic Services 19

Figure 4.7 Independent Variables Correlation Matrix 21

Figure 4.8 Off-Farm Income Probability Change for Hiring an Agronomist 26

Figure 4.9 Education Probability Change for Hiring an Agronomist 26

Figure 4.10 Irrigation Percentage Probability Change for Hiring an Agronomist 27

Figure 4.11 Age Probability Change for Hiring an Agronomist 28

Figure 4.12 Acres Probability Change for Hiring an Agronomist 28

Figure 4.13 Percentage Crops to Livestock Probability Change for Hiring an Agronomist 29

LIST OF TABLES

Table 4.1 Numerical Independent Variable Statistical Analysis 12

Table 4.2 Percent of Producers with an Agronomist Above and Below the Variable Mean 16

Table 4.3 Probability of Contracting with an Agronomist in Levels 22

Table 4.4 Probability of Contracting with an Agronomist in Logs 24

ACKNOWLEDGMENTS

The author wishes to thank my wife Kaylinda and children for being supportive throughout school and beyond. I would also like to thank my major professor Dr. Featherstone for working with me throughout a challenging semester. Finally, the survey respondents and many others that helped distribute the survey made this research possible.

CHAPTER I: INTRODUCTION

There has been a push towards producing food more sustainably, a global trend important in every industry. Numerous sustainable and best management practices can be implemented and adopted by farmers. Agronomy focuses on soil health, fertility, pesticide applications, and other facets of production, so this field and related industry is in a position to help align technical goals across multiple parts of production to satisfy ever changing global sustainability needs.

This study benefits agronomists and row crop producers of corn and soybeans primarily in Nebraska. Agronomists benefit from understanding a producer's perceived value for their services. Understanding what makes a producer likely to outsource to a specialized agronomist helps agronomists tailor their service offerings. Agronomic service providers focusing on the value that they bring to row crop producers increases the industry's role in crop production and improves the agricultural economy. This can help the industry tailor its offerings to what customers see as valuable. Rather than a qualitative approach, or simply an opinion of what value they bring to the producer, this study examines answers in a more quantitative approach.

Producers can benefit from understanding the value that their peers see in agronomic services. They are able to look at the factors that are common among producers that employ an agronomist in some capacity and inversely the factors that are common among producers that perform their own agronomic tasks. Studying the producers that employ an agronomist can identify the perceived benefit of those services.

1.1 Research Question and Sub-Objectives

The research presented here is a market analysis of agronomic services and customers' perceived value. We are interested in answering the question: what factors influence a producer's decision to hire a specialized agronomist and what value do they perceive from their services? The research is based primarily in Nebraska. There is little research on this specific topic, but there is an abundance of research on the methods used. The process of analysis drawn from other studies using similar methods are as follows. First a questionnaire needs to be completed by enough producers for statistically significant results. Next a regression analysis is estimated to determine the factors that have the most influence on a producer's decision to hire a specialized agronomist. The final part of the questionnaire is for producers that use an agronomist. It focuses on the cost associated with hiring a crop consultant and the benefits received from their services. There is a list of common services provided by crop consultants that they order in value. With that information, it is possible to estimate descriptive statistics and determine the value a producer sees in this decision.

1.2 Thesis Outline

This chapter discussed agronomics and more specifically showed the importance of this research question to two distinct groups, namely agronomists or crop consultants and row crop producers. The chapter looked at the objectives of the study and how the study is to be completed.

In the following chapter, a literature review examines related research. The literature addresses four primary areas of importance in previous research and in this study. First, it outlines the value of agronomy in today's agricultural industry. Next, it looks at regression analyses used in marketing research. The third part of the literature review addresses the snowball sampling method that was applied in this study. Finally, the review of literature addresses the relationship between marketing and customer loyalty indicating that there may be costs and benefits associated with working with an agronomist that cannot be captured quantitatively. In chapter 3, the theory and methods are discussed. First, economic and business theory are tied to the study. Next the data collection and estimation methods for the study are discussed. In chapter 4, the regression results along with descriptive statistics from the survey are discussed. Chapter 5 discusses the summary, conclusion, and suggestions for further research.

CHAPTER II: LITERATURE REVIEW

This chapter reviews the literature relating to a market analysis of agronomic services and the producers value perception of those services. The first section reviews literature related to the importance of agronomy in production agriculture establishing the importance of the research question. Next, the methods used in market analyses are discussed. The final section looks at the different forms of perceived value of consumers of agronomic services, which may be nonpecuniary, that may not be fully captured in a financial analysis of farmer's value perception of agronomics.

2.1 Importance of Agronomy in Production Agriculture

According to Lichtfouse, et al. (2009) agronomy may soon be a leading factor in the improvement of farming systems as a whole. They discuss some of the ecological issues facing the world, and the problems commonly identified with agriculture such as water pollution and soil erosion. Agronomy may be a leader in bringing a comprehensive system to feed the world and sustain agriculture because "in the next few decades most improvements of farming systems will rely on enhancing positive interactions among various parts of farming systems" (Lichtfouse, et al. 2009). They discusses how agronomy encompasses many dimensions of crop production. Problems are being dealt with by aligning the system as a whole, a systems approach, rather than looking at the individual parts of the system separately. This illustrates the importance of agronomy and why it is important to know its value whether completed by a producer or outsourced to an agronomist.

Kik, et al. (2021) looks at the importance of soil management for sustained economic profits. A major takeaway from this study is that there is a high amount of complexity in farm management. As the article states, “For a farmer as a financially rational decision maker aiming at maximization of long-term income and farm continuity the key question is how to choose PM (production management) in such a way that long-term farm income is maximized in a sustainable way” (Kik, et al. 2021).

2.2 Regressions for Marketing Analysis

Armstrong and Andress (1970) discuss the benefits and disadvantages of using a tree analysis versus using regression analysis. The article discusses regression analysis and how it uses each observation efficiently. It compares the regression method with the tree analysis method because regression analysis is well known and commonly used in academia. The article concludes that there are situations where tree analysis is a viable option when there are large data sets, but it ultimately gives credibility to the use of a regression analysis.

The next piece of literature discusses the logistic regression model and its role in market research. Constantin (2015) looks at the logistic regression model in detail and discusses the binary logistic regression model. This article goes into detail on the interpretation of logistic regression models and discusses how this method is instrumental in market research.

Mason and Perreault, Jr. (1991) discuss the application and interpretation of regression analysis. The article points out the two purposes for which regressions are used, prediction and drawing conclusions about predictive variables. It discusses some of the shortfalls of regression, such as when predictor variables are correlated that can result in collinearity problems. It gives a good overview of regression analysis and the problems that can be encountered when using regression analysis. Along with this literature

Studenmund (2016) also provides an overview of the application and interpretation of regression analysis.

Finally, Burinskiene and Rudzkiene (2007) look at the use of logit regression models as the type of model that identifies market segments. If the answer to a research question is a yes or no answer, or will a producer hire an agronomist based on a set of independent variables, the logit model conceptually makes sense. The logit model estimates a probability that is between 0 and 1. It is useful in determining factors that make a person more or less likely to make a particular decision, in this case the decision of hiring or choosing not to employ a crop consultant. The article also discusses the use of pseudo-variables in marketing research since research of this type often uses survey work with yes and no answers to form conclusions.

These articles highlight uses of regression analysis in market research. As seen from the scope and volume of literature on this subject, it is a common method used in market research.

