Farm Resilience, Management Practices, and Producer Sentiment: Segmenting U.S. Farms Using Machine Learning Algorithms

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Abstract

Farm managers exhibit a broad spectrum of capabilities, ranging from tech-savvy, strategically focused managers, to those grappling with operational challenges. Our study uses survey data from 403 U.S. commercial producers to investigate disparities in producer sentiment and farm characteristics. Specifically, utilizing various supervised and unsupervised machine learning techniques, we uncover farm characteristics with the most pronounced variations in responses. These key characteristics are considered when implementing a clustering algorithm to categorize farms into distinct groups. Wards Hierarchical Clustering and Fisher's Exact tests are used to cluster farms and determine the significance of differences in characteristics across the three constructed clusters. Results display varying levels of resilience to strategic risk, managerial ability, producer sentiment, technology adoption, and demographics among commercial farms. In particular, we observe a tradeoff among farms in regard to management ability and farm resilience. Farms with the highest resilience levels tend to show slightly lower managerial abilities. Conversely, those with the greatest managerial abilities have slightly poorer farm resilience. The third group of farms, which makes up 48% of our sample displays the lowest levels of farm resilience, technology adoption, managerial abilities, and has the poorest growth expectations.

Introduction

The agricultural industry is riddled with an array of challenges, ranging from inconsistencies in farm management practices to issues of resilience and overall performance. Farm managers find themselves surrounded by rapid technological advancements and increasing globalization, causing the agricultural sector to evolve at an unprecedented pace. Concurrently, increasing frequency of natural disasters serve as a reminder of the vulnerability and risks associated with farming. As the agricultural industry continues to evolve, it's clear that exogenous shocks farms face will increase in prevalence. These challenges not only pose significant threats to longevity and performance of individual farming operations, but also to the future of production agriculture and global food security. Considering these issues, it is pivotal to understand what sets exceptional operations apart, and how struggling farms can improve.

This research categorizes farms into distinct segments based on management practices, resilience to strategic risk, and additional farm characteristics. The analysis section begins by identifying traits that are correlated among farming operations, the magnitude, and sign of correlations. Emphasis is placed on factors such as management proficiency and farm resilience, as these are pivotal in differentiating between good and exceptional agricultural operations. By uncovering the factors that separate groups of producers, we strive to identify key contributors to farm success and, conversely, discern early indicators of a farm's potential decline.

Throughout this study we will examine characteristics which determine how farms are categorized, bringing to light the interactions between management strategies, technological integration, and adaptability in the face of uncertainties. We strive to improve understanding of the current farming landscape and equip farm operators with insights that are crucial for resilience in an ever-evolving business environment.

Review of Prior Literature

Agriculture and related industries contribute approximately $1.264 trillion to annual gross domestic product within the United States and employ around 10.4% of the population (USDA-ERS, 2023). Moreover, investment in agriculture, particularly on a national level, is a major means of improving our knowledge base and efficiency, ensuring stability, and reducing risk for farming operations. However, trends in our survey data indicate that 50% of producers from nationwide survey still lack a comprehensive resource and knowledge base pertaining to farm management and risk mitigation strategies, particularly in regard to strategic risk management.

Risk can be defined as the variability in possible outcomes or the chance of loss. The first step in managing risk is to identify and classify prospective risks (Crane et al., 2013). Major sources of risk include production risk, marketing risk, financial risk, legal risk, human risk, and strategic risk. Agricultural risk management typically focuses on short-term risks associated with production, marketing, and financial risk. Production risk emanates from weather, climate change, pests, diseases, technology, and input quality. Changes in supply and demand fundamentals lead to fluctuations in input and output prices, or marketing risk. Financial risk involves items such as the cost and availability of capital, the ability to meet cash flow needs, and the ability to maintain and grow equity. Thus, much of the prior research on managing risk in agriculture focuses on the same general concepts, market volatility, price, yield, and revenue risks (Patrick, 1998; Tomek and Peterson, 2001; Varangis, Larson, and Anderson, 2002; Velandia et al., 2009). Agricultural programs developed and offered in the United States have been used for decades to address these common sources of risk (Szekely and Palinkas, 2009).

By taking advantage of government programs and crop insurance, agricultural producers may reduce or eliminate some sources of risk (Hardaker et al., 2015). But, other risks, namely strategic risks, remain difficult to mitigate with off the shelf risk management tools. Strategic risks are unique in that they arise from a variety of sources including changes in government policy and consumer preferences, climate change, and technological uncertainties. Neither private markets nor government programs have developed mitigation strategies for negative effects of strategic risk (Aimin, 2010), forcing farm operators to constantly evaluate how strategic risks will impact their operations. A possible explanation for the lack of resources on managing strategic risk is presented by Boehlje (2003), stating that strategic risks are often overlooked because they are perceived to have low probability of occurrence compared to the frequency of other sources of risks. However, with increases in international trade and industrialization of agriculture, what were once low probability risks are becoming increasingly important.

Realization of these “low probability” risks have destabilized agricultural markets in recent years, creating high levels of uncertainty. Recent examples include price volatility from trade wars, supply chain issues stemming from the war between Russia and Ukraine, and market shocks caused by the Covid-19 pandemic - all of which have had significant negative impacts on U.S. agricultural producers (Beckman and Countryman, 2021). These risks will continue to grow in prevalence in future years due to lack of predictability regarding international relations, resource limitations, increased transmissibility of disease, and synchronized crop failures.

With off-the-shelf strategic risk management tools remaining unavailable for farmers (unlike availability of forward pricing commodities, hedging commodities using futures and/or options, locking in input prices for financial, marketing, and production risk), many producers still believe that strategic risks are “unmanageable”. This, however, is a misconception.

Strategic risk management requires a more deliberate approach, namely creating operational resilience (i.e., enhancing farm agility and absorption capacity).

Resilience is "the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a shock or stress in a timely and efficient manner" (Mitchell and Harris, 2012). Strategies to improve farm resilience include maintaining financial savings, shifting production timing to deal with seasonality, and enterprise diversification using agritourism, conservation, and on-farm sales (Crane et al., 2013; Spiegel et al., 2021). Research performed on a sample of European farms find farm resilience is linked to operator age, lower levels of risk aversion, larger farm size, and relatively greater optimism (Spiegel, et al., 2021).

Our research poses a series of six questions on farm agility and absorption capacity to gauge farm resilience to strategic risk within the United States. Agility measures a farm's ability to identify and capture business opportunities more quickly than rivals, while absorption capacity is related to a farm's ability to withstand shocks.

We expect resilience to strategic risk to play a large role in determining which farm enterprises survive and which falter amid increased uncertainties and innovation in agriculture. This study provides an in-depth analysis using data from commercial agricultural producers within the U.S. to analyze how resilience to strategic risk relates back to management practices, risk aversion, adoption of precision agriculture technologies, and producer sentiment. Thus, establishing a precedent for why resilience to strategic risk is critical for farming operations.

Data and Methods

Data for this research was collected via a phone survey between April 3rd-7th, 2023. Survey data was collected from 403 commercial producers, using the same methodology as the *Ag Economy Barometer* (Purdue University, CME Group, 2023). Commercial producers are defined as agricultural producers with an annual market value of production which is equal to or exceeding $500,000.

