Value Added What??...Horizontal versus Vertical Expansion in Iowa Production Agriculture

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ABSTRACT

Farm investment in value-added agricultural firms continues to grow in the United States. Using farm-level, asset allocation models, value added investments were found to be advantageous for farms with below average earnings or older operators. Farms with superior financial performance benefited from a portfolio allocation that favored farm expansion.

Introduction

Investment in farmer-owned, value-added businesses has skyrocketed since the early 1990s. This shift in farmers' investment preferences has the potential to transform many rural landscapes from endless fields to a combination of fields, processing facilities, and additional animal confinement units. Historically, farmers have added value to their crops through on-farm livestock production. More recently, farmers have invested in manufacturing facilities to produce bio-fuels, egg proteins, and other products.

Because increases in value-added agricultural manufacturing in rural areas can stimulate rural economies, local and national lawmakers are interested in stimulating growth in this area. As of May 2001, all 50 states had at least one program to assist value-added agricultural businesses. In the 1998-99 fiscal year, states around the nation budgeted more than $280 million dollars for value-added agriculture programs (Kilkenny 2001).

Numerous theories have attempted to explain shifts in farmer investment preferences, growth in farmer-owned businesses, and willingness of the government to subsidize value-added agriculture. Two reasons suggested are the overall change in farm structure and the need for rural development.

As farms have grown over the past century, they have also increased in complexity. Today, farmers are also managers, marketers, and operators. As farm size has increased, the number of farmers has dramatically decreased. This trend toward fewer, larger farms has resulted in more competitive, qualified farmers, both locally and internationally.

Along with the growth in farm complexity is worldwide pressure on the United States to reduce direct and loan deficiency payments to farmers. While this limits farm income from subsidies, with these gradual declines in direct payments comes more flexibility in crop and livestock production decisions. As a result, producers may be looking for alternative ways to enhance income in the event that direct farm subsidies are terminated.

The increased complexity, farm size, competition, and government payment limitations have forced farmers to develop new production and marketing opportunities in order to enhance farm incomes. An overall and popular attitude towards becoming more competitive in the worldwide marketplace is to add value to basic commodities by processing them into differentiated food products or finding non food uses.

New farmer-owned businesses can potentially increase rural incomes by providing new jobs, hence stimulating the local economy and widening the tax base. Many new farmer-owned businesses are locating near rural areas because of the proximity of primary inputs.

Traditionally, growth in farm size, or horizontal expansion, was seen as the only option for producers to combat highly volatile farm incomes in the face of real declines in output prices along with real increases in input prices. In the case of farm expansion, average costs decline over certain levels of production due to economies of scale. There is little research evidence that suggests that average costs will increase rapidly at increased levels of output in US agriculture (Cooke 1996). However, technical barriers such as access to additional land and capital can limit farm expansion at some point.

A variable relevant to farmers in addition to increasing or decreasing production costs is how farm expansion affects the variability of farm income. As a farm expands, the level of farm income is expected to increase. However, the level of variability of farm income may not decrease, but increase due to larger investments in a similar, if not identical, commodity.

An alternative to horizontal expansion is to vertically expand through investments such as a farmer-owned, value-added business. This may allow producers to capture or create more value from products originating from farm commodities. This is in direct contrast to a situation in which the producer only owned the commodity in its basic form, and then sold it to another firm, which transformed it into another state while sharing no ownership with the producer.

The two questions that this research will attempt to answer are (1) whether vertical or horizontal expansion is more profitable for agricultural producers and (2) what attributes of an individual farm make it more efficient for them to vertically or horizontally expand. In answering this question, the possible advantages and disadvantages to adding value-added investments to a portfolio of farm assets will be explored. Additionally, the attributes that make non-farm assets attractive to farmers will be identified.

Conceptual Framework

The choice of vertical or horizontal expansion by individual farmers is an empirical question. Therefore, empirical results are needed in order to determine whether vertical or horizontal expansion is more efficient for Iowa producers. We will discover results through portfolio analysis.

To begin, we assume that a producer is considering whether or not to expand his/her current farm operation or to invest in some form of vertical expansion, including value-added agricultural manufacturing and/or stock market investments. Taking into account his attitude toward these risks, the producer will optimize his portfolio holdings in farm and non-farm asset expansion based on expected risks and returns. The producer is assumed to optimize his holdings such that his portfolio lies on the lend/borrow line between the risk-free rate of return and the point of tangency with the Markowitz's E-V frontier as illustrated in Figure 1.

There are several quantitative asset allocation models that will optimize an investor's portfolio. However, since we had no access to each investor's risk aversion coefficient, this research will utilize Sharpe ratio maximization.

William Sharpe, who developed the Sharpe ratio in 1966, described it with the coined term "reward-to-variability." Along the lines with portfolio allocation, if a portfolio is balanced such that the Sharpe ratio is maximized, that portfolio is said to be on the E-V frontier; mathematically:

$$S_i = \frac{E(R_{pi}) - rf}{E(Var_{pi})}$$

Where:

$E[R_{pi}]$=Expected return of portfolio *i*.

$E[Var_{pi}]$=Expected variance of portfolio *i*.

rf=Risk-free rate of return

The Sharpe ratio is equal to the slope of the lend/borrow line. Therefore, maximizing the Sharpe ratio will maximize the lend/borrow line's slope, indicating that the portfolio has the greatest expected return given the risk-free rate of return.

Investing in Farm Expansion

Farmers have historically relied on horizontal growth or expansion as a strategy to improve their financial positions. A consequence of horizontal growth is increased farm size, the substitution of capital for labor, and an increased risk exposure due to specialization and relatively constant average costs.

However, due to physical constraints such as land availability in close proximity to the existing farm operation, farm expansion may be limited. Producers may also lack the available capital to further expand their farms if there is no additional land or facilities available for lease and have to purchase a sizeable tract of land or build additional livestock facilities.

Studies conducted on farm expansion found that actual cases of rising average costs with additional output in American agriculture are very rare (Cooke 1996). Work evaluating the cost advantages of large scale farms concluded that farms with more than 2,500 acres of corn could purchase production inputs for as much as 20% less than smaller corn farms (Krause 1971). It has also been concluded that large farms are more likely to adopt and gain the benefits of increased technologies than smaller farms (Stanton 1987).

Investing in Value-Added Agriculture

Over the past decade, farmers have been encouraged to consider investments in value-added agriculture as an alternative to farm expansion and a way to avoid the economies-of-scale treadmill that continually requires expansion to stay competitive. By investing in value-added agriculture, firms can capture value downstream from their production process. In 2004, producers received less than 20% of the value of gross US food expenditures, with the balance going to the value adding sector (USDA).

Value-added agricultural investments may also improve the diversification of the farm's portfolio. For example, suppose a farmer whose major output is corn owns shares in a business whose major input is corn. Holding yield constant, in years where corn prices are relatively low, farm returns will be also be relatively low. However, during these low price periods, the return to the value-added business will be relatively high.

