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Investment in the stock market and value-added agricultural businesses as portfolio investment alternatives to farm expansion

Joshua David Roe
Iowa State University

Investment in the stock market and value-added agricultural businesses as portfolio investment alternatives to farm expansion

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Joshua David Roe

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Robert W. Jolly (Major Professor)
Maureen R. Kilkenny
Gary D. Koppenhaver

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Joshua David Roe

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ABSTRACT

In the past decade, farmers have increasingly invested in value-added agriculture. Analysis of these investments compared to farm expansion by farmers was conducted from a portfolio optimization standpoint. Farms with similar investment patterns were identified by cluster analysis. When individual farm characteristics were analyzed to determine how these attributes affected investment choices, clear influences were found.

In general, value-added agricultural investments were found to be an efficient investment alternative to farm expansion. Because of their larger risk, stock market investments play a smaller role in an optimized producer portfolio.

1.0 INTRODUCTION

The Value-Added Business Boom

Investment in farmer-owned, value-added businesses has skyrocketed since the early 1990s. With this increased interest in investment, research in value-added agriculture has increased dramatically. 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.

Value-added manufacturing can be defined as adding value to basic farm commodities through additional processing and marketing (Gale 2004). 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. Examples of off-farm value-added manufacturing businesses are listed below.

Ethanol production illustrates both a current and future shift in investment preferences by many Iowan agricultural producers. Currently, 18 Iowa ethanol plants are producing 729 million gallons of ethanol and generating the equivalent of more than 2.29 million tons of dried distiller's grain with solubles (DDGS). This process uses 270 million bushels of corn annually (Wisner 2005). Of these 18 plants, 12 are organized as farmer-owned cooperatives (Otto 2003). The average cost to plan and construct an ethanol is approximately $1 per gallon of future plant capacity. The average new plant produces approximately 60 million gallons annually, requiring a significant capital investment.

Future investments in ethanol will be significant. Approximately 16 additional ethanol plants are currently in construction or in planning stages. This adds an additional 433 million gallons of ethanol for a total of 1.16 billion gallons produced in Iowa alone. Long-term estimates indicate that by 2010, Iowa will produce up to 7.5 billion gallons of ethanol (Wisner 2005).

An example of a farmer-owned Iowa ethanol plant is Midwest Grain Processors (MGP) in Lakota, Iowa (Leibold 2005). MGP began production in 2001 and was organized by a local farmer-led investment group, Ag Ventures Alliance. MGP became a separate entity in 2002 and operates a 45 million gallon ethanol plant, annually consuming more than 17 million bushels of corn (Ag Ventures Alliance). MGP plans to more than double its capacity to over 100 million gallons by the end of 2005. MGP is owned by 1,200 individual investors. Because of its organization as an agricultural cooperative under section 512 of the Internal Revenue Service's code for cooperatives, investors are required to be individual farmers, farm partnerships, farm corporations, or farmer-owned cooperatives (Midwest Grain Processors).

Another major source of value-added business expansion in recent years is egg production. In 1990, approximately 8.2 million egg-laying hens in Iowa produced 2.1 billion eggs. Today, recent estimates in Iowa reveal that the number has grown to an annual production of 10.8 billion eggs by more than 40 million hens (Lawrence 2005). These hens consume an estimated 34 million bushels of corn and 370,000 tons of soybean meal (Lawrence 2003).

Golden Oval Eggs, headquartered in Renville Minnesota, is a prime example of a farmer-owned value-added business. Golden Oval Eggs was formed in 1994 with 383 members who invested $8 million dollars of capital at $3,500 a share. Each share obligates the investor to deliver 1,000 bushels of corn to the facility. Golden Oval Eggs established a production and processing facility in Iowa in 1999. Since its inception, Golden Oval Eggs has increased production four-fold and its main platform for expansion has been Iowa. (Golden Oval Eggs 2005).

Government Support

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. Program types include promotion and state labeling, business and technical assistance, loans, grants, directories, market research, jobs and training, and legal assistance (Kilkenny 2001). In the 1998-99 fiscal year, states around the nation budgeted more than $280 million dollars for value-added agriculture programs (Kilkenny 2001).

Iowa has four separate financial assistance programs available to value-added agricultural businesses. Financed through state user taxes, their primary purpose is rural development (Kilkenny 2001). User taxes are generated through additional taxes on rural utilities such as electricity and water and other public goods used by rural individuals and businesses (Kilkenny 2005). Other common assistance programs include county property tax abatements and income tax credits. One program, either under consideration or implemented in Iowa, Minnesota, and Illinois, is to set a minimum level of ethanol content for all gasoline sold in-state.

What caused this shift?

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 steadily in size over the past century, they have become a more complex business entity. Today, farmers are also managers, marketers, and operators. As farm size has increased, the number of farmers has dramatically decreased. This narrowing of numbers has resulted in more competitive, qualified competitors, 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 a differentiated food product or finding non food uses.

Changes in size and numbers of farms have negatively affected rural development, reflected by declining populations and incomes. 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.

Horizontal vs. Vertical Growth

Traditionally, growth in farm size 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. This expansion allowed producers to gain economies of scale while increasing their capital-to-labor ratio, which increases output per unit of labor. Economies of scale are evidence that average costs decrease as output is increased. Basic economic theory states that a firm should expand up to the point where their average costs are minimized, but beyond that point, a firm might face increased average costs per unit of output (Besanko 2004).

In the case of farm expansion, average costs may decline over certain levels of production due to a declining labor/output ratio as output is increased. At this point, farm income will rise as production is increased due to these declining costs. As the labor/output ratio declines to a certain level, average costs may be constant over another range of production, but then increase at some point of output for a specific farm. These rising costs can be attributed to rising marginal costs in the production of additional output. 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.

Vertical expansion is profitable if a firm is able to create more value through the next production or marketing stage while successfully competing with existing processing firms. Through this form of expansion, the business faces new competition from past buyers of the firm's product. In order to successfully expand, the firm must have access to specialized skills to manage their new production or marketing process. In order to determine potential customer demand, farmer investors of value-added agriculture must insure that their managers have increased market knowledge, instead of merely producing basic commodity inputs and selling them on the open market. Because value-added manufacturing mainly deals with raw farm commodities, producers of these commodities may be more attracted to the investment than non-producers of raw commodities. This can be attributed to the additional marketing channels that value-added manufacturing provides to farmers.

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.

This question will be answered from a portfolio optimization standpoint. Portfolios for individual farms with differing characteristics will be optimized to determine the best horizontal and vertical expansion mix for individual farms.

Overview of the Remainder of the Thesis

The remainder of the thesis will identify and quantify vertical and/or horizontal expansion opportunities available to Iowa producers. This will be conducted via portfolio optimization and statistical clustering. A multinomial logit model will also be used to determine if farm characteristics affect investment patterns.

2.0 CONCEPTUAL FRAMEWORK

The choice of a 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. In this chapter, we will explore the theory and methodology that will be used to conduct these studies. We will also explore the benefits and risks of selected investment alternatives readily available to Iowa producers.

Portfolio Theory

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.

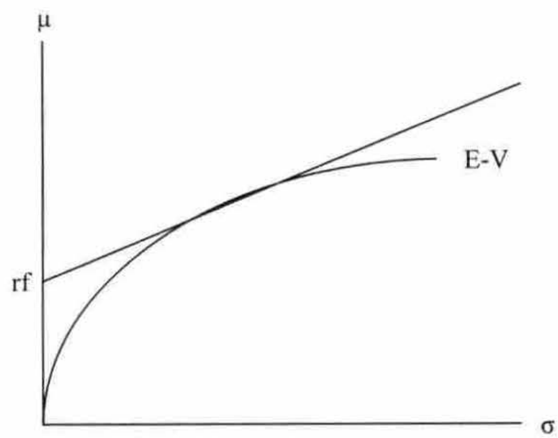
One of the fundamental concepts in portfolio allocation was developed by Markowitz who derived an expected return-variance (or E-V) frontier and proved that every point along the frontier maximized the investor's utility. This frontier was defined by Markowitz as a combination of investments that provide the highest rate of portfolio return, given the level of risk (measured by variance) or the lowest risk for a given return.

Diversification is central to portfolio theory. The theory of diversification states that unless all assets in a given portfolio are perfectly correlated, an optimal mix of assets can be obtained to give the same return with lower risk than a single asset. Portfolios located on the E-V frontier have been diversified to provide the lowest level of risk given their expected return (Markowitz 1959).