2.3 Snowball Sampling Method

The snowball sampling method is used when hard to reach populations need to be surveyed. Handcock and Gile (2011) provide an overview of the history of the use of snowball sampling and highlights its strengths when more common approaches are not viable. A researcher uses "mutual relationships or social circles in the population" (Handcock and Gile, 2011) to distribute a survey questionnaire to a small group in the population and those relationships continue to pass on or provide additional participants to complete the survey questionnaire until a sufficient sample size is achieved. The article briefly addresses the idea that people seek out people who are similar to them that can cause bias in network sampling procedures, but by diversifying sampling starting points one can control this.

2.4 Relationship marketing and customer loyalty

Ndubisi (2007) investigates the multiple facets of what builds a customer's perception of value. In the past, there was often a simple give and get mentality when selling a product. The author approaches the subject believing that multiple aspects enter into what a customer sees as value and concludes that value is more than just monetary exchange. Much of this is centered around what the author calls relationship marketing.

Agronomics has a lot of traits discussed in the article. There are often relationships and customer loyalty involved. This study examines the monetary value that producers see in an agronomist, and this article indicates that there may be other forms of value that a producer receives in agronomic services that are not included.

CHAPTER III: THEORY AND METHODS

The theory and methods relevant to the objective of this study are discussed in this chapter. First the economic and business theories underpinning the research question and the assumptions made in formulating the inquiry are presented. Second, the specific methods and data needed to apply those methods with the purpose of answering the study's research objective are addressed.

3.1 Economic and Business Theory

Opportunity cost as defined by Baye and Price (2020) is "The explicit cost of a resource plus the implicit cost of giving up its best alternative use". Explicit costs are the accounting costs accrued. Implicit costs are the "cost of giving up the best alternative use of the resource" Baye and Prince (2020). Specifically, if a producer were to give up their time to perform their own agronomics, from an accounting perspective this may or may not be fiscally justified. Looking at the economic profits however, there is a cost associated with a producer doing something that he or she may not be specialized in and taking time away from what they are specialized in. Survey questions in this study addressing where else producers spend their time (off-farm income, cattle operations, etc.) take into account the implicit costs that producers have so that they can be taken into account for value assessment. It is a safe assumption to say that agronomic management is a necessary part of row crop production. Whomever that management comes from, the individual must make pesticide, fertilizer, and various other crop production and crop input management decisions. As shown in the literature this task becomes more crucial with a push towards more sustainable agriculture.

Agronomic services have been, and all signs point towards it continuing to be an important input in row crop agriculture, but little has been done in terms of valuing this input. This is likely because as Baye and Prince (2020) state, "Implicit costs are very hard to measure and therefore managers often overlook them". To gain an understanding of the financial valuation of what it costs to outsource an agronomic input or management decision in row crop agriculture, a strong understanding of the opportunity costs incurred by a producer for performing their own agronomic work need to be understood.

3.2 Data Collection and Examination Methods

Data collection and methods are best described by asking three questions. What will be done? How will it be done? Why will it be done in the specific manner proposed? In the following section, these questions will be addressed in that order.

A survey questionnaire (See Appendix A) was distributed to producers to collect demographic information, operation information, and the value that they perceive of an agronomist and the services they provide. This was an online survey done through a website link. The example questionnaire in the appendix is a copy mirroring the questions asked in the online version. After the data are collected and evaluated, complete responses are analyzed using a regression from data obtained from the first two sections of the survey.

The survey was conducted using the snowball method. A relatively small group of producers are the initial survey respondents and these respondents are then used to find new respondents through their social networks, allowing the distribution of the survey link to be forwarded to those new connections, until the sample size reaches a desired level. The questionnaire was initially distributed through multiple channels of grower networks including but not limited to soil laboratories, commercial applicator operations, and crop insurances agents. People with producer networks were relied upon to distribute the survey to their initial network and the producers were asked to continue distributing the survey to producers that they think would respond. Other data collection avenues were explored but none yielded sufficient results in terms of the number of respondents needed.

One type of regression model applicable to analyze the survey data is the (linear probability model(LPM)). The LPM model is used when the answer is not a continuous quantitative value but a probability. The model described here was considered for use, but ultimately the logit binary model was the actual model estimated. The dependent variable was measured as whether a producer does or does not hire a crop consultant. This variable is coded 0 or 1. The independent variables influencing this probability and taken from the survey are the producer demographic questions of producer age, education level, location, and the operational information related to operation size, off-farm income, percentage of crops to livestock, and percentage of crops irrigated. It is important to note that education level, location and off-farm income are binary variables. The education variable, although ordinal, was made binary by assigning a 0 to those having a high school education or lower and 1 to those having above a high school education level. The regression equation is as follows:

$Y = \beta_0 + \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X4 + \beta 5X5 + \beta 6X6 + \beta 7X7$

where:

Y = Probability of producer employing an agronomist,

X1 = Producer Age,

X2 = Producer Education Level,

X3 = Location of Operation,

X4 = Off-Farm Income,

X5 = Size of Operation in Acres,

X6 = Percentage of Crops to Livestock, and

X7 = Percentage of Irrigated to Non-irrigated Cropland.

3.3 Predicted Versus Actual Model

The predicted model was explained prior to this section. Models estimated are as follows. Model one is a logit model where the variables are not in log form and the second model also is a logit model where the continuous variables are in log form. In each of the models, the dependent variable is whether a producer employs an agronomist represented by 0 and 1. When measured in logs, the percentage irrigated variable was percentage of crops irrigated plus one so that it could be a log variable. If some producers were entirely dryland or rainfed producers, 0 cannot be put in the log form. It should be noticed the location variable was dropped from the model because it was highly correlated with irrigated acres.

CHAPTER IV: ANALYSIS

This chapter addresses the analysis portion of the research. There are three components of data analysis. First, the descriptive statistics are examined, followed by a discussion of the regressions expected signs, and finally the chapter concludes with the regression estimates and interpretation. The descriptive statistics are summaries of the numerical independent variables. The results of producers employing an agronomist compared to those who are not employing an agronomist are reported. Finally, how demographics affect the percentages of producers employing an agronomist and the value perception piece was examined.

4.1 Descriptive Statistics

The continuous independent variables are age, acres in crops, percent of crops to livestock based on final income, and the percentage of farmland irrigated. The percentage of crops to livestock and percentage of irrigated cropland had 35 and 29 responses, respectively.

Table 4.1 Numerical Independent Variable Statistical Analysis

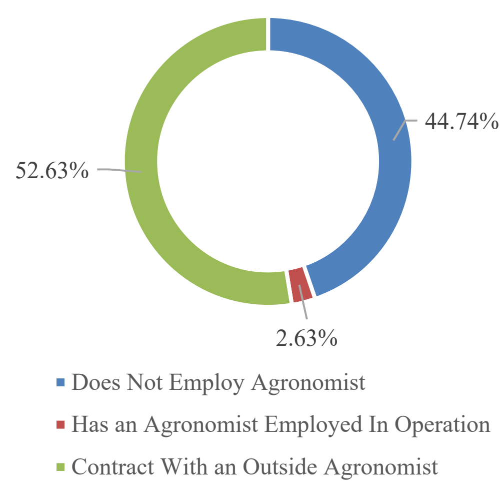
Statistical Analysis	N	Mean	S.D.	Min.	Max
Age	38	42.40	14.00	22	69
Acres in Crops	38	1,326.50	2,088.80	25	12,500
Percent Crops-Livestock	35	75.60	28.30	0	100
Percent Irrigated	29	69.50	30.10	0	99

Total respondents were 38. The lack of responses to irrigated cropland is assumed to occur because of respondents' locations being highly rainfed areas, and two respondents from Nebraska that farm under 50 acres likely farming dryland. Of those who did not respond, two were small operations from central Nebraska. One was from Dakota Nebraska where rainfed operations are common. States with one response were Illinois and Ohio, and states with two responses were Iowa and North Dakota.