For this research, data analysis is comprised of three major sections, each strengthening the argument that resilience to strategic risk is a necessity for long-term, successful farm performance. Analysis begins by identifying correlation coefficients between farm characteristics within the pooled survey data. Correlations offer valuable insight into overarching trends within the data and the interplay between farm characteristics. The conclusions drawn from this analysis reaffirm the relationships from prior research, highlighting the connections between producer risk preferences, demographic factors, producer sentiment, farm growth, management practices, and the adoption of precision agriculture technologies. Resilience to strategic risk is then incorporated into the discussion, as it complements findings of prior research and plays a vital role in determining business prospects.

Correlations among variables helps to identify key survey questions within our dataset which significantly impact resilience to strategic risk, as well as those that have minimal relevance. This motivates the next phase of our analysis, where the data set is reduced using variable selection methods. Various variable selection methods are tested, each of which is hypothesized to produce similar results. These include calculations of variance, Principal Component Analysis (PCA), Laplacian Scores (LS), and Random Forest modeling (RF).

Reduction of the data set is critical prior to applying a clustering algorithm. Applying a cluster analysis across all variables would categorize farms by variables which may lack explanatory power. For clustering, hierarchical clustering is used, followed by Fisher's Exact Tests to distinguish differences in means across clusters.

Kendall's Tau Correlation Coefficients

This section of the results has two main focuses. First is to compare correlations between farm growth, managerial ability, risk perception, educational attainment, and operator age to findings from prior research. A comparison of our survey results to prior research ensures our findings align with theoretical and past empirical results. Subsequently, correlations among characteristics are then presented in relation to resilience to strategic risk.

<u>Risk Preference, Farm Growth, Operator Age, and Managerial Ability</u>

Correlations among risk preferences, farm growth expectations, demographic characteristics, and management practices indicate that farmers who are less willing to take on risk, thus categorized as 'risk averse', are hesitant to adopt new farming practices or farm technologies, often have a lack of self-efficacy, are reluctant to engage in social network, maintain large financial reserves, and avoid taking on debt (Sulewski and Kłoczko-Gajewska, 2014; Finger et al., 2022). Negative relationships are also observed between operator age and risk preference, both in on farm and off farm settings (Lins, Gabriel, and Sonka, 1981; Halek and Eisenhauer, 2001). In theory, farmers with less experience and poorer managerial ability try to avoid taking on more risk (Bar-Shira, Just, and Zilberman, 1997; Nuthall, 2009), while farms that are more risk seeking have greater farm growth expectations, wealth (approximated by farm size), education, and superior managerial ability (Bar-Shira, Just, and Zilberman, 1997; Villatoro and Langemeier, 2006).

Risk preferences elicited in this survey corroborate results of prior research, showing positive, statistically significant relationships with farm growth expectations, farm size, managerial ability, use of succession planning, use of written lease agreements, use of variable rate fertilizer application, grid or zone soil sampling, GPS guidance systems, and the use of drones (Table 1).

While risk aversion is related to many farm characteristics, other characteristics including farm growth, operator age, and managerial abilities also display correlations with one another. Survey results show a positive and significant relationship between farm growth, management practices, risk preference, farm size, and adoption of precision agriculture technologies (Table 1). The only variable in which farm growth displayed a negative relationship to at a statistically significant level was operator age. Villatoro and Langemeier (2006) draw a similar conclusion, indicating farm growth rates are negatively related to operator age. In general, operator age displays the most negative relationships with other variables. Statistically significant correlations indicate that increases in operator age are negatively related to managerial ability, use of written lease agreements, use of financial ratios to inform farm decision making, use of crop pricing alternatives, and failure to adopt new precision agriculture technologies, in addition to farm growth (Table 1). Similar results have previously been shown by Daberkow and McBride (2003), finding that older producers are often unaware of precision agriculture technologies, less educated, and farm fewer acres.

Theory on firm competitive advantage, management skills (Itami & Roehl, 1987), and 'knowledge-based theory' attribute knowledge and experience as a catalyst for superior farm performance and a competitive advantage (Grant 1996; Liebeskind, 1999; Spender and Grant, 1996; Nuthall, 2009). Relationships among the survey data corroborate these claims. Managerial ability displays positive, statistically significant relationships with farm growth expectations, farm size, each of the specific management practices, adoption of all listed precision agriculture technologies, and educational attainment (Table 1).

Resilience to Strategic Risk

Correlations among the survey data indicate positive statistically significant relationships between resilience to strategic risk, producer sentiment, farm size, managerial ability, most management practices, and adoption of precision agriculture technologies (Table 2). Resilience displays negative, statistically significant correlations with operator age and respondents that indicated that they did not adopt any of the listed precision agriculture technologies. Producers that are unwilling to adopt new technologies are comparable to those Olsson (1988) categorized as defensive strategists, unwilling to reinvest in the business, characterized by diminishing farm productivity, and low farm resilience to market shocks. Finally, as anticipated, resilience to strategic risk is positively associated with each of the questions on agility and absorption capacity that make up the index. Agility measures a farm's ability to identify and capture business opportunities more quickly than rivals, while absorption capacity is related to a farm's ability to withstand shocks.

We hypothesize that resilience to strategic risk is positively associated with all measures of agility and absorption capacity. This would suggest that producers that perform well across one metric of agility or absorption capacity perform well across most, if not all metrics. Resilience to strategic risk aids producers in obtaining advantageous positioning in an industry filled with uncertainty, lending resilient farms a better ability to bounce back after an external shock and greater ability to withstand these shocks.

Survey questions on agility asked about established goals, objectives, and core values; exploration of new enterprises; and if the business assesses advantages and disadvantages relative to other farms (Table 3). Across the three questions, correlations with other survey variables generally trend together, indicating agility is positively correlated with farm growth, managerial ability, use of financial ratios to make on farm decisions, use of crop pricing alternatives, use of standard operating procedures, use of yield monitors, and use of drones. Operator age was the only variable with a negative correlation to the three agility questions, indicating that older operators are less likely to establish goals, objectives, and core values; to explore new enterprises; or to assess the farm's relative advantages and disadvantages.

Absorption capacity inquired about per unit fixed costs, farm diversification, and balance sheet strength (Table 4). Correlations in survey responses indicate that producers with low per unit fixed costs and high balance sheet strength have greater farm growth expectations, more positive sentiment, greater managerial ability, are less concerned about financial risk, and have a higher cumulative resilience to strategic risk score. Farm diversification displays positive statistically significant relationships with farm growth expectations, managerial ability and resilience to strategic risk, but displays a negative relationship with operator age.

Conclusions from Correlation Coefficients

Positive, statistically significant relationships across all metrics of resilience to strategic risk confirm our initial hypothesis that producers with high resilience perform well across all metrics of agility and absorption, while those that struggle in one area generally perform poorly across many categories. Results imply that resilience to strategic risk, like managerial ability, provides farm operations with distinct competitive advantages. Resilient producers are aware of the negative effects associated with unanticipated market shocks and build buffers against them accordingly. By assessing their farm's position relative to competitors, resilient farms identify weaknesses and opportunities of current and new business ventures. They practice informed decision making, backed by their superior managerial abilities, take advantage of promising new opportunities, and maintain financial buffers to shield against risk.