Value-added agricultural investments may also be desirable because farmers are better informed than non-farm investors. A farmer is also more likely to know more about an investment involving his commodity (i.e. corn processing company) than an investment that has little or nothing to do with his commodity (i.e. aerospace engineering firm). Hence investments in value-added agriculture may be more enticing to producers due to their more in-depth knowledge of the subject.

As stated earlier, a majority of new value-added agriculture businesses are locating in rural areas. If a new value-added agricultural business has considered locating in close proximity to a producer's operation, he may be more willing to invest in the business. His support can stem from an expectation that the new business may create local jobs and increase the local tax base or from the hope that the new business will provide an additional marketing channel for his commodity. The producer may also be able to monitor the business activity directly or through social networks.

However, these apparent benefits from investment in value-added agriculture also come with risks. These risks are especially likely if the investment requires significant capital outlays to purchase processing facilities and to hire management and marketing staff.

Startup costs for a value-added business may be large, requiring both significant capital investments as well as substantial commitments of the commodity from the investors. Consequently, debt financing would need to be obtained from bonds and/or from private financial institutions. If this additional financing is required, investors will likely hold a residual claim to early profits incurred by the business and may lose their entire investment if the entity fails.

Research analyzing value-added agriculture investments by hog and cattle producers has been recently conducted. These studies concluded that a portfolio consisting of value-added investments and farm assets provides better returns and lower risk than a portfolio consisting of farm assets alone (Detre 2002), (Jones 1999).

Investing in Stock Indexes

Investments in agricultural firms not closely tied with farm returns or those that have no apparent correlation with farm returns are also readily available to producers. These investments include investment in a stock market index or in a portfolio of food and agribusiness stocks. These investments can be viewed as alternate routes of vertical expansion for the farm since the structure of these investments are substantially different from those of value-added agricultural manufacturing.

Producers may benefit from investing in a mutual fund such as the type that contains the same stocks as those measured in the S&P 500. These indexes will increase the value of a portfolio over time due to the long-term upward movements in the financial markets. Investment in an index also provides portfolio diversification because its movement is contingent on many more factors than those affecting agricultural markets.

Another benefit to this investment is its liquidity. A producer can buy and sell mutual funds in these indexes at any time and in varying amounts. In contrast, an investment in a single, value-added agriculture business may be a fixed amount, require delivery of a significant amount of corn or soybeans, and may not be as liquid as a widely-traded mutual fund.

Since these indexes capture the entire market, the investor bears virtually no unsystematic risk with the addition of the asset. However, even though this method should increase equity over a long horizon, it provides little short and intermediate term assurance because farm and financial markets may not be correlated. Several instances of this lack of correlation between farm and financial markets occurred in the 1920s. The farm market was in collapse following World War I, while the financial market was experiencing the “Roaring 20s” (negative). The farm crisis in the 1980’s coincided with rampant unemployment and inflation (positive). Also, the technological boom in the mid 1990s in the stock market coincided with the Asian crisis in the agricultural sector (negative). Therefore, investing in a market portfolio may not completely mitigate production risks encountered by a producer.

Studies show that when producers invest in stock indexes, it is a viable investment. Research evaluating stock index investment in addition to farm assets concluded that in times of highly variable farm incomes, investment in stock indexes can reduce expected risk and increase return (Serra 2003).

Investing in Food Processing and Agribusiness Stocks

Investing in food processing companies and agribusiness stocks that are involved in the processing and marketing of agricultural commodities presents a similar opportunity to capture downstream profits than investing in a value-added business.

The main difference between this investment and investment in a local value-added business is mainly that the company will be less likely to be in close proximity to the farm enterprise and the producer will have even less management power. This is because to many food and agribusiness stocks, the expense of the raw agricultural commodity is significantly less than for a smaller scale farmer-owned, value-added agriculture business. In general, commodity inputs are a small part of their costs. Since a majority of these firms' costs are labor and management, they will likely choose to locate near specialized labor pools in urban areas (Kilkenny 2001).

However, these differences bring possible benefits. The company is likely to be located in an optimal location, which may give it access to a better skilled and more specialized labor and management pool than a business located in a rural area. Investment in agribusiness companies has the same liquidity as stock indexes. However, the investor may be prone to both unsystematic and systematic risks and returns. If their returns are relatively less correlated with farm returns, diversification benefits may also be lost. Studies evaluating the addition of food and agribusiness stocks to a farm asset portfolio concluded that they capture additional benefits beyond diversifying with stock indexes (Featherstone 2002).

Model Specification

The asset allocation problem is solved by maximizing the expected Sharpe ratio for each farm in the sample by varying the portfolio weights of each asset. Using time series data, the basic Sharpe Ratio is specified as:

$$\max S = \frac{\dfrac{\sum_{i=1}^{n}\sum_{j=1}^{k}(w_j * r_j)}{n} - r_f}{\sqrt{\dfrac{\sum_{i=1}^{n}\sum_{j=1}^{k}(w_j * r_j - w_j * \overline{r}_j)^2}{n}}}$$

$$s.t$$

$$.\sum_{j=1}^{5} w_j = 1$$

$$0 \le w_j \le 1$$

Where:

n=Number of periods

k=Number of assets

w_j=Weight of asset j,

r_j=Return of asset j in period i

$\overline{r}_j$ =Expected mean return of asset j

r_f=Risk-free rate of return.

In a one period, or static approach, the Sharpe ratio does not account for correlation among the investment alternatives. When the multi-period form of the Sharpe ratio is used to estimate optimal portfolio weights, the formula for portfolio variance incorporates covariance among assets. Once the above expression is maximized subject to its constraints, the portfolio is considered to be on the efficient frontier. Previous studies have used this multi-period form of portfolio optimization in evaluating asset choice models for agricultural producers (Detre 2002).

The Solver add-in to Microsoft Excel was used to maximize the Sharpe ratio to acquire a unique portfolio for each farm. The risk-free rate of return was assumed to be 3%, and is consistent with an average rate of return from a relatively low risk asset in today's market.

Detre (2002) used the Sharpe ratio in this form to optimize a portfolio for agricultural producers. However, in that particular study, farm returns were averaged across the state so a single average portfolio was optimized. However, individual portfolio results can provide more detailed results and when averaging returns across the state across multiple years, the true in farm-level returns can be significantly underestimated.

Portfolio Result Interpretations

Because one investment is mutually exclusive to each agent (their farm returns), their optimal portfolios will be unique. In other words, each agent has a uniquely shaped efficient frontier because of unique portfolio investment opportunities. Figure 2 illustrates different E-V frontiers and tangency points for two (hypothetical) individuals with access to the same risk-free rate of return As illustrated, individual b has access to higher rates of return given a level of risk due to farm returns larger than a, or a stronger negative covariance among potential assets.