The E-V frontier is a monotonically increasing function with respect to return and variance. Its convexity implies that as expected portfolio return increases, expected variance increases at a greater rate. This goes along with Markowitz's theory of portfolio allocation, which states that as an investor balances his portfolio along the E-V frontier, he will take on more risk for relatively smaller increases in expected portfolio return.

As illustrated in Figure 2.1, any point on the line between the point of tangency and the risk-free rate of return is an optimal portfolio with respect to risk and return. The risk-free rate of return is the rate of return that a conservative investment, such as government treasury bills, yields. The basic premise for a risk-free asset is that the standard deviation of the investment's return must be smaller than the expected return, translating to a positive expected return. An investor who balances his or her portfolio to the tangency point is considered risk neutral and an investor who balances his or her portfolio on the risk-free rate of return is considered risk averse. The line between the risk-free rate and the point of tangency is known as the lend/borrow line. The lend/borrow line illustrates an efficient combination of risk and return where an investor can efficiently lend or borrow money to achieve a portfolio on the E-V. According to an investor's level of risk aversion, he will balance his portfolio on the lend/borrow line between the point of tangency and the risk-free rate of return (Markowitz 1959).

Figure 2.1: Tangency of the Borrow/Lend Line and the Markowitz Efficient Frontier



Asset Allocation Models

There are several quantitative asset allocation models that will optimize a portfolio's mean and variance mix. This research will use two separate approaches to portfolio optimization; quadratic programming and Sharpe ratio maximization.

Portfolio optimization using quadratic programming maximizes the expected portfolio return given the expected portfolio variance and the investor's coefficient of risk aversion, mathematically:

$$
\begin{aligned}
&\max E(R_{pi}) - \frac{1}{2} * p * E(Var_{pi}) \\
&where\ E(R_{pi}) = \sum_{j=1}^{n} w_j r_j \\
&where\ E(Var_{pi}) = \sum_{k=1}^{n} \sum_{j=1}^{n} w_k w_j p_{kj} \sigma_k \sigma_j \text{ for } k \neq j \\
&s.t: \\
&\sum_{j=1}^{n} w_j = 1 \\
&0 \leq w_j \leq 1
\end{aligned}
$$

Where:

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

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

n=Number of assets.

r_j=Expected rate of return of asset j.

ρ=Coefficient of risk aversion.

p=Covariance between assets k and j

σ_k and σ_j=Standard deviation of assets k and j, respectively

w_j=Weight of asset j.

The most commonly used risk aversion coefficients used in this modeling framework are those derived by Pratt and Arrow (Hardaker 2004). These aversion coefficients are derived by dividing the first derivative of an investor's utility function by the second derivative of the same function, mathematically:

$$U_i = U(w_i)$$
$$\frac{dU}{dw} = U^{'}(w)$$
$$\frac{dU^2}{dw} = U^{"}(w)$$
$$r_a(w) = -\frac{U^{"}(w)}{U^{'}(w)}$$

Where:

U_i=The utility that individual i receives from wealth

$U^{'}(w)$ and $U^{''}$=The first and second derivatives of U_i with respect to w

$r_a(w)$=Coefficient of absolute risk aversion

Anderson and Dillon used this framework to classify an individual's degree of risk aversion. They did this by determining what percent of total wealth an individual would be willing to stake in order to receive a 50% chance of a 20% increase in total wealth (Hardaker 2004). If an individual would be willing to invest 20% for the opportunity, his corresponding risk aversion coefficient would be zero and he would be classified as completely risk-neutral. On the other hand, if an individual would not be willing to invest any portion of his current wealth for the opportunity, his corresponding risk aversion coefficient would be infinite and he would be classified as completely risk-averse. Table 2.1 classifies feasible ranges for an individual's risk aversion coefficient, and corresponding willingness to invest for the opportunity.

Table 2.1: Risk Aversion Given a 50% Chance to Increase Wealth by 20%

Risk Classification	Risk Aversion Coefficient	Maximum Stake (% of Wealth)
Risk Neutral	0	20%
Somewhat Risk Averse	1	17%
Rather Risk Averse	2	14%
Risk Averse	3	12%
Very Risk Averse	4	11%
Extremely Risk Averse	5	10%

One of the major difficulties in quadratic programming is that one must know either the shape of the investor's utility function to calculate the coefficient, or the coefficient directly. Once this is known with certainty and the objective function is maximized, the portfolio lies on the efficient portfolio frontier.

Another method of mean-variance optimization is to maximize the Sharpe ratio. William Sharpe, who developed the 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. If a portfolio is optimized such that the Sharpe ratio has a value greater than one, the expected return of the portfolio will be at least that of the risk free rate of return.

For the remainder of this chapter, we will focus on investment choices readily available to agricultural producers in Iowa. Investments in farm expansion, value-added agricultural businesses, and the stock market will be evaluated and justified.

Investing in Farm Expansion

Farmers have historically relied on horizontal growth or expansion as a strategy to improve their financial positions. These horizontal expansions allow farmers to produce at lower per unit costs, allowing them to gain economies of scale. 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. As Figure 2.2 illustrates, average farm size both in Iowa and the United States has risen steadily over the past 43 years.

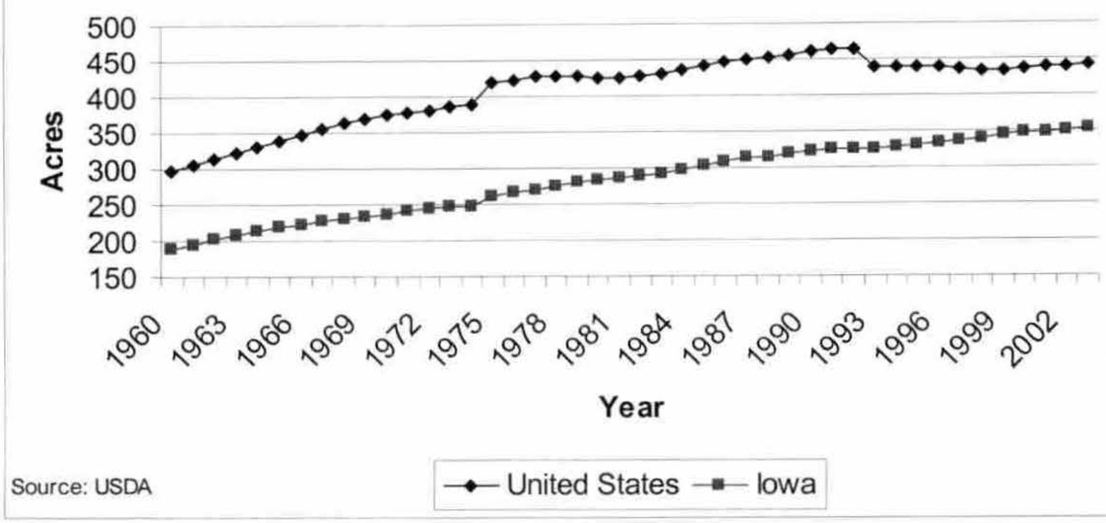


Figure 2.2: Average US and Iowa Farm Size, 1960-2003

However, due to physical constraints such as land availability in close proximity to the existing farm operation, farm expansion may be limited. For example, if the only land available for a producer to expand on is a considerable distance away from existing land, increased transportation and labor costs may make it cost prohibitive for producers to expand their operation.

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. Producers may also have limited access to additional capital due to a poor relationship with their local agricultural lender or if the lender considers further farm expansion a poor investment.

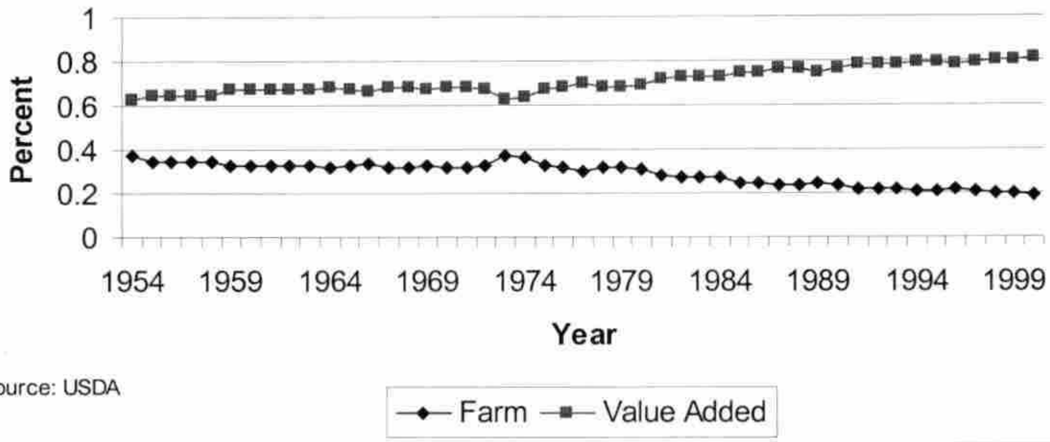
Previous work evaluating the addition of farm assets to a portfolio concluded that their addition to a well balanced portfolio will reduce overall portfolio risk (Barry 1980). Studies conducted on farm expansion found that actual cases of rising average costs with additional output in American agriculture 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

As stated earlier, investment in farmer-owned, value-added businesses and cooperatives are readily available to producers. These investments expose producers to many new risks and returns. These new risks and returns will now be discussed in detail.