Variable Selection and Cluster Analysis

Correlation coefficients excel at identifying relationships across variables, but are unable to distinguish which variables capture significant variation within the data set. This results section presents our variable selection strategies and cluster analysis, used to separate farm level data-based similarities in characteristics among farm operator groups. The variables included in the cluster analysis are those identified using variable selection algorithms. Results are presented for each variable selection strategy, compared across strategies, and used to determine which variables should be included in the cluster analysis.

Variance Computations

Variance is often an initial strategy employed for variable selection. From the dataset, it is evident that variance is not comparable across aggregate measures like measures of producer sentiment and the remaining survey questions which have limited ordinal responses (Table 5). Because aggregate measures are calculated for each producer dependent on their responses to five component questions also included in the survey, exclusion of aggregated measures of producer sentiment would not remove information from the data set. Questions evaluating operational threats and identification of major risk sources to the organization exhibit relatively low variance levels across responses (Table 5). These same questions are for the most part uncorrelated with resilience metrics at a statistically significant level. Similarly, questions regarding the adoption of precision agriculture technologies show limited variance, especially in the cases of 'no precision agriculture technologies' and 'adoption of drones'.

Variable Selection: Laplacian Score

Laplacian scores identify uniqueness of variables as well as relative explanatory power with in a data set. Results from calculating Laplacian scores indicate the variables assessing managerial ability and farm resilience to strategic risk are the most important, followed by self-assessed risk preference and education level (Table 5). In contrast, the variables evaluating threats to the organization, identification of major risk sources, and aggregate measures of producer sentiment are of least importance.

Variable Selection: Principal Component Analysis

For variable selection using Principal Component Analysis (PCA), we start by constructing the principal components and creating a scree plot to display the relative explanatory power of each component. An 'elbow' point on the plot indicates when the additional explanatory power of each additional principal component is significantly reduced.

In Figure 1, we observe that after the first five principal components, the additional explanatory power of each variable decreases substantially, providing an ‘elbow’ point. Subsequently, we calculate and rank the cumulative loading values for each constituent variable within these first five principal components, as they are believed to drive variation among the data set.

Variables with the highest loading values are those which capture the greatest variation. From the data set, PCA reveals variables with the lowest cumulative loading values are operational threats, identification of major sources of risks, and operator age (Table 5). These are the candidate variables for removal before clustering the dataset. Conversely, variables with the highest squared loading values include resilience to strategic risk, managerial ability, questions on producer sentiment, and the adoption of precision agriculture technologies.

Variable Selection: Random Forest Modeling

Random Forest (RF) is a classification model used to assess the relative explanatory power of independent variables within a dataset. Variables negatively affecting model performance reduce its ability to predict the dependent variable accurately when included in the model. We conducted various RF model variations using resilience to strategic risk, and each metric of agility and absorption capacity as dependent variables. In regard to resilience to strategic risk farm size, identification of threats to the organization, use of no-till practices, and adoption of some precision agriculture technologies had relatively low importance (Table 6). Across metrics for agility and absorption capacity, results consistently indicate that questions evaluating threats to the operation and those evaluating major risk sources contribute little to no positive explanatory power in the models (Table 7-8)

Conclusions for Variable Selection

Across each metric of agility and absorption capacity, identification of major sources of risk, threats to the operation, and use of no-till practices ranks as having low explanatory power. These findings align with the variables that are uncorrelated at statistically significant levels in Tables 2-4. These results confirm a consistent pattern across various algorithms, including both supervised and unsupervised models.

As a result of these findings, producer data related to operational threats, identification of major risk sources, use of no-till production practices, and aggregate measures of producer sentiment are to be removed before clustering. Aggregate measures of producer sentiment differ in scale in comparison to other variables and are captured elsewhere in the data set, thus they will be removed prior to clustering. While an argument may be made for removing variables on the adoption of precision agriculture technologies, due to their relevance in prior research, significance of correlation coefficients, and our belief that 'no precision agriculture technologies' and 'drones' will create significant separation within the dataset, these variables are retained.

Cluster Analysis

Cluster analysis systematically categorizes farm-level survey data into an optimal number of distinct groups based on shared characteristics, revealing patterns within the data set. Application of a cluster analysis algorithm will determine if there are similarities in levels of risk aversion, farm growth, management practices, sentiment, and the ability to evaluate strategic risk across farms. Removing variables that lack influence in the data set ensures that we are not clustering data arbitrarily, but rather focusing on the aspects relevant to resilience to strategic risk.

A hierarchical clustering algorithm is implemented using Manhattan distances. Various linkage methods were tested, but Ward's clustering algorithm outperforms all others, with an agglomerative coefficient of .931. Alternate methods have much lower agglomerative coefficient values indicating poor fit (Boehmke & Greenwell, 2020). These include the single linkage method with a coefficient of .440 and complete linkage with a .774 coefficient value.

Clustering the data set results in three primary clusters. The dendrogram is shown in Figure 2, and cluster summaries are presented in Tables 9-12. The three clusters are as follows: Cluster 1 (n = 102), Cluster 2 (n = 102), and Cluster 3 (n = 199). Notably, the two smaller clusters (Cluster 1 and 2) exhibit higher resilience to strategic risk (Table 9) and a more positive outlook on the state of the agricultural economy (Table 10).

Farms in Clusters 1 and 2 demonstrate greater levels of risk aversion, higher expectations for farm growth, larger farm size, higher educational attainment, and a higher proportion of younger operators (Table 11). Operators in these clusters tend to implement more management practices, including the use of written lease agreements, financial ratios for decision-making, and the documentation of standard operating procedures (Table 12).

Farms categorized in Cluster 3 represent approximately 50% of our nationwide sample. Within this cluster, over 89% of farmers exhibit average or below-average managerial abilities compared to other farms. Similarly, these farms show the lowest resilience to strategic risk, with 100% reporting average or below-average resilience levels, the highest levels of risk aversion and the lowest adoption rates for precision agriculture technologies.

Differences in Means Across Clusters (Fisher's Exact Test)

Fisher's Exact Tests identify differences in means across clusters. Results of the Fisher's Exact Tests (Table 9-12) demonstrate clusters differ significantly in terms of all metrics for resilience to strategic risk, several metrics for producer sentiment, risk aversion, farm growth expectations, farm size, operator educational attainment, operator age, all management practices, and adoption of all precision agriculture technologies.

Cluster 3 holds particular interest due to its representation of approximately 50% of the sampled farms. These farms perform relatively poorly in comparison to the other 50% regarding resilience to strategic risk, growth expectations, and managerial acumen. These farms also adopt less precision agriculture technologies and display a higher aversion to risk. On average, these farms are smaller, have older operators, and have operators with relatively lower levels of education.

Cluster 1 and Cluster 2 both demonstrate relatively strong performance; however, they have intriguing differences from one another. Notably, a tradeoff is evident between these groups regarding managerial ability and resilience to strategic risk. In Cluster 1, 66% of respondents exhibit high resilience to strategic risk, while 34% display medium resilience levels. In contrast, Cluster 2 shows 1% with high resilience and 84% with medium resilience.