In effect, the fact that each producer has a unique investment alternative is parallel to a custom product given to an investor due to each farms' unique returns. Because of this, the argument that the capital asset pricing model does not account for individual characteristics is ignored because each individual is given a mutually exclusive investment alternative in the form of his own farm business returns (Featherstone 2002).

Nonetheless, the optimized portfolio weights only reflect the producer's optimal risk and return tradeoff given the risk-free or loan rate. Individual demographics and farm characteristics play little or no role in the optimization outside of the observed farm returns because the portfolios were optimized using only information about farm and asset alternative returns. In reality, each producer's optimized Sharpe Ratio is unique due to economic and demographic characteristics of the individual. This is because these attributes may directly affect the farm's return to expansion, which affects the rates of return that a producer can access.

Therefore, farms that have similar investment patterns may or may not be similar in their characteristics. To determine this, groups of farmers with similar portfolio weights need to be identified. This allows the researcher to determine if they are, in fact, similar and if their individual characteristics affect their portfolio weights. K-Means Clustering was utilized in order to determine clusters of farms that are similar with respect to their investment weights. For a rigorous derivation of K-Means Clustering, see Das (2003).

Cluster analysis will determine which farms are similar based on their portfolio weights. It is hypothesized that each cluster's efficient frontier will have a similar shape because of similarities in their optimal risk and return tradeoff. The E-V frontier within clusters will only vary by the variability of the farm returns and the covariance among asset alternatives.

If individual farm characteristics and demographic variables can be used to predict which cluster a farm is in, it can be determined if individual farm characteristics affect their optimal investment patterns. This will answer the question of what characteristics of a farm make it more profitable to invest in vertical or horizontal expansion. Multinomial logit modeling will be used to link a farm's characteristics to their optimal investment patterns.

Estimation of Asset Returns

Data on actual Iowa farm characteristics and performance were obtained from the Iowa Farm Business Association's annual individual farm records (Iowa Farm Business Association). Electronic records of the data were available from 1993-2003. A balanced panel of observations for all years was constructed. The balanced panel dataset contains 191 unique farms that represent a good sample of commercial operations across Iowa.

Table 1 presents average 1993, 1998, and 2003 values of selected financial and demographic characteristics of farms included in the dataset. The definitions of ratios used are presented in Appendix A. Consistent with state and national averages for farms, the operator's age, farm size, crop yields, and non-farm income increase steadily throughout the time period. Interest expense as a percentage of total farm revenues decreased over the time period, likely due to decreasing interest rates.

The rate of return for each farm throughout the time period was calculated as the rate of return on farm equity plus gains in capital asset values. Accounting for gains in capital asset values allows the rate of return to farming to be compared directly to rates of return on stocks and business investments. For example, in calculating the rates of return on a stock investment over the course of a year, both the capital appreciation of the stock's value and the amount of dividends earned over the time period are included. Therefore, in calculating the return to farming, both the increase in capital assets (stock value) and net farm income (dividends) are included to make these rates of return comparable. The rate of return on farming plus gains in capital assets for each year was calculated using the following equation.

$$ROE_f = \frac{NFI - UL + (A_l * w_l)}{E_e}$$

Where:

ROE_f=Return on equity to farming and fixed assets before taxes

NFI=Farm net income from operations before income taxes

UL=Unpaid labor to the principal farm operator

A_l=Annual change in the average acre of owned land

w_i=Total land value divided by total farm assets

E_e=End of Year Farm Equity Balance.

An implication to calculating the return in this manner is that it must be considered as an expected rate of return to farm expansion, not as a direct return from farming. That is, future income will be used to adjust the portfolio, not past earnings. This is because a producer, on average, does not annually acquire appreciation in land values in the form of a cash payment unless he liquidates his land holdings; rather, he acquires the appreciation in the form of an increased farm asset and equity balance. The year ending equity was used because the producer is assumed to make the choice based off of their current return to farm expansion. Therefore, the farmer with an optimized portfolio that suggests a 0% investment in the farm should not consider farm expansion. However, that does not imply that he should liquidate his farm assets completely. Economic factors such as the ability to cover fixed costs and personal characteristics of the operator determine the continuation of the farm, not financial theory used to optimize the portfolios. This argument adds to the validity of the results obtained in this research since it is unlikely that a producer would liquidate his farm assets due to an optimization of his investment portfolio. Many other factors intervene, such as lifestyle choices and the utility obtained from farming.

Because of their ease of investment and worldwide popularity, two different stock investments were included as asset alternatives: Investment in the S&P 500 market index and a mutual fund consisting entirely of food and agribusiness stocks; the Fidelity Food mutual fund. Historical data on their prices and dividends were downloaded from Yahoo Finance for 1993-2003.

Because of their popularity in Iowa, investments in ethanol and egg production were included as alternatives to farm expansion.

Historical returns to ethanol production were estimated using a spreadsheet that calculated return on equity for a representative ethanol plant in the Midwest (Tiffany 2004). Underlying assumptions are that the ethanol plant has a maximum production capacity of 60 million gallons per year; one bushel of corn yields 2.7 gallons of ethanol and 17 pounds of distillers dried grains with solubles (DDGS). The plant also uses 0.165 million British thermal units (mmBTU) of natural gas, roughly 2 gallons of water, and 1.04 Kwh of electricity to process one bushel of corn (Paulson). The short-term interest rate was set at 6% and no tax subsidies or value-added payments were assumed. The return on equity of the plant was calculated with average annual corn, ethanol, and DDGS prices for 1993-2003.

Data on returns for egg production were calculated using USDA/ERS and Iowa State University Extension estimates for costs of production and prices received by farmers for one-dozen eggs for the time period 1993-2003 (Lawrence 2003) (USDA/ERS 2004). The net returns per dozen were calculated to derive a rate of return on a one dollar investment in an egg production facility. The returns are estimated for a 110,000 hen facility with building, equipment, and land costs of $700,000; layers initially cost $2 per bird and follow a 90 week lay/molt/lay cycle and are disposed of at no value; 1,650 man hours of labor are required annually at the average annual wage rate for farmer workers; and 200,000 kwh of electricity are required annually at the average annual commercial rate (Lawrence 2003). Tables 2 and 3 present the average returns and the correlations among the four asset alternatives by year.

Over the time period, the layer facility is the investment with the lowest measures of risk and return. The steady returns can be attributed from a steady growth in the demand for eggs over the time period. However the real increase in the price of eggs and energy limited the returns to egg production. The Fidelity Food mutual fund yields the highest expected return while the S&P 500 is expected to vary the greatest. These investments performed well at the beginning of the time period but decreased due to the drop in the stock market in the late 1990s. The ethanol plant investment is the riskier of the two value-added stocks, but its risk appears to be less than that of the Fidelity mutual fund. The ethanol plant's returns increased as the time period progressed due to increases in the price of DDGS and ethanol, while the price of corn decreased overall.