Age has a mean of 42.4 with a standard deviation of 14.0. The average producer sampled was middle aged. Acres in crops had a large standard deviation. Looking through the data, many observations were near 1000 acres, the largest observation (12,500) affects the standard deviation, however. The percentage crops to livestock have a range from 0 to 100%. With a mean of 75.60%. The percentage of irrigated cropland also has a mean, range and standard deviation of 69.50%, 0 to 99%, and 30.10% respectively.

With 38 observations, 17 did not employ an agronomist, 1 employed an agronomist as part of their operation, and 20 contracted with an outside agronomist. The following figure illustrates this in percentages.

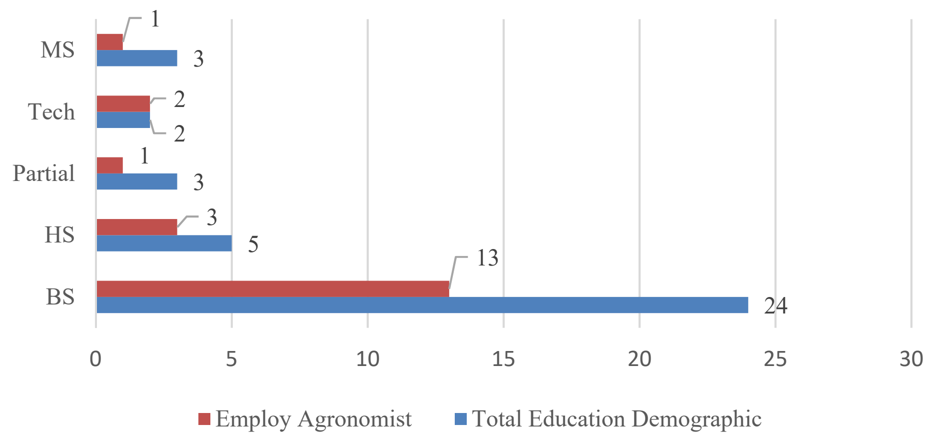
Figure 4.1 Percent of Total Producers Employing an Agronomist



Most producers surveyed employ an outside agronomist. This is followed by 44.74% of producers that do not use an agronomist in any form. The lowest percentage is the 2.63% of producers that have an agronomist working as part of their agricultural operation, one would have expected that to be a higher percentage.

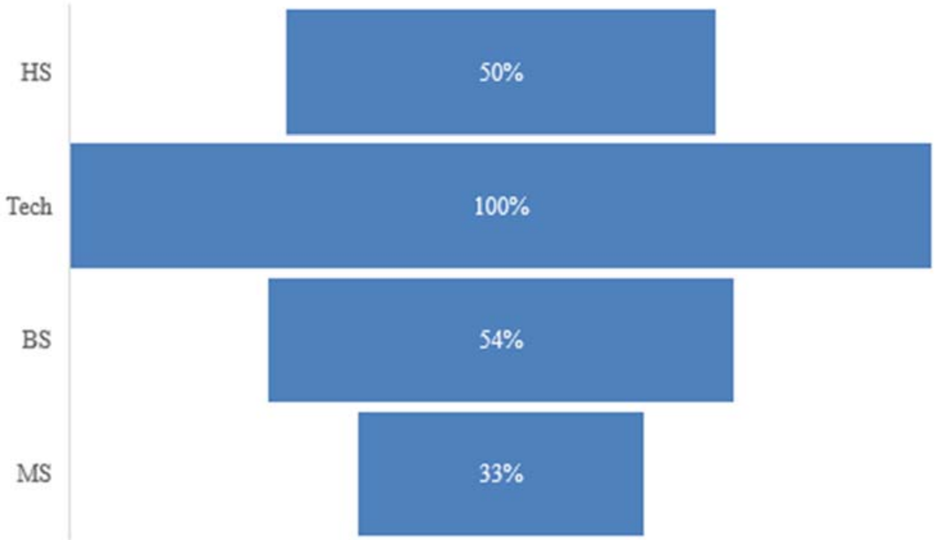
The demographics of producers and how those demographics affect the decision to employ an agronomist starting with education is discussed. Producers were broken into groups based upon education level. These groups are those with a bachelor's degree, high school education, partial college, technical college education, and those with a master's degree. The following figure illustrates the respondents from each group, and how many of those respondents employ an agronomist.

Figure 4.2 Producers Employing Agronomist Sorted by Education (N=37)



From the figure, the highest number of respondents was the bachelor's degree at 24. This demographic also employed the highest number of agronomists with 54.2% of that demographic employing a crop consultant. A tech school education had the highest percentage employing an agronomist at 100%. High school education had 5 respondents with 3 employing an agronomist and so on. The data is consistent when high school education and partial college education are combined, and it is represented in percentages.

Figure 4.3 Percentage of Education Demographics Employing an Agronomist



It appears there may be higher returns from agronomic services with lower levels of education followed by diminishing returns as a producer attains higher levels of education.

The off-farm income variable was included in the analysis because it was thought that if a producer was splitting their time between multiple enterprises there would be a higher need for help in production management or agronomics. The off-farm income variable indicated a relatively even split between the producers who had off-farm income and those who did not. Of those who did not have off farm income, 44% employed an agronomist and of those who did have off-farm income, 65% employ an agronomist consistent with prior expectations.

Using the independent variable averages and examining producers that employ an agronomist, above and below the independent variable averages are summarized in Table 4.2.

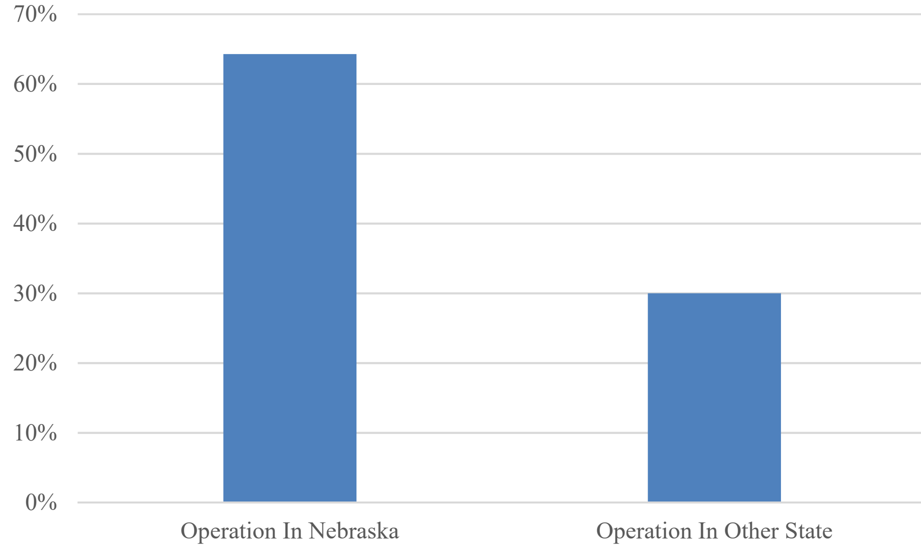
Table 4.2 Percent of Producers with an Agronomist Above and Below the Variable Mean

Independent Variable	Total	Number With Agronomist	Percent
Above Mean Irrigated	21	13	62%
Below Mean Irrigated	8	5	63%
Above Mean Acres	9	4	44%
Below Mean Acres	29	17	59%
Above Mean Percent Crops	19	10	53%
Below Mean Percent Crops	16	9	56%
100% Crop Operation	15	8	53%
Above Mean Age	18	10	56%
Below Mean Age	20	11	55%

Most of the above percentages are relatively close, between a 1-3% difference. The percentage of producers who employ an agronomist above and below the mean acres has a 15% difference which is significant. This difference runs counter to expectations. One would have expected that as an operation grows in size, help in managing that operation's agronomics would increase. Instead, the data shows the opposite. Smaller operations are more likely to employ an agronomist. One possible explanation is the amount one pays to outsource this service on many acres. It is surprising that larger operations do not hire more agronomists from within an operation as discussed earlier in the summary statistics.