Regarding managerial ability, Cluster 1 comprises 29% of respondents with above-average managerial ability and 66% with average managerial ability. On the other hand, farms in Cluster 2 have 52% with above-average managerial ability and the remaining 48% with average abilities. Both clusters excel in terms of resilience and managerial abilities in comparison to farms in Cluster 3 but have different operational priorities. Cluster 1 allocates greater resources to building long-term resilience, while Cluster 2 focuses on refining current management practices.

These findings align with the research of Olsson (1988) and Hardwood (1999). Respondents in Cluster 2 encompass the highest proportion of individuals who self-identify as having the lowest risk aversion, hence exhibit the most risk seeking behavior. These farms also boast the highest adoption rates of precision agriculture technologies, corresponding to Olsson's 'entrepreneurs' category.

In contrast, farms in Cluster 1 possess slightly lower managerial abilities, higher resilience to strategic risk, slightly lower risk appetite, and slightly lower adoption rates for precision agriculture technologies. These farms are what Olsson (1988) categorizes as 'cautious strategists'. Farms in Cluster 1 have highly competent and methodical farm managers but tend to be more reserved when making business decisions.

Cluster 3 reflects farms with significantly lower success rates. These farms align with the 'defensive strategists' category, as described by Olsson (1988), demonstrating reluctance to take on risk, adopt new technologies, or expand their operations. They tend to have lower levels of education and a greater proportion with below-average managerial abilities. According to

Olsson (1988), such farms often fail to reinvest in the entity, resulting in diminishing returns and the eventual loss of the business.

Conclusions

Correlation coefficients draw a consensus among our survey data and prior literature, indicating managerial abilities, risk aversion, operator age, and education are all deeply intertwined. Each of these characteristics display positive relationships with one another, with the exception of operator age. Along with these factors, correlation coefficients clearly demonstrate resilience to strategic risk, measured by agility and absorption capacity, is positively and significantly correlated with managerial abilities, education, and producer sentiment.

Variable selection methods indicate a farm's identification of threats to their operation and use of cover crops fail to capture significant levels of variation in survey responses across farms. Thus prior to applying a clustering algorithm, these variables and aggregate measures of producer sentiment were removed from the data set.

Clustering algorithms categorized farms into three distinct segments, each of which differs from the others at statistically significant levels. Cluster 1 and Cluster 2 together represent approximately 50% of our sample of U.S. commercial farms. These farms are well-managed and exhibit strong resilience to strategic risks. Operators in these clusters allocate significant resources to enhance their managerial abilities and prepare their operation to withstand exogenous shocks. Among these businesses, 70% plan to expand their operations over the next five years, over 94% actively evaluate opportunities that new enterprises may offer, and over 94% maintain strong balance sheets.

The remaining 50% of farms fall into Cluster 3. On average, these farms demonstrate much lower resilience to strategic risk and have lower managerial abilities. Less than 35% of farms in this group make financial decisions based on ratios, fewer than 35% plan to expand their operations within the next five years, and 59% of these farms lack succession plans. Cluster 3 exhibits the lowest adoption rates for precision agriculture technologies across all surveyed technologies and the highest levels of risk aversion. The differences across clusters highlight clear discrepancies in management practices, resilience to strategic risk, and overall farm performance.

Domestic agricultural production is a matter of homeland security within the United States. Agriculture in the U.S. provides a significant amount of stability, cultural identity, and economic prosperity. Yet our research based on a sample of over 400 commercial producers indicates that on average approximately 50% of producers struggle to effectively manage their operations, lack sufficient resilience to weather strategic risks, and possess relatively poor growth prospects. For the pivotal role agriculture plays in U.S. culture, stability, and economic prosperity, there certainly remains a disconnect between sufficient investment in agriculture, research and development, and educational programs which would yield improvements to business management, performance, and resilience for agricultural producers.