Egg, ethanol, and stock investments are positively correlated throughout the time period. However, the correlation is weaker for ethanol. Egg and ethanol production returns appear to be uncorrelated. This may occur because of large differences in the market for ethanol and eggs. As one might expect, the correlation between the two stock investments is positive.

Operator Demographic Hypotheses

Operator Age

As a farm operator's age increases into their senior years, their investment preferences can shift two ways. If the operator views his increasing age as a signal to be more conservative with his money, he will choose to invest excess farm equity into an investment that provides a viable return at very low risk levels. At this point in their investment experience, he will know the risks and returns associated with the expansion of their operation with fair certainty. If he views his farm's return as stable and adequate, he will choose farm expansion. However, if he is unsatisfied with the risks and returns of his operation, he may choose to invest in an alternative, such as a value-added agricultural business if he believes the investment consequences will be positive. Another factor that might encourage non-farm investments is if they view themselves as unable to take on additional operational and management labor to manage a bigger farm, because non-farm investments will require significantly less labor. Older producers may also have more liquid assets to disperse into a non-farm business compared to a producer who is relatively younger.

In this modeling framework, we only have information on a farmer's age and farm returns, not information on how a farmer views his farm returns and the returns to a value-added agricultural business. Thus we must explore the correlation between age and investment choices by looking at the correlation between farm productivity and the age of the operator. Previous studies linking the age of an operator to farm productivity concluded that farm productivity increases with operator age until the operator is roughly in his mid- to late- 40s, then farm productivity decreases while the operator continues to age. This decrease in productivity occurs because of his declining physical labor productivity and unwillingness to adopt new, labor saving technologies (Tauer 2000). Other studies have stated that the rate at which an operator expands his operation increases into his mid-thirties, then declines at a non-linear rate with age until no further farm expansion occurs (Weiss 1999). If the results of this research align with previous studies, then the negative relationship between operator age and farm returns will shift the optimal investment mix to a portfolio of asset alternatives (besides farm expansion), for clusters with a higher mean age, ceteris paribus.

Non Farm Income Levels

A producer's level of non-farm income can have a significant effect on his investment choices. A producer with a larger non-farm income than another will have more off farm time commitments; whether the commitments are a full time job outside of the farm or actively managing a stock portfolio. Hence, clusters with a relatively higher non-farm income should be more prone to invest in non-farm assets because they are unable to provide more farm management labor.

Farm Leverage

A producer with a significant amount of farm debt can be looked upon as a risk tolerant individual or one with poor financial management skills. In either case, it is hypothesized that significant farm debt levels should trigger off farm investments. In the case of poor financial management skills, the producer might not be willing to expand an already inefficient operation or may not have access to adequate credit in order to expand, hence encouraging non-farm investments. In the case of a risk tolerant operator, outside investment may be viewed as an opportunity for additional income. The level of uncertainty associated with non-farm investments will not heavily weigh into their decision. Therefore, clusters with high debt levels should also choose vertical expansion.

Farm Profitability

A producer with a relatively profitable and productive farm operation will mainly choose to expand the farm up to his limit of management labor available and/or the availability of additional land and capital. However, if he has reached these limits or can see benefits in non-farm investments, he may choose non-farm investments. Due to their above average and stable farm returns, he will be more likely to invest in investments that have the highest expected returns, even if they bring on more uncertainty, because of their current low levels of risk. Therefore, if there is a strong negative correlation to farm returns to vertical investments within certain clusters, they will optimally choose vertical expansion.

Farm Type

The primary commodities produced by a farm will have a significant effect on a producer's investment decisions due to their different marketing channels. For instance, a producer who feeds a majority of his crops to his own livestock has less need for an additional marketing channel than a producer who sells a majority of his crops on the open market. Producers who sell a majority of their crops on the open market are not currently adding any value to their commodities, thus an outside investment into an entity that adds value to their commodity will be enticing to them because it provides an additional marketing channel. Also, if the negative correlation between farm returns and value-added businesses that was discussed previously occurs in most years, the outside investment will lower their portfolio's risk.

The results of the multinomial logit model will test the above hypotheses and quantify their effects. This will allow us to evaluate one of the main objectives of this research: What factors will affect the efficiency of a farm to expand horizontally or vertically?

Results and Interpretation

For the Sharpe ratio maximization, the average portfolio is balanced mainly between farm expansion and egg production. Due to their relatively large expected risk when compared to farm expansion, ethanol, and egg production, stock investments do not play a role in the portfolio.

Figures 3a-e illustrate the distributions of farm expansion and asset alternative weights yielded by Sharpe ratio maximization.

As Figure 3a illustrates, producers would optimally choose a wide variety of portfolio weights for farm expansion. The optimal weights on farm expansion vary wider than any other asset because the returns to farm expansion are unique for all 191 observations, whereas returns available from the other four asset alternatives are the same. About 40% of producers would optimally place little or none of their portfolio in the ethanol plant with about 30% placing 10-20% and 20-30%. Because of its low risk, as figure 3c illustrates, producers would optimally choose to balance their portfolios with a wide range of egg production. Its relatively low risk and high return give producers an opportunity to lower their expected portfolio variance.

Producers, in general as figures 3d-e illustrate, would optimally limit stock market investments due to their high risk relative to the other assets. However, it is worth noting that a few producers would optimally choose to invest in as much as 40% S&P 500 and 25% Fidelity Food. Further investigation into these farms reveals that their expected return from farm expansion is much greater than average with relatively small fluctuations. These producers could optimally take on the high risk stock investments for a greater expected return because they have a relative low amount of risk in farm expansion.

Cluster Analysis

As previously discussed, the optimal portfolio weights estimated by the Sharpe ratio model only reflect the estimate of risk, return, and covariance among the five assets. These differences, namely the shape of their individual E-V frontiers, are due to each farm's unique characteristics. In order to quantify these characteristics, we need to determine which farms are similar to one another with respect to their portfolio weights.

Table 4 shows the summary statistics for different values of *k* clusters that were considered. As *k* increases, the maximum Euclidean distance within the clusters decreases, which indicates that farms inside each cluster are more alike. However, notice that when the number of clusters allowed increases above five, the number of farms in each cluster falls to as low as one. From a statistical and economic view, a cluster containing one observation is not significant. Also, in general, as the number of clusters increase, the distance between the nearest clusters decrease, leading one to believe that the clusters are not that different. The F-Statistic tests the hypotheses that the difference between each cluster and its closest counterpart is equal to zero. The F-Statistic peaks at five clusters. Since the F-Statistic peaks at five clusters and reducing *k* to four makes little difference in the number of farms per clusters, we used the five-cluster model in our further analysis.

Table 5 presents summary statistics for each cluster for 2003, Appendix A contains financial ratio definitions. Figure 4 illustrates the distribution of average portfolio weights for each cluster.