The second variable is the average irrigated acres. Both above and below the mean have a high percentage of producers that employ an agronomist. As discussed earlier this variable was one with less observations. Many of the observations for this variable came from Nebraska, and Nebraska has a higher percentage of producers employing an agronomist according to this survey's results (Figure 4.4).

Figure 4.4 Percentage of Producers with Agronomist; Nebraska vs. Out of State



If the surveys that did not answer this question it was assumed to be zero, one would expect that the percentage of producers employing an agronomist below the mean irrigated level would decrease. Out-of-state producers are included in that descriptive statistic, and out-of-state producers employed an agronomist less often than Nebraska producers did. This fits well into the value perception portion of the descriptive statistics.

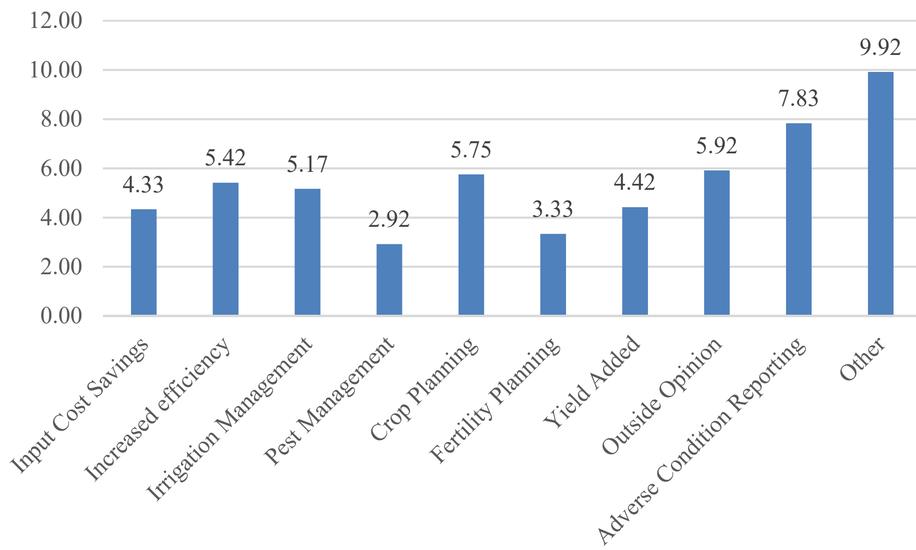
The survey, as seen in appendix A, asks producers to rank from 1to 10 what they value most in agronomic services. The services are as follows.

- Cost Savings on Inputs
- Time Savings/Increased Efficiency
- Irrigation Management
- Weed and Other Pest Management (Including Disease)
- Crop Planning
- Fertility
- Added Yield

- Outside Opinion/Expertise
- Adverse Weather Reporting (Weather, etc.)
- Other/Miscellaneous Benefit

There are 12 observations from producers ranking agronomic services. A rank of 1 means the producer values that service the most and inversely a rank of 10 means the producer values that service the least. A weighted average was then taken of the rankings of the ten agronomic service benefits. The highest weight was placed on the lowest rankings, so in the following figure the lowest weighted average is that service being consistently valued highest by producers that employ an agronomist.

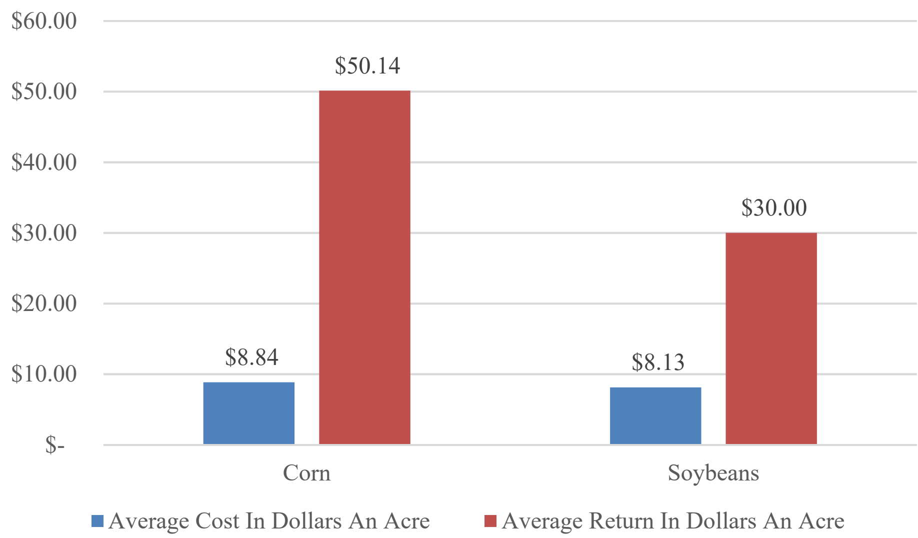
Figure 4.5 Weighted Average of Perceived Value in Agronomic Services



As seen from Figure 4.5, pest management, fertility, and input cost savings are ranked the highest with 2.92, 3.33, and 4.33 respectively. This is closely followed by yield at 4.42 and then there is a larger gap between the top four and the middle-ranked services. The least valued are other, adverse conditions reporting, and outside opinion at 9.92, 7.83, and 5.92, respectively. The average cost for agronomic services on corn and soybeans is $8.84 and

$8.13 respectively. Returns estimated by producers averaged $50.14 on corn and $30.00 on soybeans (Figure 4.6).

Figure 4.6 Average Cost and Return per Acre for Agronomic Services



The difference between cost and returns per acre in corn is $41.30 and in soybeans is $21.87. Consistently producers estimated that they receive more value from agronomic services than the cost. It is possible to hypothesize the regressions independent variables signs.

4.2 Regression Estimation Expected Signs

The regression variables in the model are as follows:

Y=f(X1, X2, X3, X4, X5, X6, X7) where

Y = Probability of producer employing an agronomist (dependent variable)

X1 = Producer Age;

X2 = Producer Education Level;

X3 = Location of Operation;

X4 = Off-Farm Income;

X5 = Size of Operation in Acres;