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. As Figure 2.3 illustrates, the percentage of Americans' food expenditures that goes to the farm gate has steadily declined, while the expenditure toward food processing and marketing has significantly increased.

Figure 2.3: Farm Value and Value Added Value of Food Expenditures as a Percent of Total US Food Expenditures, 1954-2000



Source: USDA

If a producer invests in further processing and marketing of his products and the sector is profitable, he will add value to his farm commodities by receiving part of the profits from the "value-adding" sector.

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. The opposite is true in periods of relatively high prices. If this is the case, a producer could reduce his overall portfolio risk by diversifying his investment between the farming enterprise and the value-added agriculture company.

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. A producer may also gain intrinsic value from a value-added business located close by, because he will be able to literally see his investment on a regular basis. He 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.

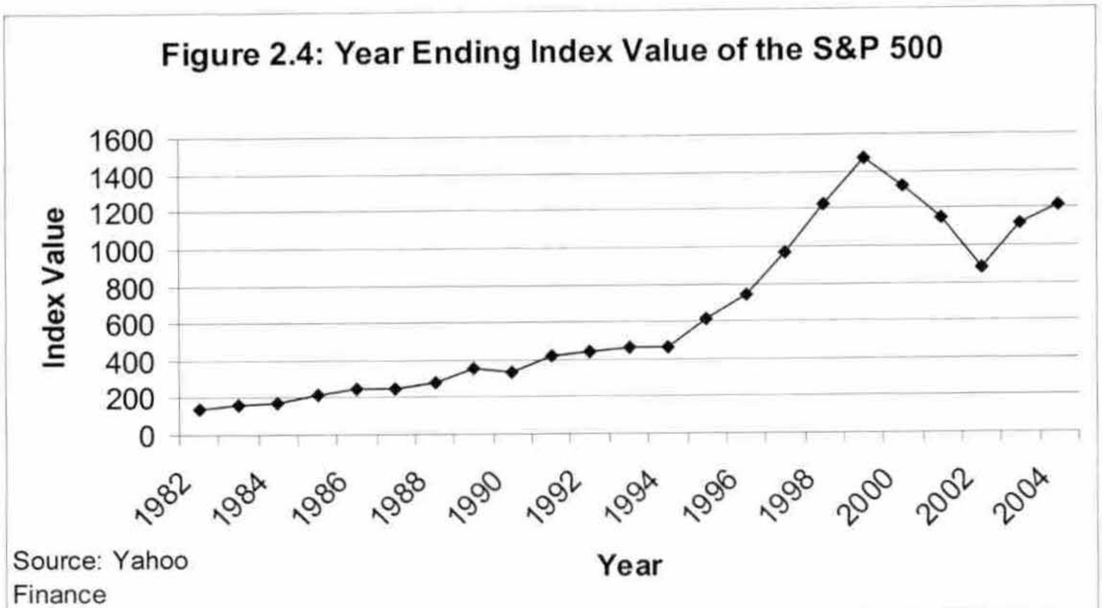
Startup costs for a value-added business may be large, requiring both significant capital investments as well as substantial commitments of the commodity from the investors. Businesses that require the construction of new production facilities will more than likely require more startup capital than the investors can provide and the local/state government is willing to subsidize. 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. Additionally, operating costs of a new business may be underestimated, which may require additional capital outlays from the investors, as well as supplying more of the commodity for a price below its market value.

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).

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.

Investing in Stock Indexes

Producers may benefit from investing in a mutual fund such as the type that contain 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. As Figure 2.4 illustrates, the S&P 500 has experienced long-term growth.



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.

With the addition of these new assets come new risks and returns. Systematic risks and returns affect the entire market. In other words, all aspects of the market will tend to move in the same direction. For example, the 9/11 terrorist attack moved a vast majority of all asset returns downward, so an event such as this is considered a systematic risk. On the other hand, the long-term increase in stock indices is considered a systematic return.

Unsystematic risks and returns are variables that affect an individual industry or company. For example, an investigation of a company by the SEC that causes the share price to tumble is an unsystematic risk. On the other hand, a company developing a popular new product that causes the share price to double is an unsystematic return.

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). When the addition of stock indexes are further supplemented by value-added agriculture investments, studies show that stock indexes lower expected portfolio risk, but appear less attractive as farm size increases (Jones 1999).

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. For example, firms such as Kraft Foods spend much more on labor and advertising than on raw materials such as wheat, corn and soybeans. 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. 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). Further studies evaluating the addition of individual food processing and agricultural business stocks to a farm asset portfolio have found that individual stocks place a portfolio on the E-V frontier, while a portfolio consisting of farm assets and stock indexes alone is prone to greater risk for a given rate of return (Detre 2002).

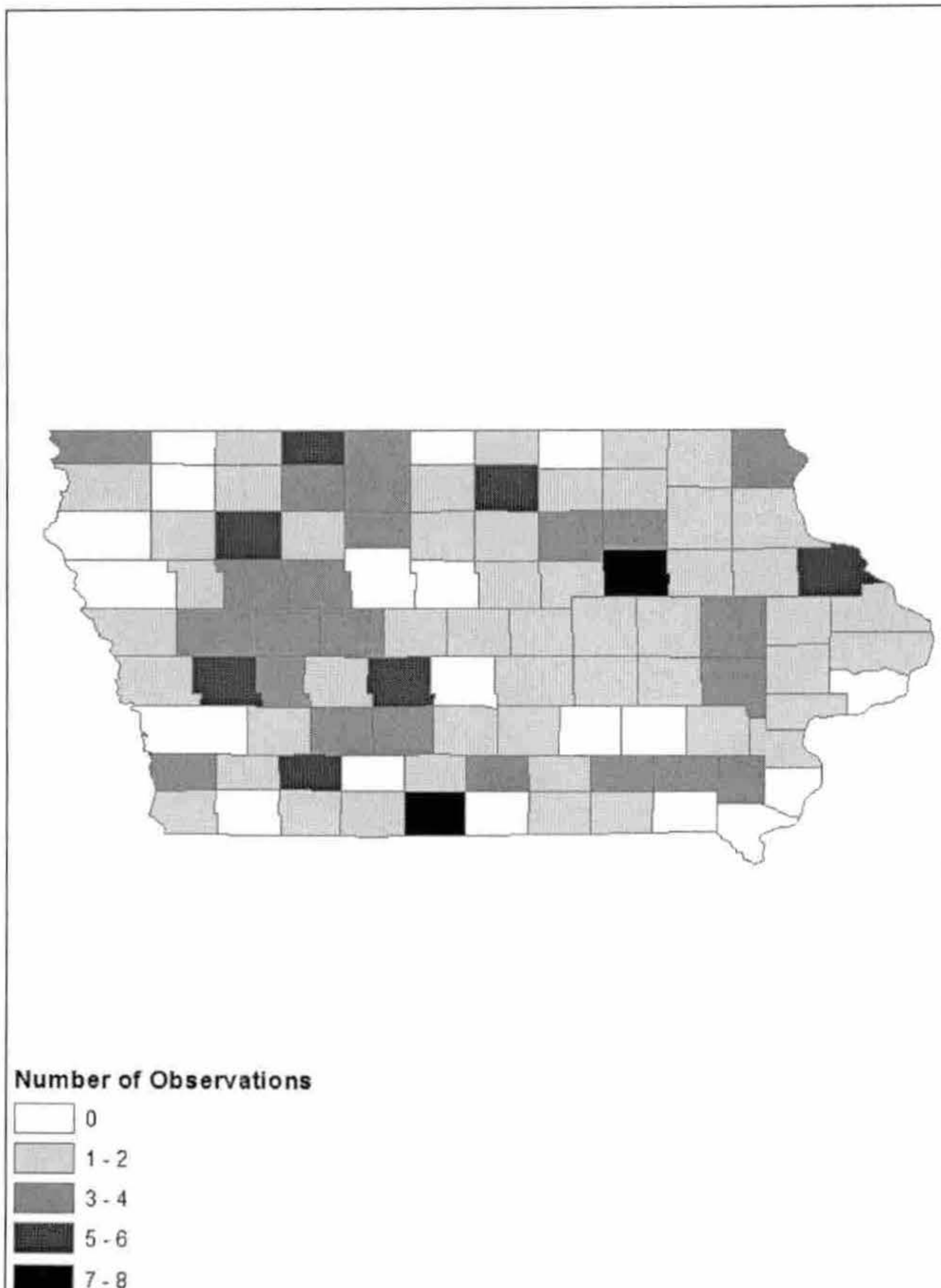
3.0 MODEL SPECIFICATION

The purpose of this chapter is to describe and justify which assets will be included in the portfolio analysis, describe the empirical modeling techniques, and discuss further modeling.