The farm characteristics of each cluster given in Table 5 and their respective portfolio weights in each asset revealed key differences among clusters. Cluster 4 has an average of 88% of its optimal portfolio in farm expansion, the largest percent of any cluster. Cluster 4 also has the largest average corn and soybean yields; the lowest debt to asset ratio; the highest net farm income ratio, return on assets, and profit margin; while having the lowest interest expense ratio.

In contrast, Cluster 1 has an average of 8% of its optimal portfolio in farm expansion, the smallest percent of any cluster. Cluster 1 has the lowest average net farm income, return to management, and profit margin while having the highest interest expense ratio. Cluster 1 also has the highest non-farm income and the largest average farm size, indicating that non-farm employment may hinder additional farm expansion and due to their relatively larger size, might have reached a limit to farm expansion.

Cluster 2 has the fewest farms – only five. As Figure 4 indicates, the primary reason they are separately partitioned is that it would be optimal for them to hold significant investments in the two stock assets compared to the other four clusters. From a farm characteristic aspect they are the youngest operators and hold 57% of their portfolio in farm expansion. Nonetheless, they earn the highest net farm income, return to management, and return on equity, while having the lowest operating expense ratio. Their relatively stable farm return on equity may allow them to take on the higher risk assets to increase expected portfolio return. They have the highest expected portfolio return, for a lower level of risk.

In the figure 5, each farm's average portfolio return less the risk free rate is plotted against portfolio standard deviation. A trend line is estimated assuming a common intercept of zero. This allows direct comparison of the slopes of each cluster's trend line. As the differing slopes of the cluster trend lines indicate, each cluster has a unique risk and return tradeoff. For example, the slope of the trend line for Cluster 4 is the steepest, indicating that these producers expected portfolio return is higher while taking on less risk, compared to the other four clusters, which have smaller slopes for their trend lines. Cluster 2 has a slope similar to that of Cluster 4, but with only five producers in Cluster 2, the validity of its true slope is questionable. Clusters 1and 5 have the smallest trend line slopes, indicating that their level of return for a given amount of risk is inferior to the other three clusters. This indicates that each cluster's E-V frontier has similar slopes while the E-V slopes between clusters are significantly different.

These results are in line with previous hypotheses stating that since farm expansion is the only firm-specific investment available to the producers, the slopes of each E-V frontier will differ. This is also inline with the previous hypothesis stating that those farms with the greatest returns to farm expansion given a level of risk will have the steepest E-V frontier slopes. Clusters 1and 2 have the highest mean farm returns, and in turn, they have the steepest E-V frontiers.

Multinomial Logit Results

A multinomial logit model was estimated using the cluster number assigned to each farm as the dependent variable. The explanatory variables used include average operator's age, grain sales ratio, net farm income ratio, return on equity, debt to asset ratio, interest expense, government payments ratio, and non-farm income. Tables 6 and 7 contain the parameter estimates for each *B* and the marginal effects of the logit model.

Overall, the model does an adequate job of predicting a farm's cluster based on the explanatory variables, using the pseudo R^2 and absolute value of the log likelihood function as measures. All explanatory variables are statistically different from zero across at least one cluster. Table 4.6 illustrates the parameter estimates of each characteristic relative to Cluster1. The marginal effects of each explanatory variable in each cluster are displayed in Table 7.

For the most part, all of the explanatory variables have the expected signs and they provide some very intuitive economic points. For example, Clusters 1 and 5 invest the least in farm expansion, but they invest heavily in the value-added agricultural businesses. The marginal effects for the grain sales ratio are positive for these two clusters and negative for the other three. This states that as a farmer relies more on the open market for the sale of his crops, he is more likely to invest in value-added agriculture. This meets the previous hypotheses that value-added investments will be attractive to cash grain farmers due to the addition of another marketing channel and the negative correlation between the value-added agricultural businesses and farm returns. As Table 8 illustrates, the correlation between farming and ethanol returns throughout 1993-2003 was -0.249, which can be viewed as a negative correlation. The correlation between farming and egg production was 0.063, which is positive, but small enough to conclude the correlation is insignificant.

The marginal effect on the net farm income ratio is negative for clusters 1and 5 but positive for clusters 2, 3, and 4. As Table 5 illustrates, the farms in Clusters 2-4 are more profitable than Clusters 1 and 5, so Clusters 2-4 place significant holdings in farm expansion. So, as the net farm income ratio rises, the farm is more profitable and productive, hence the farm is more likely to be in a cluster that invests heavily into farm expansion.

The marginal effect on the operator's age is also negative for Clusters 1 and 5 but positive for Clusters 2-4. As far as this research is concerned, as a farmer gets older (Clusters 1 and 5 have the highest average operator age), he is more likely to invest in non-farm assets and less likely to expand his farming operation. This is in line with previous research that shows that as an operator's age increases, farm productivity declines. Clusters 1 and 5 have the lowest net farm income, return to management, net farm income ratio, and return on assets.

The marginal effect on the interest expense ratio is negative across Clusters 2 and 4 and positive through the others. Clusters 2 and 4 have some of the lowest interest expense ratios and they primarily invest in farm expansion, while Clusters 1 and 5 have the highest interest expense ratios and primarily invest in the value-added agricultural businesses. With the exception of Cluster 3, the hypothesis that farms with higher debt levels will choose to invest in non-farm assets, holds.

Farms that are more dependent on government payments are more likely to be in Clusters 1 and 5. This suggests that farmers who are relatively more dependent on government payments will invest less in farm expansion and more into value-added agriculture. This also implies that farm program payments play a significant role in these farms' returns. Therefore, if farm program payments were dropped or significantly reduced, their returns would be significantly lower. This makes investment in non-farm assets more enticing to these farms since they yield higher returns than farm expansion.

CONCLUSIONS

Investment in value-added agricultural businesses has significantly grown over the past decade in Iowa and the United States. The main reason for this change in the views of producers is the need to add value to their basic commodities in order to improve and stabilize farm incomes.

Over the time period of this study, investment in horizontal growth has been a good investment for a majority of producers. These results are similar to previous portfolio analyses that have been conducted (Barry 1980 and Jones 1999). The portfolio optimization concluded that value-added agricultural investments were also an efficient addition to a majority of producers' portfolios. Due to the large amount of expected risk that comes with stock investments, a majority of producers in the sample would not include them in their portfolio. Results of previous studies showed farms investing heavier in individual food and agribusiness stocks, but these studies did not evaluate investment options in value-added agriculture businesses as asset alternatives. (Featherstone 2002). Those producers with relatively higher rates of return find the addition of stocks to their portfolio efficient, which is in line with previous research (Featherstone 2002 and Serra 2004).

Cluster analysis and logistic regression explain the differences in estimated investment patterns among the producers and to describe which characteristics of their were related to their optimal portfolio.