X6 = Percentage of Crops to Livestock; and

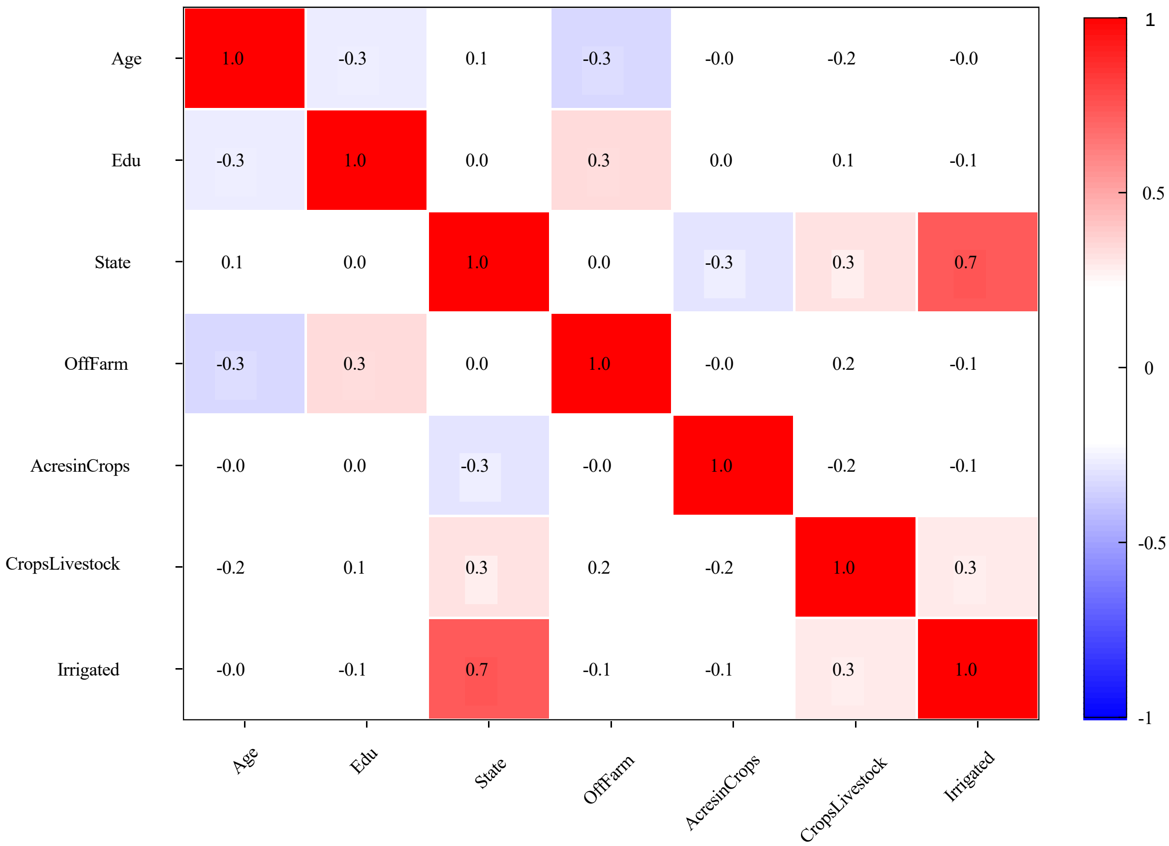
X7 = Percentage of Irrigated to Non-irrigated Cropland.

Age has little difference when looking above and below the mean at producers that employ an agronomist. One would estimate that it has a positive sign but is not a large factor. Education level has significant differences in whether a producer employs an agronomist, and one would expect a positive sign. Location split between in Nebraska and out of state has significant differences and one would expect that farming in Nebraska would increase the likelihood of hiring an agronomist. Producers with off-farm income had a much higher percentage contracting with an agronomist so one would expect off-farm income to have a positive correlation with the likelihood of a producer employing a crop consultant. Size of operation, as discussed earlier was surprising but would be expected to have a negative correlation with the likelihood of hiring an agronomist. Percentage of crops to livestock would be expected to have a negative correlation but is also a variable that one would expect to have a smaller effect on the dependent variable from the summary statistics. Percentage of irrigated to non-irrigated cropland is expected to have positive correlation, or as irrigation increases so does the probability of one employing an agronomist.

4.3 Correlation Matrix for Independent Variables

Before discussing the regression estimation, it is essential to discuss the variables excluded from the model. All the variables discussed previously were included with the exception of the location variable.

Figure 4.7 Independent Variables Correlation Matrix



It is evident from Figure 4.7 that the independent variables of state and irrigated acres are highly correlated. From the descriptive statistics section, it is evident that there were many producers that responded to the survey from Nebraska, and a smaller portion of producers that responded to the survey from numerous other states. Since this variable was a dummy variable, it was logical to break the variable into producers in the state of Nebraska and producers out of the state of Nebraska. Since Nebraska is a heavily irrigated state, there was a correlation between location and percentage of acres irrigated. Preferring to use the numerical independent variable of percentage of cropland that is irrigated, the location variable was excluded from the final regression estimations.

4.4 Regression Estimation Results

In this section the regression estimation results are presented and interpreted. The stronger of the two equations was model 1. There are 34 observations in each model because there are incomplete answers for education and percentage of crops to livestock variables for some observations. The general fit of the model is discussed, then the signs of the non-statistically significant variables, and finally the statistically significant independent variables.

Table 4.3 Probability of Contracting with an Agronomist in Levels

	Coefficient	*Std. Error*	*z*	*p-value*	
const	−1.16953	2.23736	−0.5227	0.6012	
Irrigated	0.0274392	0.0126630	2.167	0.0302	**
CropsLivestock	−0.0367941	0.0218324	−1.685	0.0919	*
AcresinCrops	6.86373e-05	0.000292080	0.2350	0.8142	
OffFarm	1.95731	1.05677	1.852	0.0640	*
Edu	1.02759	1.17018	0.8781	0.3799	
Age	0.0258259	0.0320090	0.8068	0.4198	

Mean dependent var	0.558824	S.D. dependent var	0.503995
McFadden R-squared	0.202563	Adjusted R-squared	-0.097465
Log-likelihood	−18.60514	Akaike criterion	51.21028
Schwarz criterion	61.89480	Hannan-Quinn	54.85400

** Indicates statistical significance at the 10% level, ** at the 5% level.*

f(beta'x) at mean of independent vars = 0.504
Likelihood ratio test: Chi-square(6) = 9.45205 [0.1497]

The adjusted R-squared statistic is low but is not a good measure of fit in the logistic regression model (Table 4.3). According to Smith and McKenna (2013) "The present study suggested that most commonly used pseudo R^2 indices (e.g., McFadden's index, Maddala / Cox-Snell index with or without Nagelkerke correction) yield lower estimates that their OLS R^2 counterparts…Instead, perhaps a unique (and less stringent) set of guidelines may be appropriate for the interpretation of pseudo R^2 values". The McFadden R-squared statistic is between 0.2 and 0.4. Though there are no hard guidelines on interpretation of pseudo R^2 statistics, a value between 0.2 and 0.4 is not uncommon.

The non-statistically significant independent variables are acres in crops, age, and education level. Acres in crops was predicted to have a negative correlation with the dependent variable after examining the descriptive statistics, though it has a positive sign in the regression model. Age was predicted to have a positive correlation with the dependent variable and has a positive sign in this model. Finally, education level was predicted to have a positive sign and has a positive sign in this model.

The independent variables with statistical significance are percentage of cropland that is irrigated, percentage of crops compared to livestock in an operation, and off-farm income. The percentage of cropland that is irrigated has a positive sign and was expected to have a positive correlation with the dependent variable. This is the most statistically significant variable at the 95% confidence level. A one standard deviation change will change the variables coefficient by 48%. This is the smallest percent change of the three statistically significant independent variables. The percentage of crops to livestock in an operation variable has a negative sign that was expected. This variable is statistically significant at the 90% confidence level. Its coefficient value is -0.037. Off-farm income is the third statistically significant variable. It was expected to have a positive sign. In this model the off-farm variable has a positive sign and a coefficient of 1.96.