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Figure 1: PCA Scree Plot

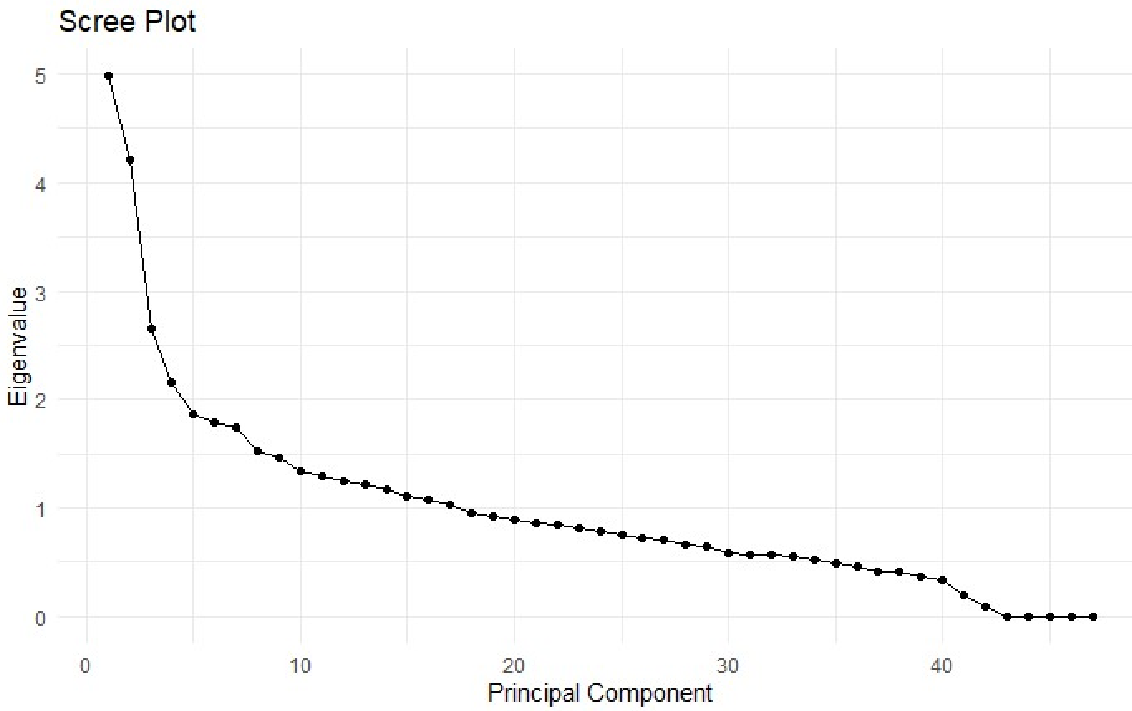

Figure 2: Cluster Dendrogram

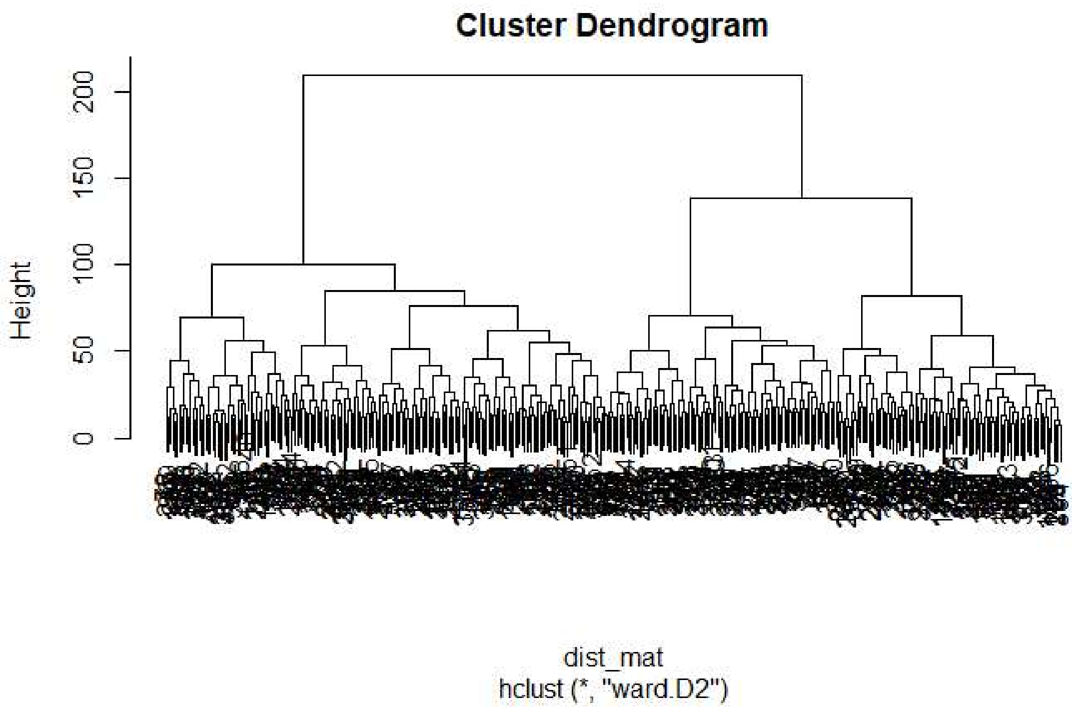

Table 1: Correlation Coefficients; Testing Established Relationships

	Self Reported Risk Preference	Farm Growth	Operator Age	Managerial Ability
Farm Growth				
Opportunities to Expand	0.094*	0.286***	-0.084*	0.088*
Farm Growth	0.127**	1***	-0.307***	0.186***
Risk Preference				
Self Reported	1***	0.127**	-0.054	0.08*
Neighbors Opinion	0.393***	0.168***	-0.134**	0.049
Demographics				
Ag Economy Barometer	-0.037	0.089*	0.012	0.003
Index of Current Conditions	-0.017	0.092*	0.007	0.032
Index of Future Expectations	-0.022	0.07•	0.01	-0.019
Farm Size	0.084*	0.157***	-0.064	0.202***
Education	0.011	0.074•	-0.047	0.14***
Operator Age	-0.054	-0.307***	1***	-0.1*
Management Practices				
Managerial Ability	0.08*	0.186***	-0.1*	1***
Succession Planning	0.079•	0.069	0.05	0.481***
Use of Written Lease Agreements	0.095*	0.166***	-0.112*	0.424***
Use of Agronomic Consultants	0.015	0.055	-0.065	0.404***
Use of Financial Ratios	0.065	0.201***	-0.127**	0.504***
Use of Crop Pricing Alternatives	0.043	0.121**	-0.122**	0.548***
Use of Standard Operating Procedures	-0.012	0.042	-0.006	0.457***
Precision Ag Technologies				
VRT fertilizer application	0.108*	0.078•	-0.055	0.206***
Grid or zone soil sampling	0.152**	0.174***	-0.073	0.134**
GPS guidance	0.099*	0.091*	-0.045	0.176***
Yield monitor	0.075	0.142**	-0.072	0.239***
Drones	0.203***	0.166***	-0.025	0.159***
None	-0.012	-0.088*	0.077•	-0.175***
Significance Levels: p < .001 '***' p < .01 '**' p < .05 '*' p < .1 '•'				

Table 2: Correlation Coefficients for Resilience to Strategic Risk

	Resilience to Strategic Risk
Farm Growth	
Opportunities to Expand	0.101*
Farm Growth Expectation	0.199***
Risk Preference	
Self Reported	0.111**
Neighbors Opinion	0.111**
Demographics	
Ag Economy Barometer	0.071•
Index of Current Conditions	0.066•
Index of Future Expectations	0.051
Farm Size	0.096*
Education	0.039
Operator Age	-0.104**
Operational Threats	
Low Market Prices	0.020
High Input Costs	-0.011
Extreme Weather Events	-0.008
Limited Ability to Find Skilled Labor	0.047
Geopolitical Conflict	-0.049
Identification of Major Risk Sources	
Financial Risk	-0.056
Legal Risk	0.056
Marketing Risk	0.031
Production Risk	0.028
Strategic Risk	0.028
Human Risk	-0.003
Management Practices	
Managerial Ability	0.175***
Succession Planning	0.098*
Use of Written Lease Agreements	0.038
Use of Agronomic Consultants	0.084•
Use of Financial Ratios	0.151***
Use of Crop Pricing Alternatives	0.138**
Use of Standard Operating Procedures	0.126**
Precision Ag Technologies	
VRT fertilizer application	0.046
Grid or zone soil sampling	0.05
GPS guidance	0.029
Yield monitor	0.061
Drones	0.085*
None	-0.089*
Strategic Risk	
Resilience to Strategic Risk	1***
Established Goals, Objectives, & Core Values	0.467***
Exploration of New Enterprises	0.501***
Assess Advantages/Disadvantages	0.45***
Low Per Unit Fixed Costs	0.447***
Farm Diversification	0.429***
Balance Sheet Strength	0.448***
Significance Levels: p < .001 '***' p < .01 '**' p < .05 '*' p < .1 '•'	

Table 3: Correlation Coefficients for Agility Metrics

	Established Goals, Objectives, & Core Values	Exploration of New Enterprises	Assess (Dis)Advantages
Farm Growth			
Opportunities to Expand	0.003	0.079•	-0.001
Farm Growth	0.106*	0.238***	0.129**
Risk Preference			
Self Reported	0.047	0.109**	0.162***
Neighbors Opinion	0.046	0.162***	0.05
Demographics			
Ag Economy Barometer	-0.012	0.023	-0.047
Index of Current Conditions	0.068	-0.009	-0.031
Index of Future Expectations	-0.055	0.030	-0.057
Farm Size	0.053	0.082•	0.022
Education	0.014	0.004	0.049
Operator Age	-0.077•	-0.151***	-0.083*
Operational Threats			
Low Market Prices	0.024	-0.034	0.033
High Input Costs	-0.001	0.051	0.019
Extreme Weather Events	-0.018	-0.042	-0.020
Limited Ability to Find Skilled Labor	0.018	0.076	-0.088•
Geopolitical Conflict	0.024	0.008	0.018
Identification of Major Risk Sources			
Financial Risk	-0.022	0.035	0.114*
Legal Risk	0.057	0.009	0.059
Marketing Risk	-0.005	0.009	0.021
Production Risk	0.036	0.016	-0.052
Strategic Risk	0.009	0.067	-0.06
Human Risk	-0.036	-0.05	-0.03
Management Practices			
Managerial Ability	0.136**	0.214***	0.092*
Succession Planning	0.089•	0.087•	0
Use of Written Lease Agreements	0.003	0.060	0.028
Use of Agronomic Consultants	0.036	0.075	0.031
Use of Financial Ratios	0.106*	0.195***	0.134**
Use of Crop Pricing Alternatives	0.135**	0.151**	0.086•
Use of Standard Operating Procedures	0.159***	0.212***	0.077•
Precision Ag Technologies			
VRT fertilizer application	0.062	0.063	0.007
Grid or zone soil sampling	0.033	0.11*	0.056
GPS guidance	0.048	0.022	-0.038
Yield monitor	0.095*	0.084•	-0.026
Drones	0.096*	0.153**	0.056
None	-0.054	-0.072	-0.054
Strategic Risk			
Resilience to Strategic Risk	0.467***	0.501***	0.450***
Established Goals, Objectives, & Core Values	1***	0.318***	0.203***
Exploration of New Enterprises	0.318***	1***	0.236***
Assess Advantages/Disadvantages	0.203***	0.236***	1***
Low Per Unit Fixed Costs	0.145**	0.110*	0.154***
Farm Diversification	0.078•	0.205***	0.088*
Balance Sheet Strength	0.288***	0.157***	0.097*