The logit model concluded that farms with higher debt levels, older operators, and a high grain sales ratio find investment in value-added agricultural businesses more profitable than farm expansion. Farms who are above average in terms of size also invest more heavily in value-added agriculture than farm expansion. However, as the optimization models concluded, those farmers with relatively higher returns, lower operating and interest expense, and less dependence on government payments find it most efficient to expand their operation.

Figure 1: Tangency of the Borrow/Lend Line and the Markowitz Efficient Frontier

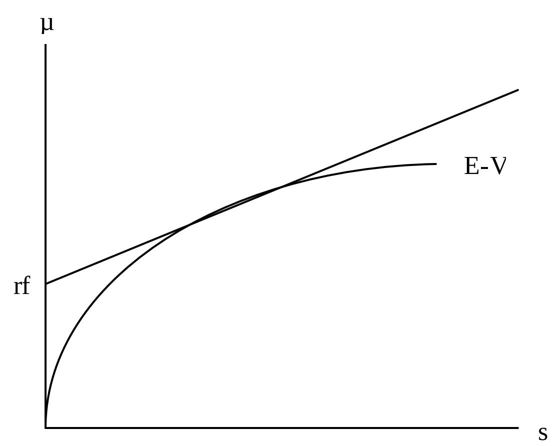
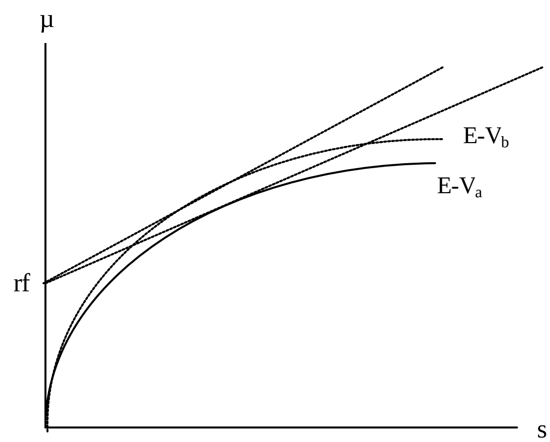
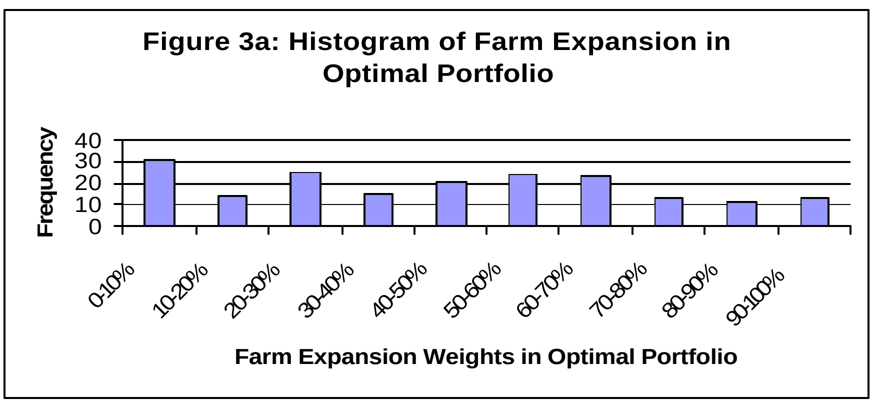