Table 4.4 Probability of Contracting with an Agronomist in Logs

	Coefficient	*Std. Error*	*z*	*p-value*	
const	4.25408	7.60571	0.5593	0.5759	
Log of Age	0.690178	1.31378	0.5253	0.5993	
Log of AcresinCrops	−0.0560311	0.365144	−0.1534	0.8780	
Log ofCropsLivestock	−2.20844	1.34039	−1.648	0.0994	*
Log of Irrigated plus 1	0.579095	0.249181	2.324	0.0201	**
OffFarm	1.79148	1.05417	1.699	0.0892	*
Edu	1.02304	1.13971	0.8976	0.3694	

Mean dependent var	0.558824	S.D. dependent var	0.503995
McFadden R-squared	0.222701	Adjusted R-squared	-0.077327
Log-likelihood	−18.13530	Akaike criterion	50.27059
Schwarz criterion	60.95511	Hannan-Quinn	53.91432

** Indicates statistical significance at the 10% level, ** at the 5% level.*

f(beta'x) at mean of independent vars = 0.504
Likelihood ratio test: Chi-square(6) = 10.3917 [0.1091]

Table 4.4 contains the estimates of the model where the continuous variables are measured in logs. The adjusted R-squared statistic is low, but it is not a common measure of goodness of fit in the logistic regression model. More importantly the Mcfadden R-squared statistic is between 0.2 and 0.4 which is common.

Age, education, and acres in crops are not statistically significant. The irrigation variable is the variable plus 1 so that it can be logged since some producers are 0% irrigated. Age and education have positive signs and were expected to have positive signs. Acres in crops has a negative sign and was expected to have a negative sign. As noted, these variables are not statistically significant.

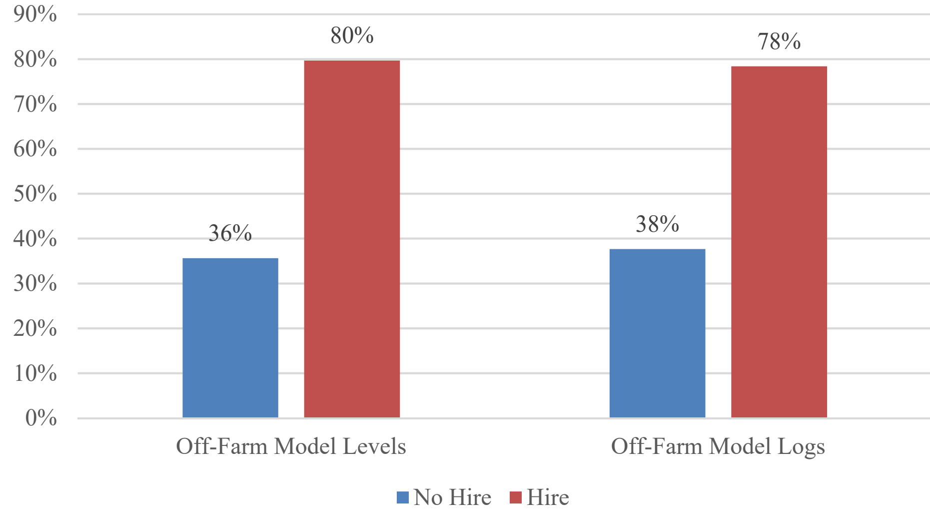
The statistically significant variables are irrigated acres at the 95% statistical significance level, and crops to livestock and off-farm income at the 90% statistical significance level. These are the same variables that the levels model found statistically significant. Also similar to the levelsmodel, crops to livestock has a negative sign while irrigated acres and off-farm income both have positive signs, all of which were expected.

The largest difference between the models is in coefficient and standard deviation values. Crops to livestock has a higher coefficient at -2.21 meaning that a one percent increase in crop proportion of an operation decreases the likelihood of a producer hiring an agronomist by 2.21%. The irrigation variables coefficient is 0.579 meaning a 1% increase in proportion of acres irrigated increases the likelihood of a producer hiring an agronomist by 0.579%, and off-farm incomes coefficient is 1.791 meaning a producer having off-farm income increases a producer's likelihood of hiring an agronomist by 1.791%. It is important to note that these coefficients cannot be directly comparable without further analysis.

4.5 Change in Probability as the Independent Variables Change

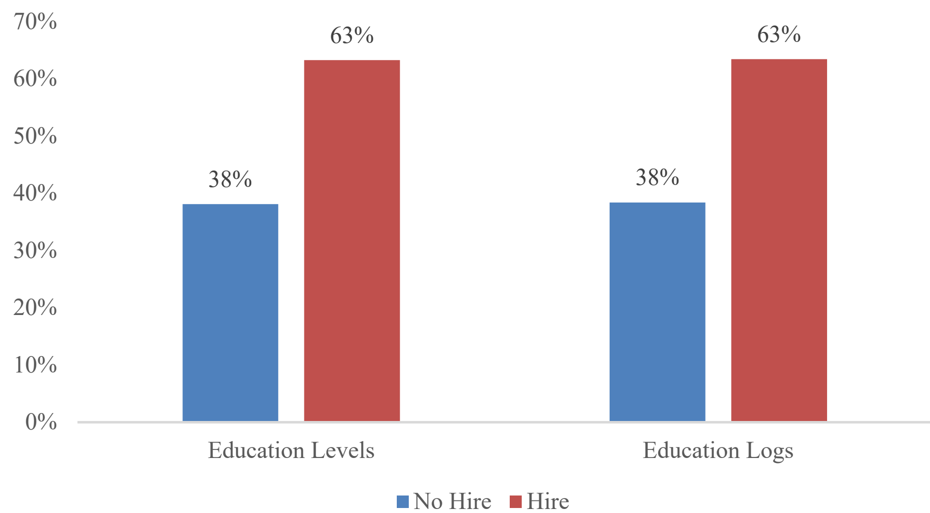
This section examines the change in probability of a producer employing an agronomist as individual variables change all else held constant. This is computed by changing the value of the variable through a range, holding the other variables constant, and tracking the probability that the regression equation produces. Comparing the variables across models shows similarities and differences between the models. This examination is based on the method used by (Featherstone, Roessler and Barry 2006).

Figure 4.8 Off-Farm Income Probability Change for Hiring an Agronomist



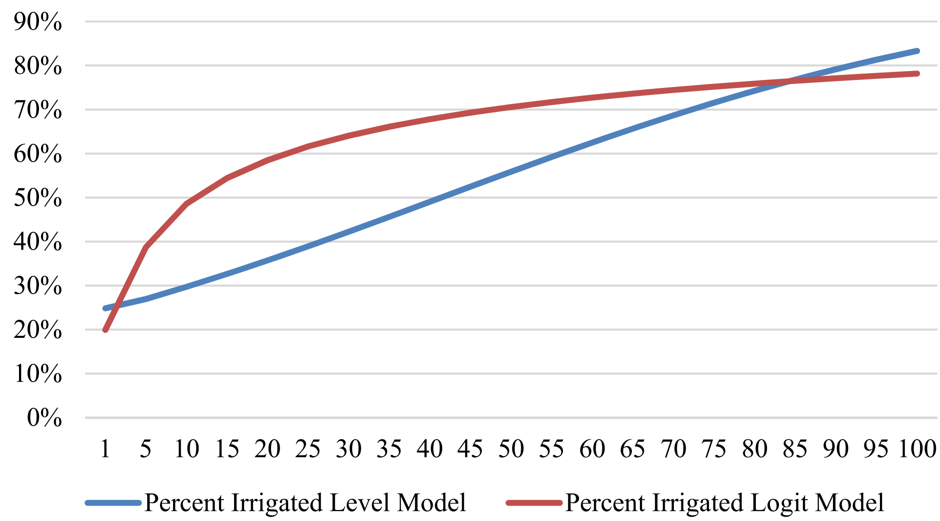
In the levels model, off-farm income has a greater effect on the probability that a producer will contract with an agronomist than the log model. The change from 36% to 80% and 38% to 78% respectively is relatively large. This variable behaved similarly in both models. Off-farm income was statistically significant at the 10% confidence level in both models.