Significance Levels: p < .001 '***' p < .01 '**' p < .05 '*' p < .1 '•'

Table 4: Correlation Coefficients for Absorption Capacity Metrics

	Low Per Unit Fixed Costs	Farm Diversification	Balance Sheet Strength
Farm Growth			
Opportunities to Expand	0.096*	0.062	0.103*
Farm Growth Expectation	0.109**	0.078•	0.085*
Risk Preference			
Self Reported	0.02	0.041	0.065
Neighbors Opinion	0.065	0.026	0.07
Demographics			
Ag Economy Barometer	0.199***	-0.045	0.184***
Index of Current Conditions	0.110**	-0.028	0.191***
Index of Future Expectations	0.196***	-0.046	0.136**
Farm Size	-0.012	0.062	0.078•
Education	0.021	-0.041	0.055
Operator Age	0.003	-0.103*	0.022
Operational Threats			
Low Market Prices	0.067	-0.032	0.053
High Input Costs	0.011	-0.016	-0.060
Extreme Weather Events	-0.010	0.051	-0.058
Limited Ability to Find Skilled Labor	-0.047	0.097*	0.066
Geopolitical Conflict	-0.070	-0.051	-0.065
Identification of Major Risk Sources			
Financial Risk	-0.113*	-0.038	-0.157**
Legal Risk	0.022	0.031	0.068
Marketing Risk	-0.062	0.068	0.043
Production Risk	0.054	0.025	0.018
Strategic Risk	0.027	-0.017	0.061
Human Risk	0.005	0.022	0.006
Management Practices			
Managerial Ability	0.029	0.092*	0.097*
Succession Planning	0.019	0.017	0.142**
Use of Written Lease Agreements	-0.033	0.087•	0.031
Use of Agronomic Consultants	0.008	0.060	0.099*
Use of Financial Ratios	0.090•	0.026	0.017
Use of Crop Pricing Alternatives	0.013	0.051	0.095*
Use of Standard Operating Procedures	-0.022	0.063	-0.003
Precision Ag Technologies			
VRT fertilizer application	0.02	0.001	0.039
Grid or zone soil sampling	0.003	-0.019	0.039
GPS guidance	-0.012	-0.001	0.086•
Yield monitor	0.032	-0.058	0.135**
Drones	0.012	0.013	0.062
None	-0.049	-0.045	-0.05
Strategic Risk			
Resilience to Strategic Risk	0.447***	0.429***	0.448***
Established Goals, Objectives, & Core Values	0.145**	0.078•	0.288***
Exploration of New Enterprises	0.110*	0.205***	0.157***
Assess Advantages/Disadvantages	0.154***	0.088*	0.097*
Low Per Unit Fixed Costs	1***	0.061	0.274***
Farm Diversification	0.061	1***	0.014
Balance Sheet Strength	0.274***	0.014	1***
Significance Levels: p < .001 '***' p < .01 '**' p < .05 '*' p < .1 '•'			

Table 5: Variable Influence (Variance, PCA, Laplacian Score)

Variable Influence	Variance		Laplacian Scores	PCA
Top 10 Variables				
1	Index of Current Conditions	13520.22	Managerial Ability	Resilience to Strategic Risk
2	Index of Future Expectations	7178.08	Resilience to Strategic Risk	Managerial Ability
3	Ag Economy Barometer	6038.33	Risk Preference: Self Reported	Ag Economy Barometer
4	Resilience to Strategic Risk	6.16	Operator Age	Index of Future Expectations
5	Managerial Ability	2.56	Balance Sheet Strength	Index of Current Conditions
6	Risk Preference: Self Reported	2.48	Established Goals, Objectives, & Core Values	Precision Ag: GPS Guidance
7	Operator Age	1.80	Exploration of New Enterprises	Precision Ag: Yield Monitor
8	Farm Growth	1.78	Farm Growth	Exploration of New Enterprises
9	Use of No-Till	1.68	Low Per Unit Fixed Costs	Barometer Question 1
10	Farm Size	1.42	Assess Advantages/Disadvantages	Barometer Question 3
Bottom 10 Variables				
1	Precision Ag: Yield Monitor	0.22	Precision Ag: Drones	Risk Preference: Self Reported
2	Risk Sources: Human	0.20	Extreme Weather Events	Extreme Weather Events
3	Precision Ag: Drones	0.20	Geopolitical Conflict	High Input Costs
4	Precision Ag: Grid or Zone Soil Sampling	0.20	Limited Ability to Find Skilled Labor	Operator Age
5	Extreme Weather Events	0.19	Risk Sources: Legal	Risk Sources: Human
6	Geopolitical Conflict	0.19	Precision Ag: None	Risk Sources: Production
7	Limited Ability to Find Skilled Labor	0.17	Risk Sources: Strategic	Risk Sources: Legal
8	Risk Sources: Legal	0.10	Index of Future Expectations	Risk Sources: Marketing
9	Precision Ag: None	0.08	Ag Economy Barometer	Risk Sources: Strategic
10	Risk Sources: Strategic	0.07	Index of Current Conditions	Geopolitical Conflict

Table 6: Random Forest (Resilience to Strategic Risk)

Influence	Dependent Variable: Resilience to Strategic Risk	
Top 10 Variables		
1	Farm Diversification	14.37
2	Low Per Unit Fixed Costs	12.35
3	Exploration of New Enterprises	11.93
4	Assess Advantages/Disadvantages	11.91
5	Established Goals, etc.	9.69
6	Balance Sheet Strength	8.72
7	Use of Crop Pricing Alternatives	1.18
8	Education	1.05
9	Farm Growth	0.84
10	Managerial Ability	0.80
Bottom Variables		
38	Marketing Risk	-0.06
39	Extreme Weather Events	-0.06
40	Use of No-Till	-0.11
41	Precision Ag: None	-0.11
42	Precision Ag: VRT Fertilizer Application	-0.14
43	High Input Costs	-0.19
44	Financial Risk	-0.21
45	Production Risk	-0.23
46	Legal Risk	-0.28
47	Farm Size	-0.28

Table 7: Random Forest (Agility)