Farm Description and Return Calculation

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 operations across Iowa. Figure 3.1 illustrates the number of farms in the dataset in each Iowa County. The farms appear to be spread across the state adequately enough to ensure that there are no regional biases in the panel.

Figure 3.1: Number of Observations in Each County



In order to extract further farm characteristics, farm financials were analyzed to determine which commodities were primarily produced on each farm. After examination of the data, seven different farm types were calculated based off of the distribution of farm sales (Jolly 1998). Table 3.1 describes the criteria for each farm type and the number of farms in the dataset that qualify as each type.

Table 3.1 Farm Type Criteria

Farm Type	Criteria	Number of Farms
Cash Grain	Corn and soybean sales accounted for at least 95% of total cash receipts.	53
Crop	Corn and soybean sales accounted between 50-95% of total cash receipts.	38
Hog	Hog sales accounted for at least 50% of total cash receipts.	38
Cattle	Cattle sales accounted for at least 50% of total Cash receipts.	11
Dairy	Milk sales accounted for at least 50% of total Cash receipts.	3
Out of Hog Production	Initially, hog sales accounted for at least 50% of total cash receipts, but sales dwindled below 50% or went to zero over the time period.	23
Other	Farms that met none of the above described criteria.	25

Table 3.2 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 located in Appendix A. Inline 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. The year 1998 was in the heart of the Asian crisis and very low Iowa hog prices, which had a significantly adverse impact on farm exports and income; farm returns were

significantly lower. Interest expense as a percentage of total farm revenues decreased over the time period, likely due to decreasing interest rates during the time period.

Table 3.2: 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*

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_l=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. 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 what there current return to farm expansion was.

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.

Asset Alternatives, Description and Return Calculation

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 the Fidelity Food mutual fund.

The S&P 500 is a broad stock index that fluctuates according to the value of its 500 stocks in virtually every industry worldwide. Price data on the S&P 500 was obtained from Yahoo Finance as the index value adjusted for stock splits and dividends. Annual returns were then calculated.

The Fidelity Food mutual fund is a fund managed by Fidelity investments and contains stocks from major food processing, retailing, and agribusiness companies. Price data on the Fidelity Food mutual fund was downloaded from Yahoo Finance. Its price was then adjusted for stock splits and dividends, and annual returns were calculated.

Because of their increasing popularity in Iowa, investments in ethanol and egg production were included as asset 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 underlying assumptions of the costs of production are 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 3.3 and 3.4 present the average returns and the correlation among the four asset alternatives by year:

Table 3.3: 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 3.4: 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

Over the time period, the layer facility is the investment with the least risk and return. The steady returns can be attributed from a steady increase in the demand for eggs over the time period, but factors such as the real increase and decrease in the price of eggs and energy, respectively 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 production and the stock investments are positively correlated throughout the time period. Ethanol production and the stock investments are also positively correlated, but on a lower level. 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.

Optimization Models

Both quadratic programming and Sharpe ratio maximization were used in optimizing a portfolio for each farm in the dataset. The result is 191 individually optimized portfolios for each of the 191 farms in the dataset. Each portfolio has unique weights in the five investments included.

Using the Solver add-in to Microsoft Excel to maximize the objective function described under the previous quadratic programming explanation, a unique portfolio will be optimized for each farm. Since it was impossible to derive each producer's coefficient of risk aversion with the available data, risk coefficients between 0.5-5 were assumed for each producer, yielding 6 optimized portfolios for each farm, depending on the level of risk aversion.

Previous research on this method proved that the initial starting weights of each asset in the portfolio are path dependent to ending portfolio weights (Black 1992). In other words, in order to accurately depict ending portfolio weights, information on each farm's starting portfolio weights would be needed. Unfortunately, due to data limitations on these farms, the initial investment weights are not available. Therefore, the initial portfolio weights are assumed to be 100% in farm expansion; with no initial investment in the other four asset alternatives.

In order to maximize the Sharpe ratio 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 according 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. Since initial portfolio weights are not path dependent to final weights and estimates of the producer's risk aversion coefficient are not required, only one portfolio for each farm will be optimized. The risk-free rate of return is set at 3%, which is parallel to an average rate of return from a relatively low risk asset in today's market.

Previous research has used the Sharpe ratio in this form to optimize a portfolio for agricultural producers (Detre 2002). 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 variance in farm returns is lost.

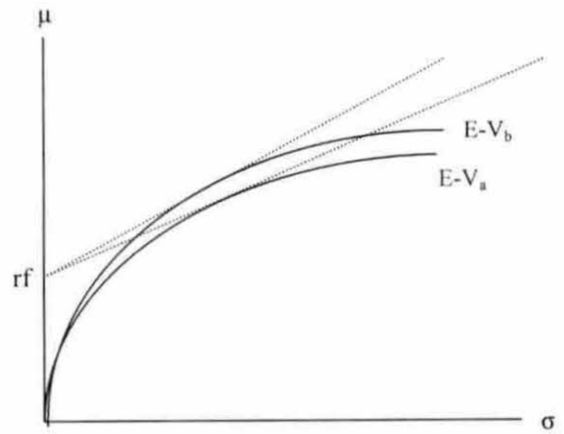
Because of the differing assumptions and risk aversion coefficients, it is hypothesized that the two methods will produce different results. These differences will be illustrated in the results section of this paper.

Portfolio Result Interpretations

Once the optimal portfolio has been calculated, the portfolio weights assigned to each individual are assumed to find the place of tangency between the risk-free rate and the efficient portfolio frontier. In an optimization problem such as this, where at least one investment is mutually exclusive to each agent (in the form of their farm returns), unique tangency points are found on equally unique efficient frontiers. That is, each agent has a uniquely shaped efficient frontier because of unique portfolio investment opportunities.

Figure 3.1 illustrates different E-V frontiers and tangency points for two (hypothetical) individuals with access to the same risk-free rate of return.

Figure 3.2: Two Unique E-V Frontiers



As Figure 3.1 illustrates for individuals a and b, individual b's lend/borrow line has a steeper slope than individual a's. This implies that for every portfolio balanced on the lend/borrow line for each individual, individual b's expected portfolio return is greater than a's for the same amount of risk. In this investment framework, the only asset return that differs is each producer's individual farm returns. This implies that individual b's returns to farm expansion may be higher with lower risk when compared to individual a's. Also, individual b's returns to farm expansion may be more negatively correlated with the investment alternatives, providing higher returns in years when farm returns are lower. The only producers in this setting who will not have unique E-V frontiers are those who find it inefficient to expand their farm.

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 illustrate 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 farm and asset alternative returns. In reality, each producer's efficient frontier has a different shape 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. Factors such as age of the operator, farm size, farm financial status, type of farm operation, and location of the enterprise are possible factors that affect the shape of the frontier.

Therefore, farms that have similar investment patterns may or may not be similar in their characteristics. To determine this, similar groups with respect to 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.