Figure 2: Two Unique E-V Frontiers





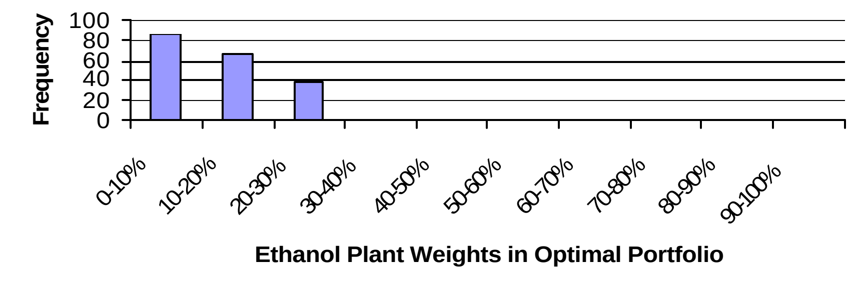


Figure 3b: Histogram of Ethanol Plant Weights in Optimal Portfolio

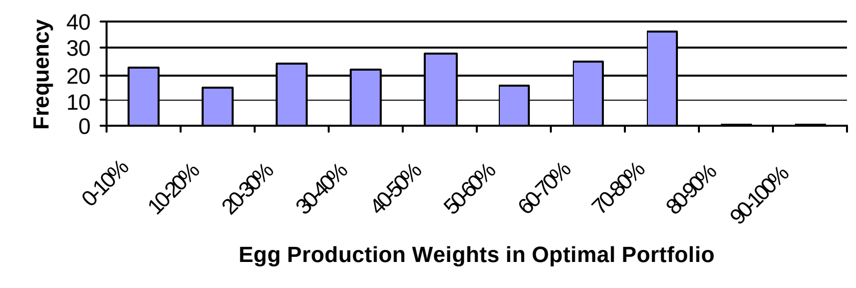


Figure 3c: Histogram of Egg Production Weights in Optimal Portfolio

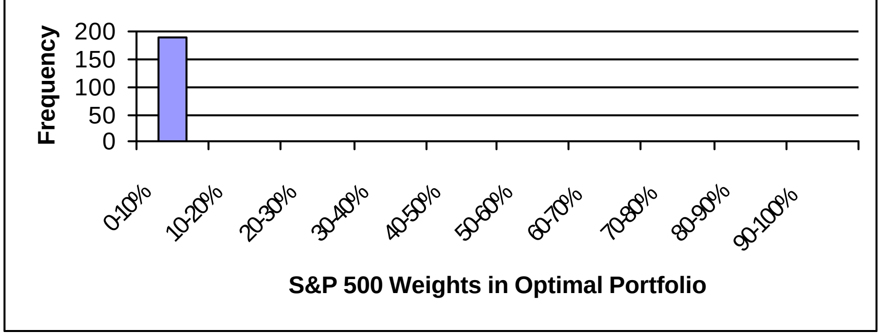


Figure 3d: Histogram of S&P 500 Weights in Optimal Portfolio

Figure 3e: Histogram of Fidelity Food Weights in Optimal Portfolio

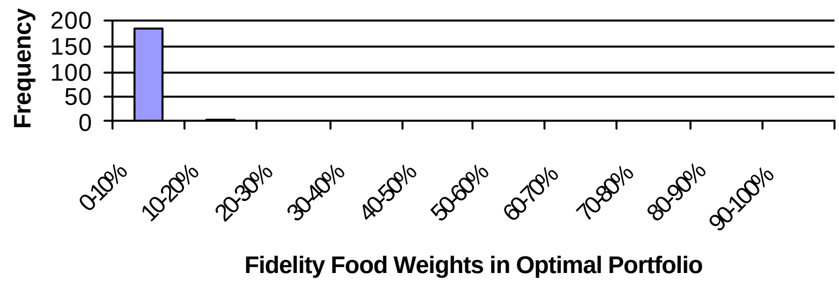


Figure 4: Distribution of Average Portfolio Weight, by Cluster

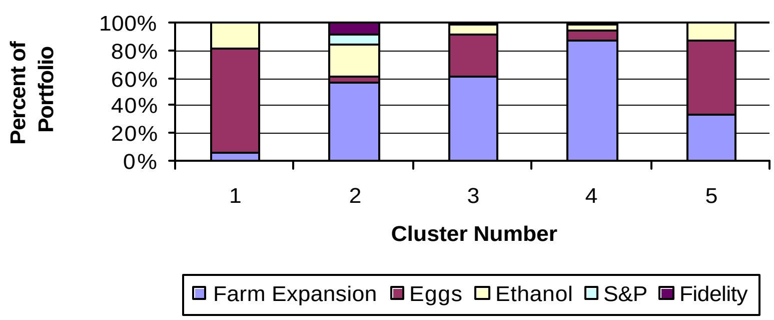


Figure 5: Portfolio Mean Less Risk Free Rate (3%), Standard Deviation, and Cluster Trend Line, by Cluster

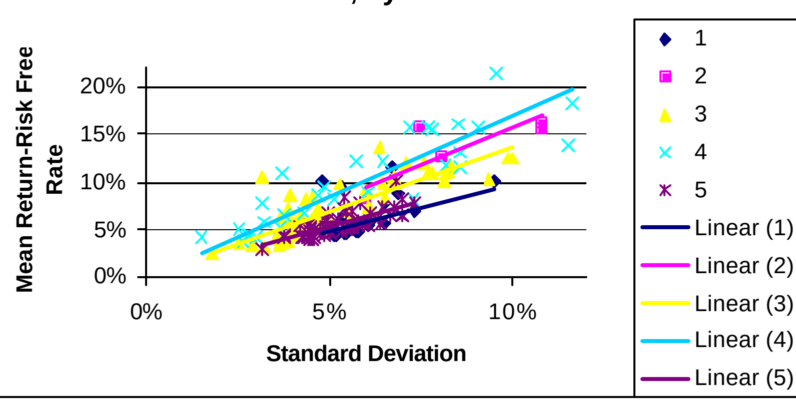


Table 1: Selected Farm Averages and *Standard Deviations*, 1993, 1998, and 2003

Variable	**1993**	**1998**	**2003**
Operator's Average Age	44.12	50.23	54.83
	12.82	*9.64*	*9.60*
Farm Size	600	778	881
	384	*475*	*809*
Percent Acres Rented	61.00%	59.88%	56.28%
	26.54%	*27.83%*	*29.88%*
Corn Yield	82.40	153.03	165.84
	20.47	*18.60*	*20.89*
Soybean Yield	30.63	51.63	36.62
	11.14	*5.81*	*6.62*
Net Farm Income	48,163	1,563	71,296
	46,539	*62,954*	*63,540*
Return to Management	3,057	-62,529	647
	41,902	*70,307*	*48,381*
Return on Assets	8.72%	0.55%	6.82%
	7.48%	*6.58%*	*4.67%*
Profit Margin	18.53%	2.83%	20.36%
	13.81%	*17.69%*	*13.95%*
Operating Expense Ratio	32.87%	33.82%	36.51%
	13.14%	*12.13%*	*11.02%*
Interest Expense Ratio	5.20%	6.55%	4.87%
	4.51%	*5.53%*	*4.18%*
Net Farm Income Ratio	18.53%	2.83%	20.36%
	13.81%	*17.69%*	*13.95%*
Return on Equity	13.25%	0.51%	10.54%
	14.90%	*11.22%*	*10.76%*
Government Payment Ratio	9.44%	9.83%	7.65%
	5.11%	*4.81%*	*3.43%*
Non-farm Income	6,773	10,939	12,721
	12,702	*16,508*	*19,313*

Table 2: Asset Alternative Annual Returns

Year	Ethanol Plant	Layer Facility	S&P 500	Fidelity Food Mutual Fund
1993	-27.09%	11.85%	7.06%	8.77%
1994	14.60%	2.55%	-1.54%	6.09%
1995	43.74%	10.35%	34.11%	36.66%
1996	12.27%	12.89%	20.26%	13.29%
1997	5.91%	11.80%	31.01%	30.31%
1998	7.21%	15.10%	26.67%	15.67%
1999	18.50%	4.13%	19.53%	-20.48%
2000	16.14%	8.87%	-10.14%	29.85%
2001	9.30%	-0.06%	-13.04%	-0.48%
2002	7.43%	-5.47%	-23.37%	-6.65%
2003	3.44%	7.48%	26.38%	14.10%
Average	**10.13%**	**7.23%**	**10.63%**	**11.56%**
Standard Deviation	**16.51%**	**6.28%**	**19.88%**	**16.98%**
Coefficient of Variation	**1.62**	**0.86**	**1.87**	**1.46**

Table 3: Correlation Matrix of Investment Alternatives

	Ethanol	Eggs	S&P	Fidelity
Ethanol	1			
Eggs	-0.092	1		
S&P	0.217	0.748	1	
Fidelity	0.257	0.626	0.418	1

Table 4: Cluster Statistics as *k* Changes

***k*=4**

Cluster Number	Number of Farms in Cluster	Max Distance Within Cluster	Nearest Cluster	Distance from Cluster Center
1	40	0.2495	4	0.3003
2	79	0.2775	4	0.3673
3	63	0.2739	2	0.4825
4	9	0.2942	1	0.3003
F-Statistic	**311.8**			

***k*=5**

Cluster Number	Number of Farms in Cluster	Max Distance Within Cluster	Nearest Cluster	Distance from Cluster Center
1	45	0.2225	5	0.3533
2	5	0.3284	3	0.3222
3	55	0.2715	2	0.3222
4	30	0.2699	3	0.3517
5	56	0.2255	1	0.3533
F-Statistic	**388.07**			

***k*=6**

Cluster Number	Number of Farms in Cluster	Max Distance Within Cluster	Nearest Cluster	Distance from Cluster Center
1	21	0.2314	4	0.3178
2	1	0	6	0.402
3	50	0.2411	5	0.3983
4	45	0.1971	6	0.26
5	65	0.2553	4	0.3792
6	9	0.2677	4	0.2906
F-Statistic	**294.59**			

***k*=7**

Cluster Number	Number of Farms in Cluster	Max Distance Within Cluster	Nearest Cluster	Distance from Cluster Center
1	24	0.1789	2	0.2814
2	5	0.1403	6	0.2703
3	49	0.2411	5	0.3764
4	1	0	6	0.4067
5	59	0.257	7	0.3578
6	6	0.265	7	0.2559
7	47	0.2059	6	0.2559
F-Statistic	**276.6**			