Influence	Dependent Variable: Agility (Assessing Advantages/Disadvantages)		Dependent Variable: Agility (Exploration of New Enterprises)		Dependent Variable: Agility (Established Goals, etc.)	
Top 10 Variables						
1	Resilience to Strategic Risk	14.12	Resilience to Strategic Risk	13.83	Resilience to Strategic Risk	10.98
2	Established Goals, etc.	3.26	Established Goals, etc.	3.75	Exploration of New Enterprises	4.32
3	Balance Sheet Strength	3.23	Low Per Unit Fixed Costs	3.19	Assess Advantages/Disadvantages	3.18
4	Exploration of New Enterprises	2.58	Assess Advantages/Disadvantages	2.67	Balance Sheet Strength	1.85
5	Farm Diversification	2.13	Balance Sheet Strength	2.28	Index of Current Conditions	1.60
6	Risk Preference: Self Reported	2.08	Farm Growth	2.26	Use of Standard Operating Procedures	1.57
7	Ag Economy Barometer	1.40	Farm Diversification	1.97	Low Per Unit Fixed Costs	1.56
8	Farm Growth	1.11	Managerial Ability	1.67	Farm Diversification	1.41
9	Barometer Question 3	1.04	Risk Preference: Neighbors Opinion	1.47	Managerial Ability	1.39
10	Low Per Unit Fixed Costs	1.01	Precision Ag: Drones	1.44	Barometer Question 1	1.31
Bottom Variables						
34	Legal Risk	-0.02			Financial Risk	-0.10
35	Marketing Risk	-0.04			Risk Preference: Neighbors Opinion	-0.13
36	Production Risk	-0.04			Precision Ag: Grid/Zone Soil Sampling	-0.13
37	Low Market Prices	-0.07			Marketing Risk	-0.14
38	Operator Age	-0.08			Low Market Prices	-0.14
39	Precision Ag: None	-0.09			Use of Financial Ratios	-0.18
40	Precision Ag: VRT Fertilizer Application	-0.17	Geopolitical Conflict	-0.08	Farm Growth	-0.19
41	High Input Costs	-0.20	High Input Costs	-0.13	Strategic Risk	-0.27
42	Risk Preference: Neighbors Opinion	-0.21	Use of No-Till	-0.14	Legal Risk	-0.32
43	Extreme Weather Events	-0.22	Education	-0.16	Human Risk	-0.34
44	Use of Agronomic Consultants	-0.27	Farm Size	-0.18	Production Risk	-0.34
45	Precision Ag: Grid/Zone Soil Sampling	-0.32	Financial Risk	-0.18	Extreme Weather Events	-0.40
46	Education	-0.49	Extreme Weather Events	-0.22	Use of No-Till	-0.43
47	Geopolitical Conflict	-0.59	Legal Risk	-0.46	Farm Size	-0.53

Table 8: Random Forest (Absorption Capacity)

Influence	Dependent Variable: Absorption Capacity (Balance Sheet Strength)		Dependent Variable: Absorption Capacity (Farm Diversification)		Dependent Variable: Absorption Capacity (Low Per Unit Fixed Costs)	
Top 10 Variables						
1	Resilience to Strategic Risk	9.92	Resilience to Strategic Risk	15.58	Resilience to Strategic Risk	13.24
2	Assess Advantages/Disadvantages	4.00	Balance Sheet Strength	3.64	Ag Economy Barometer	3.22
3	Established Goals, etc.	3.07	Established Goals, etc.	3.32	Farm Diversification	3.07
4	Ag Economy Barometer	2.29	Assess Advantages/Disadvantages	2.82	Assess Advantages/Disadvantages	2.75
5	Exploration of New Enterprises	2.22	Exploration of New Enterprises	1.65	Exploration of New Enterprises	2.67
6	Low Per Unit Fixed Costs	2.07	Low Per Unit Fixed Costs	1.55	Index of Future Expectations	2.59
7	Index of Current Conditions	1.92	Barometer Question 3	1.51	Established Goals, etc.	2.55
8	Farm Diversification	1.61	Operator Age	1.00	Barometer Question 4	1.98
9	Barometer Question 1	1.48	Ag Economy Barometer	0.90	Balance Sheet Strength	1.82
10	Index of Future Expectations	0.83	Index of Future Expectations	0.85	Barometer Question 2	1.08
Bottom Variables						
34			Education	-0.10	Precision Ag: VRT Fertilizer Application	-0.11
35			Precision Ag: None	-0.11	Farm Size	-0.15
36	Precision Ag: Grid/Zone Soil Sampling	-0.08	Precision Ag: VRT Fertilizer Application	-0.11	Precision Ag: Grid/Zone Soil Sampling	-0.17
37	Financial Risk	-0.10	Geopolitical Conflict	-0.18	Production Risk	-0.17
38	Precision Ag: GPS Guidance	-0.12	Use of No-Till	-0.20	Precision Ag: Yield Monitor	-0.18
39	Marketing Risk	-0.15	Use of Financial Ratios	-0.22	Precision Ag: GPS Guidance	-0.19
40	High Input Costs	-0.17	Human Risk	-0.22	Extreme Weather Events	-0.24
41	Geopolitical Conflict	-0.18	High Input Costs	-0.23	Geopolitical Conflict	-0.27
42	Education	-0.21	Precision Ag: GPS Guidance	-0.28	Limited Ability to Find Skilled Labor	-0.27
43	Use of Financial Ratios	-0.25	Extreme Weather Events	-0.31	Risk Preference: Self Reported	-0.31
44	Legal Risk	-0.26	Production Risk	-0.35	Education	-0.35
45	Use of Agronomic Consultants	-0.36	Legal Risk	-0.53	Opportunities to Expand	-0.44
46	Production Risk	-0.44	Risk Preference: Neighbors Opinion	-0.54	Strategic Risk	-0.50
47	Precision Ag: None	-0.57	Marketing Risk	-0.66	Legal Risk	-0.72

Table 9: Resilence to Strategic Risk & Threats to Operation

Resilience to Strategic Risk	Cluster 1 n = 102	Cluster 2 n = 102	Cluster 3 n = 199	Fishers Exact P-value
Our farm has established goals, objectives, and core values.				0.000
Agree	98.0%	96.1%	81.9%	
Disagree	2.0%	3.9%	18.1%	
Our farm looks for opportunities that new enterprises may provide.				0.000
Agree	96.1%	94.1%	70.4%	
Disagree	3.9%	5.9%	29.6%	
We regularly assess our advantages and disadvantages compared to other farms.				0.000
Agree	88.2%	65.7%	64.3%	
Disagree	11.8%	34.3%	35.7%	
We have low per unit fixed costs relative to our most efficient competitors.				0.000
Agree	94.1%	66.7%	63.3%	
Disagree	5.9%	33.3%	36.7%	
Our farm enterprise is more diversified today than it was 5 years ago.				0.000
Agree	72.5%	61.8%	42.7%	
Disagree	27.5%	38.2%	57.3%	
We have a strong balance sheet.				0.000
Agree	98.0%	94.1%	83.9%	
Disagree	2.0%	5.9%	16.1%	
Resilience to Strategic Risk				0.000
Low (6-15)	0.0%	3.9%	28.1%	
Medium (16-20)	34.3%	84.3%	71.9%	
High (21-24)	65.7%	1.0%	0.0%	
Threats to Operation	**Cluster 1** n = 187	**Cluster 2** n = 197	**Cluster 3** n = 359	**Fishers Exact** P-value
Looking ahead to next year, my farming operation has evaluated potential threats caused by …				
Low market prices	26.7%	24.4%	23.7%	0.536
High input costs	35.3%	32.5%	37.9%	0.606
Extreme weather events	13.9%	11.2%	15.6%	0.491
Limited ability to find skilled farm workers	12.8%	15.2%	9.2%	0.032
Geopolitical conflict	11.2%	16.8%	13.6%	0.140
	n = 160	n = 170	n = 310	
Which of the following risks would you say is most threatening to your organization?				
Financial	23.8%	23.5%	25.8%	0.883
Legal	8.8%	4.7%	8.1%	0.379
Marketing	25.6%	28.2%	24.5%	0.343
Production	21.9%	21.8%	18.1%	0.286
Strategic	5.6%	5.3%	4.2%	0.694
Human	14.4%	16.5%	19.4%	0.379