Figure 4.9 Education Probability Change for Hiring an Agronomist



There was no change in the probability of a producer employing an agronomist based on education from the levels to the log model. In each model obtaining education past the high school level increased a producer's probability of employing an agronomist. This variable was not statistically significant in either model and it has less of an effect on the final probability than off-farm income that was statistically significant.

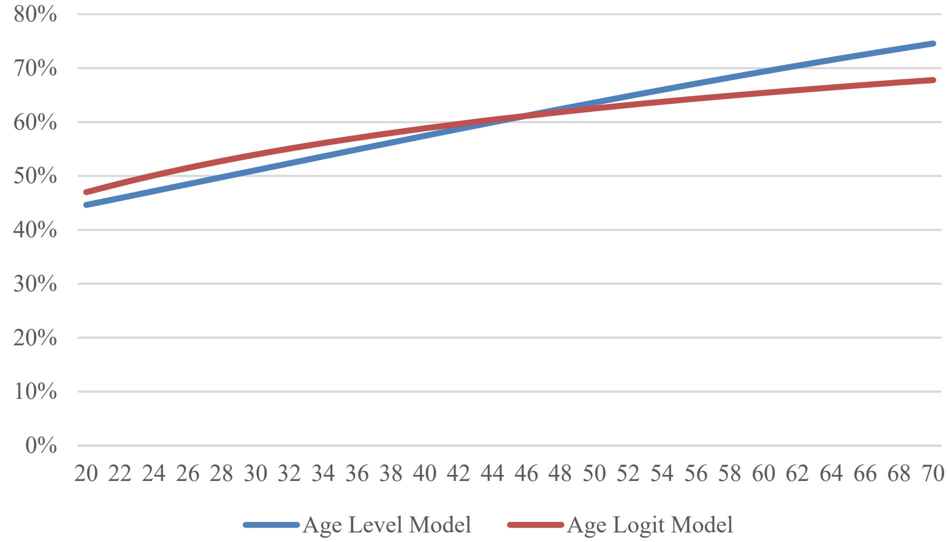
Figure 4.10 Irrigation Percentage Probability Change for Hiring an Agronomist



The irrigation variable and the following three variables were estimated in levels in model 1, and they were in their log form in model 2. The x axis shows the range of the independent variable.

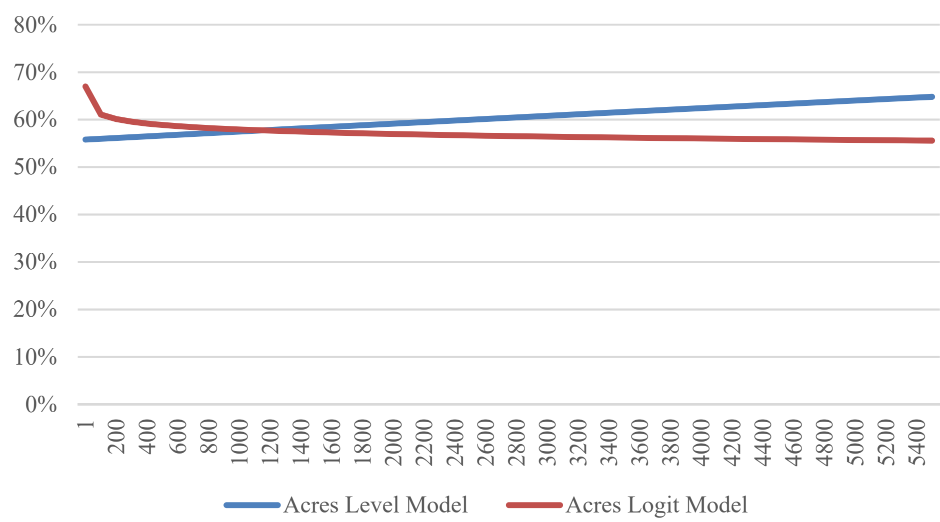
In the levels model, the probability change for a change in the percent irrigation value is more linear than in the log model. In each model this variable has a similar change in range, but in the log model much of the change in probability happens when the variable is between 1% and 50% irrigated.

Figure 4.11 Age Probability Change for Hiring an Agronomist



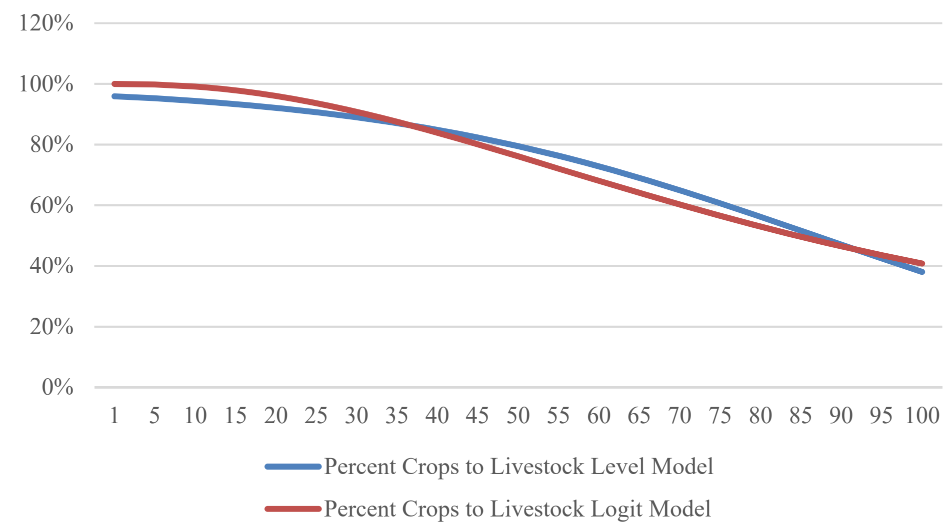
The age variable was estimated at values 20 through 70. At 20 (corresponding log of 2.996) the age variable gives the level and the log models 45% and 47% probability of employing an agronomist respectively. At the age of 70 the levels and the log models have probabilities of 75% and 68% respectively. This was not a statistically significant variable, but it does behave similarly in both models.

Figure 4.12 Acres Probability Change for Hiring an Agronomist



The acres variable sign changes from the levels to the log models. In the log form there is accelerated change in probability at the lower extreme, then it tracks inversely to the acres variable in the levels model. This variable would have benefitted from more observations as it was not statistically significant.

Figure 4.13 Percentage Crops to Livestock Probability Change for Hiring an Agronomist



Percentage crops to livestock is the final independent variable and was statistically significant at the 10% level in both models. From levels to the logs the percentage of crops to livestock has a similar impact on probability of a producer hiring an agronomist all else held the same. A low percentage of crops compared to livestock gave a producer a high likelihood of employing an agronomist while a higher percentage of crops reduced the likelihood of a producer employing an agronomist. In the level model and the log model these variables range of probability change were 38 to 96% and 41 to 99.9% respectively. In summary, most variables behaved similarly from the level to the log model, but the change in probability of a producer employing an agronomist happened throughout the variable range in the levels model. In the log model more change in probability was observed initially and less as the variable changed more. The results were robust between the two models.

CHAPTER V: SUMMARY AND CONCLUSIONS

5.1 Summary

The objective of the study was a market analysis of agronomic services and customer value perceptions of those services. Phrased as a question; what factors influence a producer's decision to hire a specialized agronomist and what value do they perceive in this action? The statistically significant variables that influence a producer's decision most are off-farm income, percent of acres irrigated, and percent of crops to livestock in an operation. These variables are operation structure related and producer demographic variables are less influential. Producers employing an agronomist perceive the highest value in weed and pest management, fertility planning, and cost savings on inputs. Inversely the least value are the other, adverse condition reporting, and outside opinion variables. The review of literature gave a backdrop to the importance of agronomy in agriculture. It shaped the method that the data was examined and helped formulate the questionnaire sampling procedure.