Clustering

K-means clustering is a common statistical procedure that places *n* observations into *k* similar groups or clusters given attributes specified by the researcher. K-means clustering also requires the researcher to specify *k* clusters. The K-means procedure initially picks *k* observations to partition into each cluster. The algorithm then proceeds through the remainder of the dataset assigning each observation to a cluster whose mean (or position in multi-dimensional space) is similar to that of the center of the cluster. The center of each cluster is calculated after a new observation is added to a cluster and if an observation is found to be closer to another cluster's center, the observation is moved to that cluster. This process repeats itself until all observations are assigned to a mutually exclusive cluster and the distance of each observation to its cluster is less than the distance to another cluster. Clustering has been used in many financial research frameworks. (See Das 2003 for a discussion of k-means clustering.)

The distances expressed between and within clusters are expressed as Euclidean distances. With two dimensions, the Euclidean distance between two points (x_1,y_1) and (x_2,y_2) is measured as:

$$E_d = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$$

With N dimensions, the expression is extended to:

$$E_d = \sqrt{\sum_{i=1}^{n} (p_i - q_i)^2}$$

Where p_i (or q_i) is the coordinate of p (or q) in dimension i (National Institute of Standards and Technology 2005)

Central to the accuracy of clustering is choosing the optimal number of clusters. If the number of clusters chosen is too small, the distance within the clusters can be so large that the validity that each cluster is in fact, similar, is questionable. If the number of clusters chosen is relatively too large, the distance between each cluster's center is so close that the validity that each cluster is unique is questionable. A good method of determining the optimal number of clusters is to vary the *k* while observing the number of observations in each cluster. If it is observed that if *k* is large and a relatively large percent of the clusters house only a few observations, and the distance between their centers is relatively small, then *k* should be lowered. However, if *k* is relatively small and the variability inside each cluster exceeds that of the distance between clusters, observations in different clusters are overlapping and *k* should be increased.

Using the PROC FASTCLUS command in the SAS system software program and considering the optimal weights calculated in the above optimization models, the farms in the dataset will be clustered. Numerous values of *k* will be experimented with. This will identify which producers are similar with respect to their asset weights.

Additional Steps

At this point, the portfolio for each farm has been optimized and each farm is placed into a cluster. These results are merely based on the capital asset pricing model and a strong statistical algorithm. Differences in farm financial characteristics and demographics that affect a farm's investment tendencies have not been considered.

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 give each producer's E-V frontier a different shape and if their investment patterns are affected. This will answer the question of what characteristics of a farm make it more profitable to invest in vertical or horizontal expansion.

Utilizing a multinomial logit modeling framework will help answer the above questions. Logit models in general are designed to numerically link a decision that an agent makes to a set of covariates that apply both to the choice that the agent made and individual characteristics of the agent (Greene 2000). Individual characteristics of the agent, information on the consequences of the choice, and the choice the individual made (in its simplest form: a yes or no) are needed in order to calculate the numerical relationship. Once calculated, the model numerically depicts shifts in the agent's characteristics and depicts if their probability of choosing yes or no increases or decreases. McFadden and Domencich were among early economists to expand the logit framework to multinomial logit, where the agent has more than two options to choose from. Instead of merely predicting if the agent will choose yes or no, the multinomial logit can predict if an agent will choose A, B, or C.

In the framework of this research we will use a multinomial logit model to predict which cluster a farm is in using their individual characteristics. Hence we will numerically link a farm to its optimal investment patterns using their individual characteristics. Mathematically, coefficients are derived such that given a farm's individual characteristics; the probability of them belonging to a certain cluster is maximized. The following equation illustrates the probability that individual *i* will choose alternative *j*.

$$\Pr(Y = j) = \frac{e^{B_j' x_i}}{\sum_{k=1}^{j} e^{B_k' x_i}} \quad \text{for } j = 1, 2, 3, 4, 5$$

Where:

Y=Which cluster the producer is assigned to

j=Total number of clusters

B=Estimated coefficient that maximizes the probability that the individual chooses the revealed alternative

x_i=Characteristics of individual i associated with their optimal type of portfolio

In order to conveniently estimate the equation, B_j is assumed to equal zero, yielding the following equation:

$$\Pr(Y=0)=\frac{1}{\sum_{k=1}^{j} e^{B_k' x_i}} \text{ for } j=0,1,2,3,4$$

This equation will yield a unique coefficient for each characteristic and choice, allowing the researcher to determine if the level of a characteristic will increase or decrease the probability of them belonging to group j. These quantitative results will determine the probability of a farm belonging to a certain cluster given its characteristics. The cluster a farm was assigned to will be used as the dependent variable and farm characteristics such as age of operator, non-farm income, farm debt levels, farm profitability, farm productivity, and farm type will be used as the independent variables. Their individual coefficients will provide a ceteris paribus approach in determining the investment tendencies of each farm and will help in explaining whether horizontal or vertical expansion is more profitable for each cluster. Following is a series of hypotheses of how individual farm characteristics will affect a farm's optimal portfolio choices.

Operator Demographic Hypotheses

As a farm operator's age increases into their senior years, their investment tendencies 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), as the operator's age increases, ceteris paribus.

A producer's level of non-farm income has significant effects 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, a producer with a relatively higher non-farm income will be more likely to choose to invest in non-farm assets because he is unable to provide more farm management labor. A producer who holds a full-time job and a viable farming operation can be viewed as someone who is relatively risk neutral compared to an individual who holds either a farming operation or a full-time job. He chooses to actively farm with a full-time career because the expected benefits outweigh the costs. If he is willing to supply up to 2,000 hours of labor outside the farm annually, when he could have made a viable living farming, he can safely be viewed as a risk neutral individual.

Farm Characteristic Hypotheses

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, 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 weigh into their decision as heavily.

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.

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. If the outside investment is successful and provides positive returns to the producer, then the producer will hold a portfolio that has a higher expected return for less risk.

All in all, 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?

4.0 RESULTS AND INTERPRETATION

Optimized Portfolio Results

Table 4.1 illustrates the average portfolio weights, expected portfolio returns, and portfolio standard deviations for varying levels of risk aversion for the quadratic programming method and the Sharpe ratio maximization across all farms in the sample.

Table 4.1: Average Portfolio Weights, Returns, and Standard Deviations for Both Optimization Methods

	Quadratic Programming Risk Aversion Coefficient						Sharpe
Asset	**0.5**	**1**	**2**	**3**	**4**	**5**	**Ratio**
Farm Expansion	43.87%	45.09%	48.29%	51.65%	53.85%	54.26%	43.97%
Ethanol Plant	0.00%	7.53%	14.40%	15.50%	14.22%	13.69%	11.32%
Egg Production	0.00%	0.00%	0.27%	0.41%	8.78%	15.02%	43.73%
S&P 500	0.00%	4.55%	7.42%	8.27%	5.72%	3.92%	0.31%
Fidelity Food	56.13%	42.84%	29.62%	24.17%	17.43%	13.11%	0.67%
Expected Return	14.98%	14.40%	13.73%	13.25%	12.71%	10.73%	10.00%
Standard Deviation	9.29%	7.61%	6.00%	5.19%	4.86%	6.44%	3.38%

At relatively low levels of risk aversion, the model balances portfolio weights between farm expansion and the Fidelity Food mutual fund. However, as risk aversion increases, it is optimal greatly reduce the weight of the Fidelity fund because it is the riskiest among asset alternatives. Farm expansion weights increase slightly as risk aversion increases, indicating that farm expansion is, on average, a lower risk asset than stock investment. At low levels of risk aversion, value-added investments do not enter the portfolio due to their lower expected return compared to stock investments, but they are optimal to enter the portfolio at relatively higher levels of risk aversion due to their lower expected risk than do the stock investments.

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.

However, the weights listed in Table 4.1 are merely averages of all 191 portfolios; no information on their distribution is given. Figures 4.1a-b illustrate how the distribution of portfolio weights with respect to farm expansion change as relative risk aversion increases.