Table 10: Measurements of Producer Sentiment

	Cluster 1 n = 102	Cluster 2 n = 102	Cluster 3 n = 199	Fishers Exact P-value
Ag Economy Barometer Index	127.8	118.6	121.6	0.446
Indices of Current Conditions	134.2	135.1	125.6	0.022
Indices of Future Expectations	124.7	110.6	119.6	0.990

Barometer Questions	Cluster 1 n = 102	Cluster 2 n = 102	Cluster 3 n = 199	Fishers Exact P-value
1.) Would you say that your farm operation today is financially better off, worse off, or about the same compared to a year ago?				
Better Off	19.6%	24.5%	17.1%	0.015
Worse Off	20.6%	36.3%	35.7%	
2.) Do you think that a year from now your farm operation will be better off financially, worse off, or just about the same as now?				
Better Off	23.5%	12.7%	20.1%	0.041
Worse Off	24.5%	43.1%	35.7%	
3.) Turning to the general agricultural economy, do you think that during the next twelve months there will be good times financially, or bad times?				
Good Times	26.5%	26.5%	23.1%	0.521
Bad Times	54.9%	53.9%	50.3%	
4.) Do you think it is more likely that US agriculture during the next five years will have widespread good times or widespread bad times?				
Good Times	33.3%	26.5%	32.2%	0.495
Bad Times	42.2%	38.2%	40.2%	
5.) Thinking about large farm investments – like buildings and machinery -- generally speaking, do you think now is a good time or bad time to buy such items?				
Good Times	13.7%	19.6%	18.1%	0.843
Bad Times	77.5%	71.6%	72.9%	

Table 11: Risk Aversion, Farm Growth, and Demographics

	Cluster 1	Cluster 2	Cluster 3	Fishers Exact
	n = 102	n = 102	n = 199	P-value
How would you rate your attitude towards risk?				0.001
Strongly Risk Averse	5.9%	9.8%	14.1%	
Moderately Risk Averse	63.7%	51.0%	64.3%	
Slightly Risk Averse	30.4%	39.2%	21.6%	
How would your neighbors describe your risk-taking behavior?				0.027
Risk Avoider	7.8%	5.9%	7.5%	
Cautious	56.9%	60.8%	72.4%	
Real Gambler	35.3%	33.3%	20.1%	
Farm Growth	**Cluster 1**	**Cluster 2**	**Cluster 3**	**Fishers Exact**
	n = 102	n = 102	n = 199	P-value
Do you think opportunities to expand your farm will be greater than, fewer, or about the same in the next 5 years?				0.000
Greater	36.3%	45.1%	11.6%	
Fewer	29.4%	14.7%	37.7%	
What is the planned annual growth rate you have for your farm over the next 5 years?				0.000
Growth	69.6%	79.4%	34.2%	
Maintain	21.6%	18.6%	48.2%	
Reduce Size	8.8%	2.0%	17.6%	
Farm Demographics	**Cluster 1**	**Cluster 2**	**Cluster 3**	**Fishers Exact**
	n = 102	n = 102	n = 199	P-value
How many total acres do you operate?				0.000
< 1000 acres	26.5%	4.9%	47.2%	
1000 to 2000 acres	27.5%	24.5%	24.1%	
2000 to 5000 acres	29.4%	50.0%	18.1%	
5000 to 10,000 acres	7.8%	11.8%	5.5%	
> 10,000 acres	8.8%	8.8%	5.0%	
What is your highest completed level of education?				0.003
High School	41.2%	27.5%	48.2%	
Undergraduate	28.4%	42.2%	30.2%	
Graduate	29.4%	30.4%	19.1%	
What is the average age of the primary farm owner/operator?				0.002
< 35 Years Old	7.8%	2.0%	4.5%	
35-65 Years Old	54.9%	74.5%	53.3%	
Above 65 Years Old	37.3%	23.5%	42.2%	

Table 12: Management Practices and Adoption of Precision Ag Technologies

Management Practices		**Cluster 1** n = 102	**Cluster 2** n = 102	**Cluster 3** n = 199	**Fishers Exact** P-value
Does your farm have written succession plans in place?					0.000
	Yes	58.8%	78.4%	41.2%	
	No	41.2%	21.6%	58.8%	
Are most of your farm's crop lease agreements written?					0.000
	Yes	61.8%	85.3%	47.2%	
	No	38.2%	14.7%	52.8%	
Does your farm use advice from agronomic consultants when making decisions?					0.012
	Yes	64.7%	64.7%	49.7%	
	No	35.3%	35.3%	50.3%	
Does your farm use financial ratios to make decisions?					0.000
	Yes	59.8%	74.5%	33.7%	
	No	40.2%	25.5%	66.3%	
Does your farm document and evaluate crop pricing alternatives?					0.000
	Yes	70.6%	81.4%	44.2%	
	No	29.4%	18.6%	55.8%	
Are standard operating procedures documented for repetitive and routine tasks?					0.000
	Yes	54.9%	65.7%	38.7%	
	No	45.1%	34.3%	61.3%	
Managerial Ability					0.000
	Below Average (6-7)	4.9%	0.0%	24.6%	
	Average (8-10)	65.7%	48.0%	64.8%	
	Above Average (11-12)	29.4%	52.0%	10.6%	
Adoption of No-Till and Precision Ag Technologies		**Cluster 1** n = 102	**Cluster 2** n = 102	**Cluster 3** n = 199	**Fishers Exact** P-value
On average, what percent of your crop acreage uses no-till practices?					0.046
	> 50%	49.0%	50.0%	42.2%	
	< 50%	51.0%	50.0%	57.8%	
Does your farm use any of the following precision agriculture technologies?					
	VRT fertilizer application	63.7%	82.4%	50.3%	0.000
	Grid or zone soil sampling	75.5%	87.3%	64.3%	0.000
	GPS guidance	69.6%	89.2%	54.8%	0.000
	Yield monitor	70.6%	92.2%	55.8%	0.000
	Drones	32.4%	45.1%	15.6%	0.000
	None	3.9%	0.0%	15.1%	0.000