Summary statistics led to an assessment of the independent variables influence on the dependent variable. They also showed that demographics such as age and education were less important than independent variables focusing on the particular operation. The value perception piece, a sub-objective of the study, had less responses but did show a trend. Of twelve observations producers valued weed and pest management, fertility, and input cost savings highly. They consistently valued expertise, miscellaneous, and adverse conditions such as weather damage reporting low. An analysis of cost to returns showed that on average a producer estimated returns of agronomic services on corn at $50.14 an acre and on soybeans $30.00 an acre. The average cost of agronomics on corn is $8.84 and on soybeans is $8.13.

Both regression models reported on were binary logit models. Model 2 had logs of the variables that this was possible while model 1 was estimated in levels. In both models, the same independent variables were statistically significant. The statistically significant variables were the proportion of crops to livestock in an operation, percentage of crop acres irrigated, and the dummy variable off-farm income. Irrigated acres were the most statistically significant independent variable in both models at 95%.

The examination of probability change of a producer employing an agronomist from the levels model to the log model showed that most variables had similar ranges of probability change, but their effects were higher at first in the log model and more evenly spread out across the range in the levels model.

5.2 Conclusions and Suggestions for Further Research

Irrigation was an indicator of a producer hiring a specialized agronomist. This makes sense considering that irrigated cropland is more costly than dryland cropland. When pushing yields higher there is more downside risk in a proportionally lower yield than average. Producers in that situation essentially get more from an agronomist than a producer growing crops on the same amount of lower productivity acres would. Off-farm income and percentage of an operation in crops compared to livestock work in tandem. As a producer becomes focused only on crop production, they are less likely to hire an agronomist. A producer that has a higher percentage of crops to livestock and does not have off-farm income or an otherwise more fully invested producer is less likely to hire a crop consultant than a producer splitting their time between alternative income streams. In the summary statistics, it was also seen that a producer farming a larger number of acres was less likely to employ an agronomist farther supporting this trend. The types of variables that were statistically significant were operation variables and less about demographics suggesting that how an operation is set up has more effect on this decision than who the producer is, speaking in a general sense. This information is valuable for agronomists knowing what type of operation is most likely to find value in their services. It is also more valuable to producers than previously thought because producers that hire an agronomist is not the simple demographic question as originally hypothesized, but rather a question of operation structure and how they want to structure their time and resources.

Crop consultants can use the results of this research to focus on the types of operation structures their producers have, and in doing so can see which types of operation they bring benefit too. A commonality in this study is that producers with alternative time uses or revenue streams, such as off-farm income or livestock operations, had higher opportunity costs in agronomic work. Because of this they were more likely to outsource some of the row crop management.

The largest limitation to the study was the difficulty in getting a large sample size.. With a larger sample size and more geographic diversity, along with more results from each geographic, a researcher might draw more conclusions from the research. Certainly, there would be summary statistics comparing both the dependent variable and the other independent variables to location.

Suggestions for future research would be improving the sampling method to increase the sample size of survey respondents. From the statistically significant independent variables, it would also be advisable to focus on operation structure more than on producer demographics.

REFERENCES

Armstrong, J. Scott., and James G. Andress. 1970. "Exploratory Analysis of Marketing Data: Trees vs. Regression." *Journal of Marketing Research* 487-492.

Baye, Michael R., and Jeffrey T Prince. 2020. *Managerial Economics and Business Strategy, Eighth Edition.* McGraw-Hill.

Burinskiene, Marija, and Vitalija Rudzkiene. 2007. "Application of logit regression models for the identification of market segments." *Journal of Business Economics and Management* 253-258.

Constantin, Cristinel. 2015. "Using the Logistic Regression model in supporting decisions of establishing marketing strategies." *Bulletin of the Transilvania University of Brasov.*

Featherstone, Allen M., Laura M. Roessler, and Peter J. Barry. 2006. "Determining the Probability of Deffault and Risk-Rating Class for Loans in the Seventh Farm Credit District Portfolio." *Review of Agricultural Economics* 4-23.

Handcock, Mark S., and Krista J. Gile. 2011. "Comment: On the concept of snowball sampling." *Sociological Methodology* 367-371.

Kik, M. C., G. D. H. Claassen, M. P.M. Meuwissen, A. B. Smit, and H. W. Saatkamp. 2021. "The economic value of sustainable soil management in arable farming systems - A conceptual framework." *European Journal of Agronomy.*

Lichtfouse, Eric, Mireille Navarrete, Philippe Debaeke, Veronique Souchere, Caroline Alberola, and Josiane Menassieu. 2009. "Agronomy for sustainable agriculture." *Agronomy for Sustainable Development* 1-6.

Mason, Charlotte H., and William D. Perreault, Jr. 1991. "Collinearity, Power, and Interpretation of Multiple Regression Analysis." *Journal of Marketing Research* 268-280.

Ndubisi, Nelson Oly. 2007. "Relationship marketing and customer loyalty." *Marketing Intelligence & Planning* 98-106.

Smith, Thomas J., and Cornelius M. McKenna. 2013. "A Comparison of Logistic Regression Pseudo R^2 Indices." *Multiple Linear Regression Viewpoints* 17-26.

Studenmund, A. H. 2016. *Using Econometrics A Practical Guide.* Boston: Pearson.

APPENDIX A

Part 1; Producer Demographics

Producer Age?

Producer Education Level?

Which state you operate in?

County you primarily operate in?

Part 2; Operation Information

Not including your spouse do you have off-farm income? Yes/No

Amount of acres in crops in your operation?

Percentage of crops to livestock based on final profits.

Crops ___%

Livestock ___%

Percentage of crops that are irrigated.

Irrigated ___%

Non-irrigated ___%

Which best describes the use of an agronomist in your operation?

A) You contract with an outside agronomist in your operation. (Often paid in $/ac.)
B) You employ an agronomist as part of your operation. (Often paid in salary/year)
C) Neither contract nor employ an agronomist in your operation.

Answer C then survey is over.

Part 3; If you answered A on the previous question

What is the annual cost in $/acre of agronomic services for your operation?

Corn ____$/acre

Soybeans ____$/acre

Alfalfa ____$/acre

Wheat ____$/acre

Other_________ ____$/acre

What is the annual estimated return in $/acre of agronomic services for your operation?

Corn ____$/acre

Soybeans ____$/acre

Alfalfa ____$/acre

Wheat ____$/acre

Other_________ ____$/acre

Please rank those that you view as being the most important/giving return to your operation up to 10 (1 being the most important/valuable).

Cost savings on inputs ____

Time savings/increase efficiency ____

Irrigation Management ____

Weed & Pest Management (includes disease) ____

Crop Planning ____

Fertility ____

Yield Added ____

Outside Opinion ____

Adverse Condition Reporting (weather etc.) ____

Other/Misc. Benefit ____

Part 3; If you answered B on the previous question

What is the annual cost in salary per year of agronomic services for your operation?

What is the annual estimated return in $/acre of agronomic services for your operation?

Corn ____$/acre

Soybeans ____$/acre

Alfalfa ____$/acre

Wheat ____$/acre

Other_________ ____$/acre

Please rank those that you view as being the most important/giving return to your operation up to 10 (1 being the most important/valuable).

Cost savings on inputs ____

Time savings/increase efficiency	____
Irrigation Management	____
Weed & Pest Management (includes disease)	____
Crop Planning	____
Fertility	____
Yield Added	____
Outside Opinion	____
Adverse Condition Reporting (weather etc.)	____
Other/Misc. Benefit	____