Figure 4.1a: Histogram of Farm Expansion Portfolio Weights, Quadratic Programming, Risk Aversion=0.5

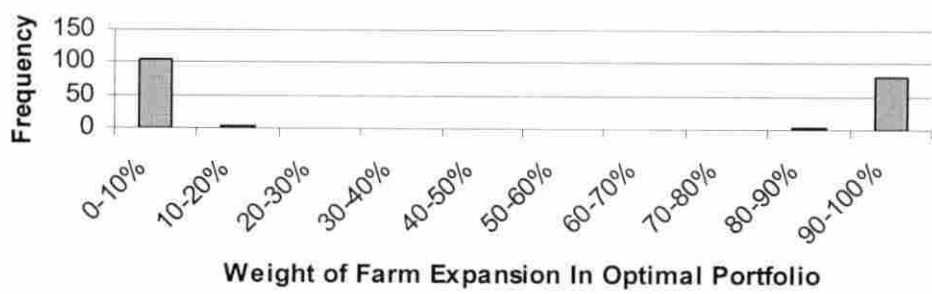
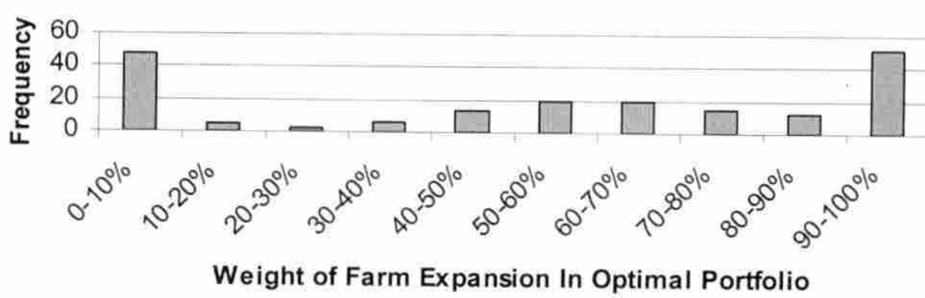


Figure 4.1b: Histogram of Farm Expansion Portfolio Weights, Quadratic Programming, Risk Aversion=5



Overall, as risk aversion increases, it is optimal for producers to balance their portfolio with more farm expansion. However, it seems that relative risk aversion does not affect the number of producers who optimally choose to mainly expand their farm; it mainly decreases the number of producers who optimally choose not to expand their operations. If risk aversion increases, and the individual producer's farm expansion returns are riskier than the value-added investments, it is more optimal for the producers to balance more of his portfolio with the value-added investments. This is apparent in the decline in the number of producers optimally choosing 75-100% farm expansion as risk aversion increases and the increases in the 25-50% and 50-75% category. The number of farmers optimally balancing their portfolio with 0-25% range constantly declines as risk aversion increases.

Figures 4.2a-e illustrate the distributions of farm expansion and asset alternative weights yielded by Sharpe ratio maximization.

Figure 4.2a: Histogram of Farm Expansion in Optimal Portfolio, Sharpe Ratio

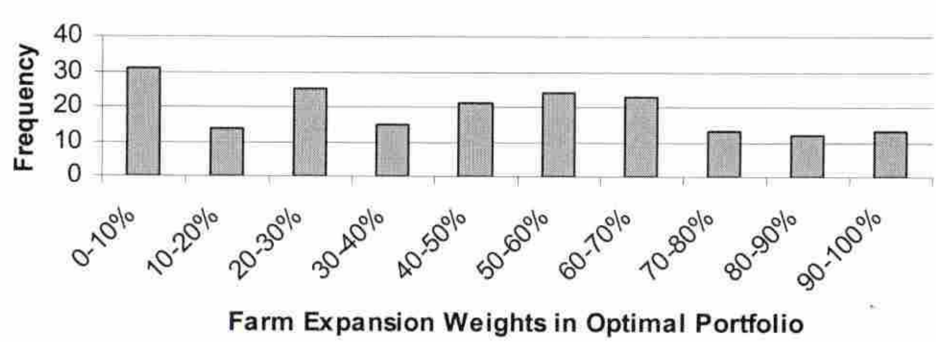


Figure 4.2b: Histogram of Ethanol Plant Weights in Optimal Portfolio, Sharpe Ratio

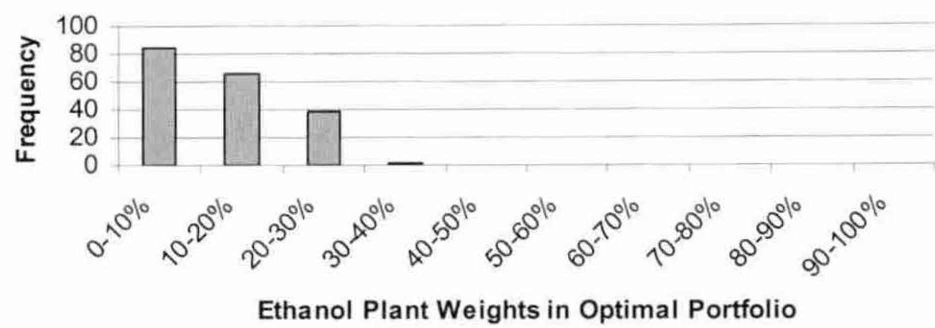


Figure 4.2c: Histogram of Egg Production Weights in Optimal Portfolio, Sharpe Ratio

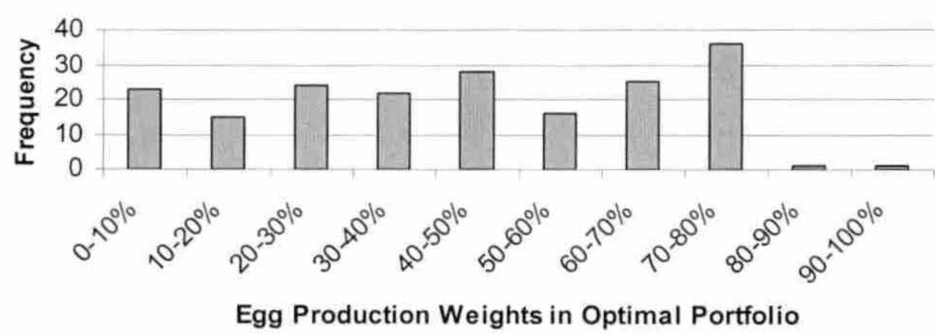
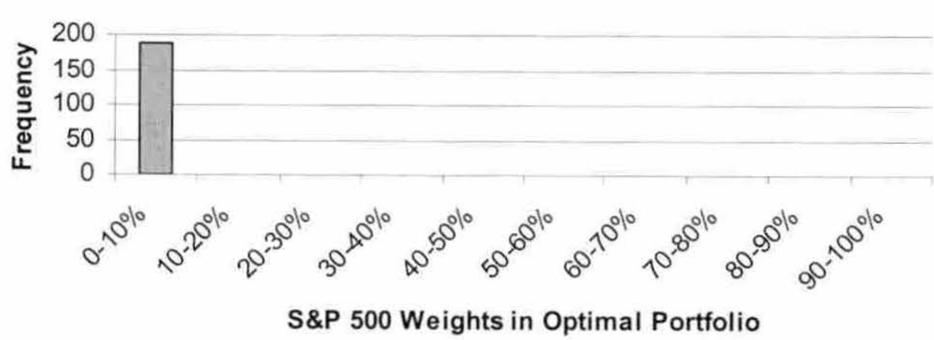
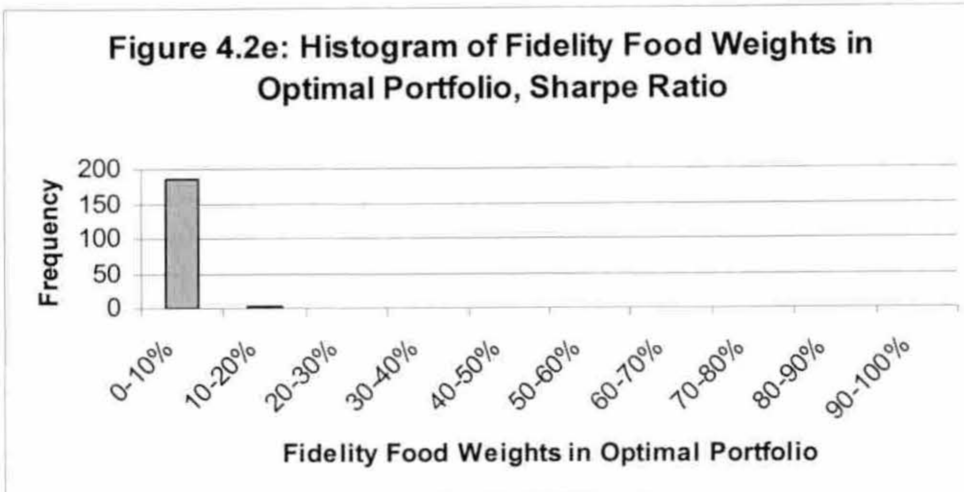


Figure 4.2d: Histogram of S&P 500 Weights in Optimal Portfolio, Sharpe Ratio



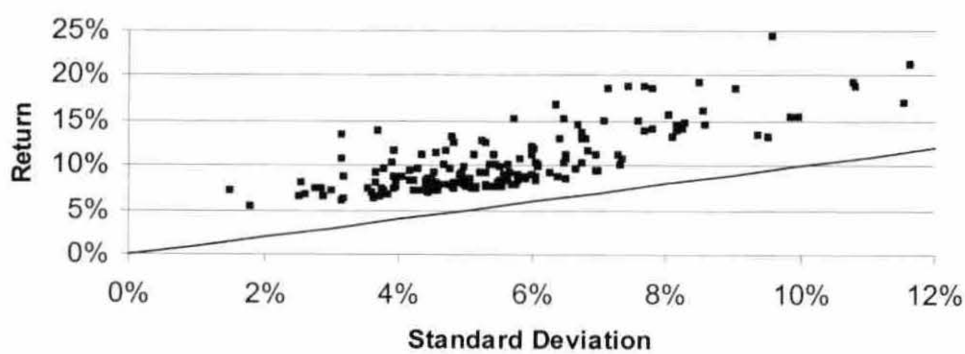


As Figure 4.1a illustrates, producers would optimally choose a wide variety of portfolio weights for farm expansion. The optimal weights on farm expansion vary wider than any other asset because the returns to farm expansion are unique for all 191 observations, whereas returns available from the other 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, 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, 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.