Table 5: Cluster Summary Statistics, 2003

Variable	**1**	**2**	**3**	**4**	**5**
Total Number of Farms in Cluster	45	5	55	30	56
Operators' Average Age	59	43	54	52	55
	11.52	*3.67*	*9.39*	*7.87*	*7.86*
Farm Size	879	729	886	857	905
	1,454	*644*	*536*	*377*	*421*
Percent Rented Acreage	55.21%	54.00%	59.23%	52.75%	56.34%
	35.16%	*34.79%*	*27.07%*	*29.80%*	*28.32%*
Corn Yield	164.16	143.75	166.65	172.13	163.55
	20.34	*15.76*	*22.52*	*20.90*	*19.31*
Soybean Yield	36.81	33.50	35.91	39.33	35.89
	6.67	*7.55*	*6.41*	*7.16*	*6.20*
Net Farm Income	52,639	110,978	70,080	110,412	62,985
	63,672	*89,510*	*53,623*	*75,612*	*54,304*
Return to Management	-8,077	49,441	-2,442	19,330	-3,673
	56,339	*69,769*	*45,200*	*42,443*	*41,705*
Debt to Asset Ratio	29.51%	51.49%	22.45%	18.04%	33.20%
	26.09%	*9.34%*	*18.16%*	*19.31%*	*21.48%*
Net Farm Income Ratio	14.93%	18.12%	23.21%	32.00%	15.87%

	11.72%	*7.09%*	*12.48%*	*13.06%*	*13.74%*
Return on Assets	6.02%	8.39%	7.07%	9.33%	5.73%
	5.44%	*3.17%*	*4.03%*	*4.24%*	*4.47%*
Profit Margin	21.15%	22.95%	27.37%	34.64%	21.56%
	11.70%	*5.91%*	*12.39%*	*12.24%*	*13.57%*
Interest Expense Ratio	6.22%	4.82%	4.16%	2.64%	5.68%
	4.52%	*1.41%*	*3.87%*	*2.59%*	*4.50%*
Operating Expense Ratio	35.14%	28.52%	39.62%	36.41%	35.32%
	11.34%	*7.27%*	*10.12%*	*9.23%*	*12.19%*
Government Payments Ratio	6.76%	6.63%	8.02%	8.53%	7.61%
	3.15%	*2.74%*	*2.72%*	*2.95%*	*4.37%*
Return on Equity	11.82%	18.32%	9.44%	12.20%	9.02%
	18.40%	*8.88%*	*5.57%*	*6.46%*	*7.67%*
Non-farm Income	16,671	3,456	9,772	14,314	12,416
	19,044	*6,370*	*15,313*	*25,623*	*19,705*
Sharpe Ratio	0.99	1.67	1.45	1.86	1.10
	0.28	*0.31*	*0.41*	*0.45*	*0.16*
Expected Portfolio Return	8.58%	16.70%	10.32%	13.12%	8.57%
	1.73%	*3.41%*	*2.99%*	*4.84%*	*1.33%*

Table 6: Multinomial Logit Parameter Estimates and Model Goodness of Fit

	Cluster (Relative to Cluster 1)							
Variable	**2**		**3**		**4**		**5**	
Intercept	8.032		3.762	**	3.807	*	1.751	
Age of Operator	-0.331	***	-0.085	***	-0.120	***	-0.038	
Grain Sales Ratio	-7.056	**	0.610		-0.001		-1.409	
Net Farm Income Ratio	24.121	***	10.551	***	15.465	***	5.572	**
Return on Equity	-11.102		-11.264	***	-10.263	***	-8.245	***
Debt to Asset Ratio	16.945	***	1.765		3.406		3.090	**
Interest Expense Ratio	-51.196	**	-13.435	**	-30.229	***	-8.801	
Government Payments Ratio	24.358		7.143		9.988		16.306	*
Non-farm Income	0.000		0.000	**	0.000		0.000	
Scaled R-Squared	**0.49**							
Log Likelihood	**-218.649**							

*Significant at the 10% Level
**Significant at the 5% Level
***Significant at the 1% Level

Table 7: Multinomial Logit Marginal Effects

	Cluster				
Variable	**1**	**2**	**3**	**4**	**5**
Intercept	-0.393	0.089	0.321	0.111	-0.129
Age of Operator	9.65E-03	-4.29E-03	-5.05E-03	-5.54E-03	0.005
Grain Sales Ratio	0.085	-0.107	0.248	0.035	-0.261
Net Farm Income Ratio	-1.231	0.253	0.583	0.789	-0.394
Return on Equity	1.342	-0.044	-0.849	-0.171	-0.278
Debt to Asset Ratio	-0.401	0.233	-0.162	0.105	0.225
Interest Expense Ratio	1.906	-0.601	0.046	-1.983	0.632
Government Payments Ratio	-1.733	0.225	-0.562	0.077	1.993
Non-farm Income	1.77E-06	1.74E-07	-3.73E-06	5.73E-07	0.0001

Table 8: Correlation Matrix of Investment Alternatives

	Ethanol	Eggs	S&P	Fidelity	Farm Expansion
Ethanol	1				
Eggs	-0.092	1			
S&P	0.217	0.748	1		
Fidelity	0.257	0.626	0.418	1	
Farm Expansion	-0.249	0.063	-0.208	0.134	1

APPENDIX: DESCRIPTION OF FARM FINANCIAL RATIOS

Net Farm Income=Net Income After Taxes-Unpaid Labor

Return to Management=Net Farm Income-(0.06*Net Worth)

$$\text{Debt to Asset Ratio}=\frac{\text{Total Liabilities}}{\text{Total Assets}}$$

$$\text{Net Farm Income Ratio}=\frac{\text{Net Farm Income}}{\text{Gross Farm Revenue}}$$

$$\text{Return on Assets}=\frac{\text{Net Farm Income}}{\text{Total Assets}}$$

$$\text{Profit Margin}=\frac{\text{Net Farm Income + Interest Expense}}{\text{Gross Farm Revenue}}$$

$$\text{Interest Expense Ratio}=\frac{\text{Interest Expense}}{\text{Gross Farm Revenue}}$$

$$\text{Operating Expense Ratio}=\frac{\text{Total Operating Expense}}{\text{Gross Farm Revenue}}$$

$$\text{Government Payments Ratio}=\frac{\text{Total Government Payments}}{\text{Total Farm Revenue}}$$

$$\text{Return on Equity}=\frac{\text{Net Farm Income}}{\text{Net Worth}}$$

$$\text{Grain Sales Ratio}=\frac{\text{Corn and Soybean Sales}}{\text{Gross Farm Revenue}}$$

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