Figure 4.3 illustrates the tradeoff between risk and return for all 191 optimized portfolios. Notice that all of the optimized portfolios through Sharpe ratio maximization lie above the line where return equals standard deviation, indicating that expected portfolio return is greater than expected portfolio risk. This also indicates that their risk premium from investing in assets with expected returns other than the risk-free rate of return is positive.

Figure 4.3: Expected Portfolio Return and Standard Deviation



As Table 4.1 illustrates, quadratic programming and Sharpe ratio maximization produce different results for portfolio weights and expected returns and risks. In part, this is due to the different magnitudes of risk aversion coefficients and the assumptions about initial portfolio allocation for the quadratic programming method. Not only does a feasible range of risk aversion coefficients need to be estimated, but one must assume that all producers have the same risk aversion coefficient as shown in Figures 4.1a-f. Due to the lack of data on each producer's risk aversion coefficient and initial portfolio weights, the remaining data analysis will be conducted using the results of the Sharpe ratio maximization.

Cluster Analysis

As previously discussed, the optimal portfolio weights solved by the Sharpe ratio model are merely optimized according to estimates of risk, return, and covariance among the five assets. As Figure 4.3 illustrates, some farms can achieve higher expected returns than others while taking on the same amount of risk. 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 4.2 shows the summary statistics for different values of *k* clusters that were considered.

Table 4.2: 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**			

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 4.3 presents summary statistics of each cluster for 2003, Appendix A contains financial ratio definitions.

Table 4.3: Cluster Summary Statistics, 2003

Variable	1	2	3	4	5
Total Number of Farms in Cluster	45	5	55	30	56
Number of Cash Grain Farms	16	0	17	8	12
Number of Grain Farms	6	1	15	7	9
Number of Hog Farms	9	1	8	5	15
Number of Cattle Farms	5	1	1	1	3
Number of Dairy Farms	0	1	1	0	1
Number of Farms Out of Hogs	5	0	5	6	7
Number of Other Farms	4	1	8	3	9
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%*

Table 4.3, Continued

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%*

Figures 4.4a-e are Box Plots of each asset illustrating the mean, median, and range of portfolio weights by cluster number.

Figure 4.4a: Box Plot of Cluster Number and Percent Farming in Portfolio

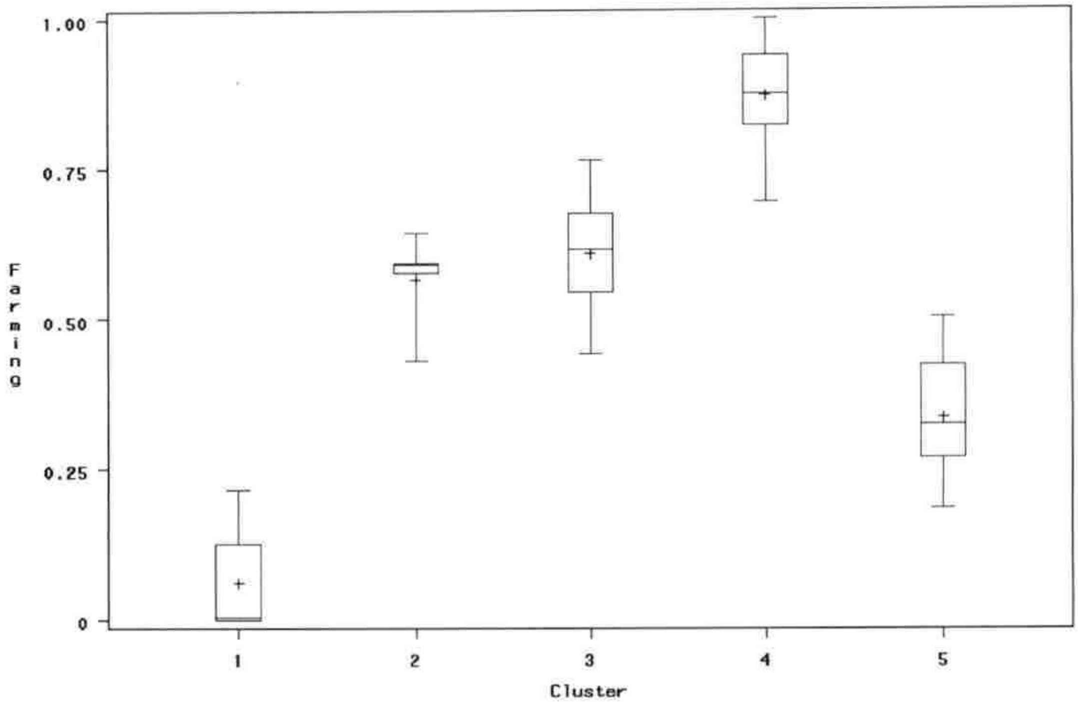


Figure 4.4b: Box Plot of Cluster Number and Percent Ethanol in Portfolio

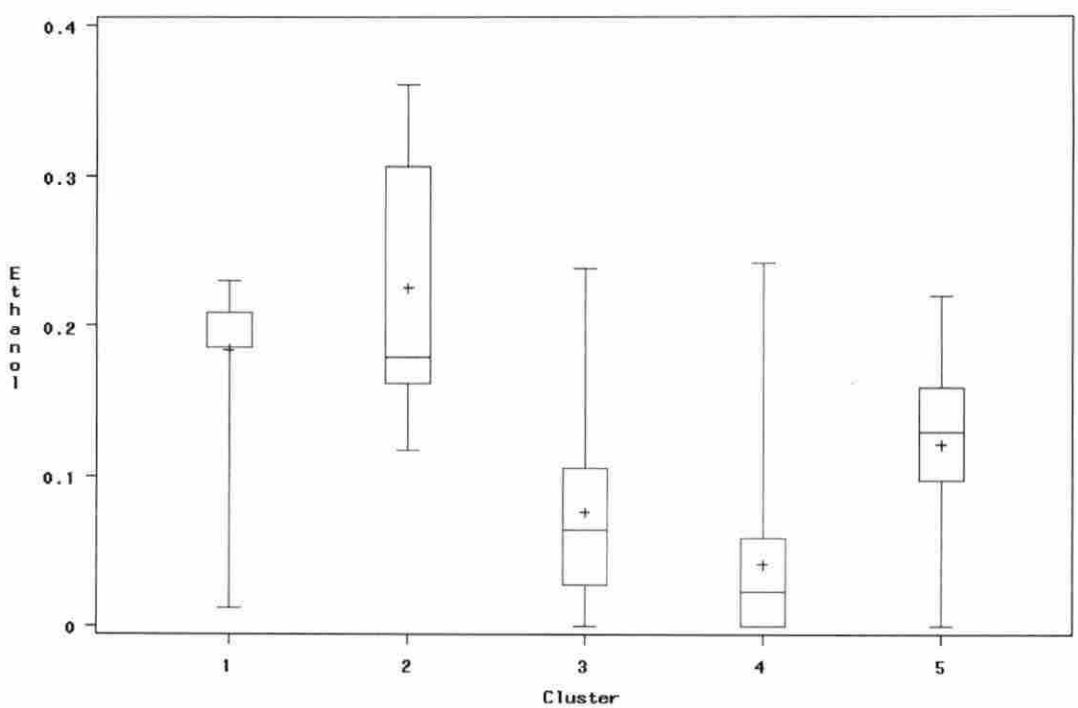


Figure 4.4c: Box Plot of Cluster Number and Percent Eggs in Portfolio

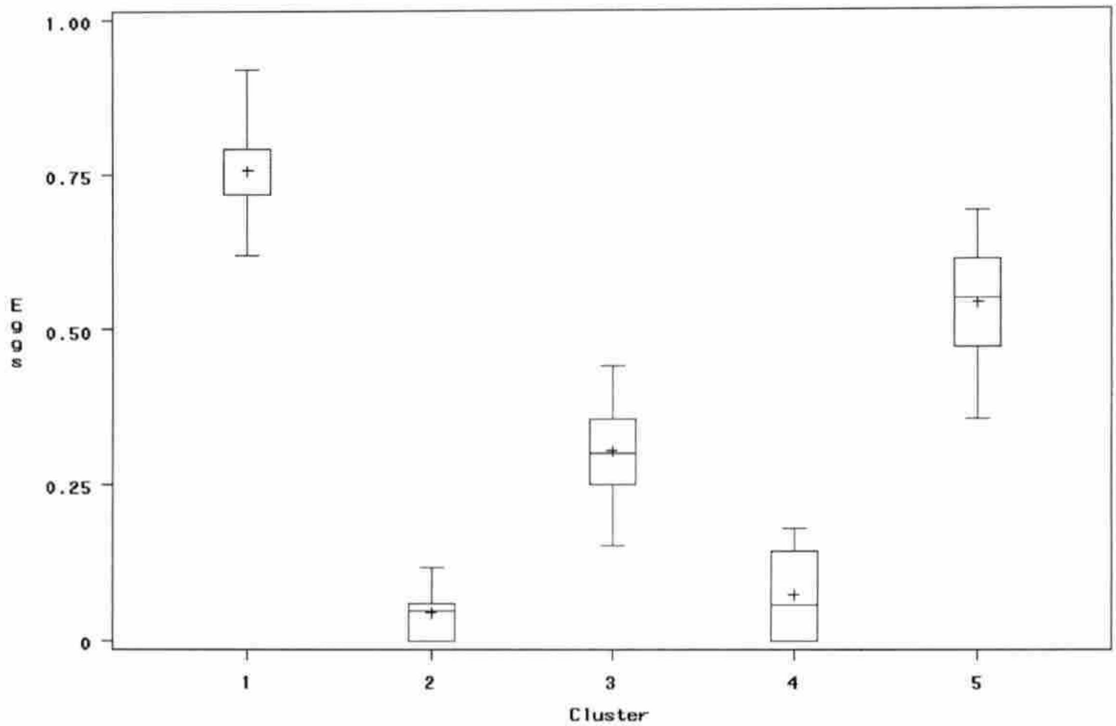


Figure 4.4d: Box Plot of Cluster Number and Percent Fidelity Mutual in Portfolio

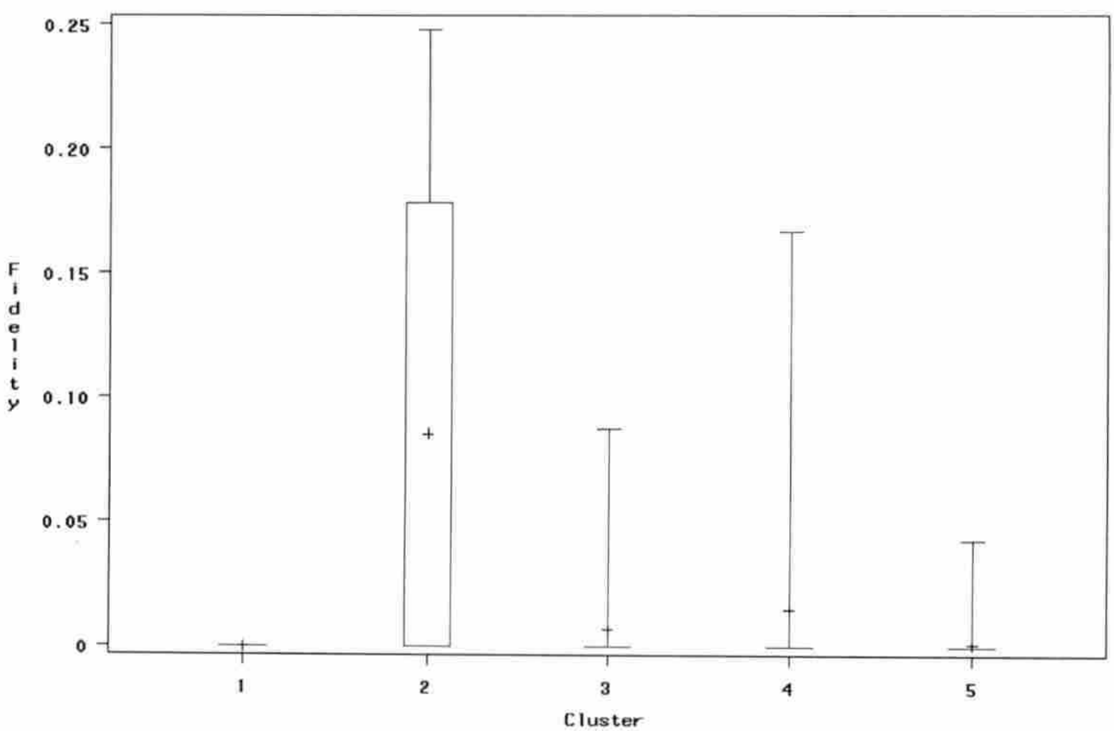


Figure 4.4e: Box Plot of Cluster Number and Percent S&P 500 in Portfolio

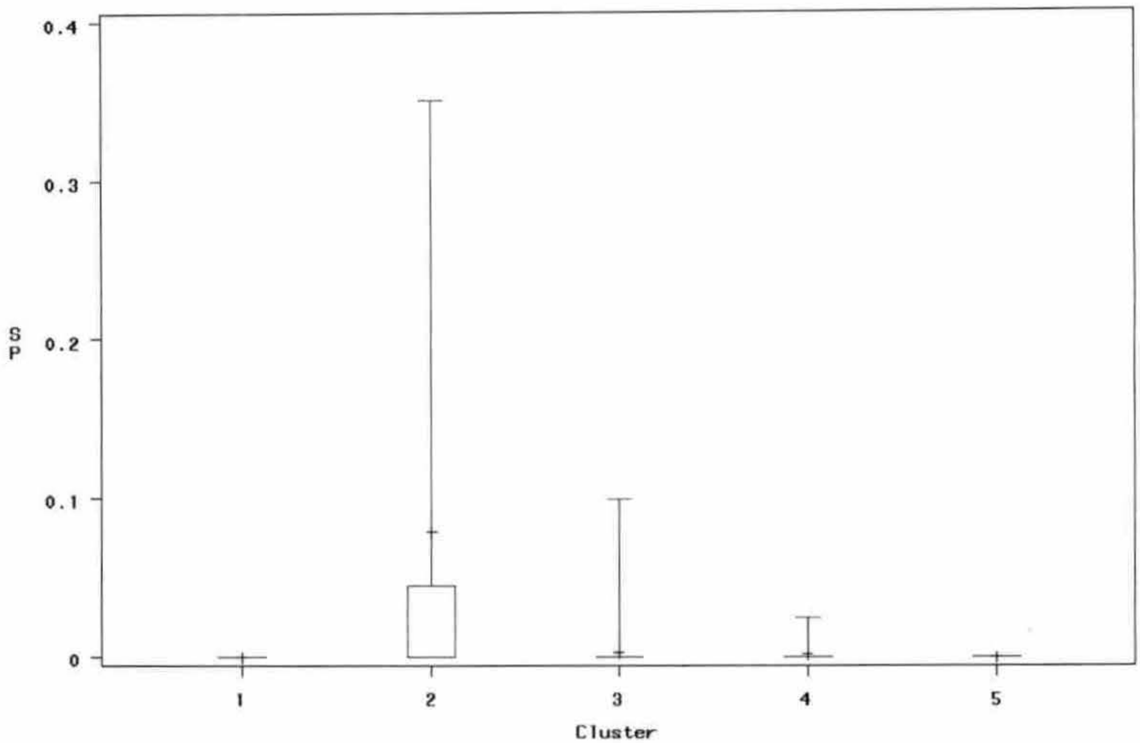
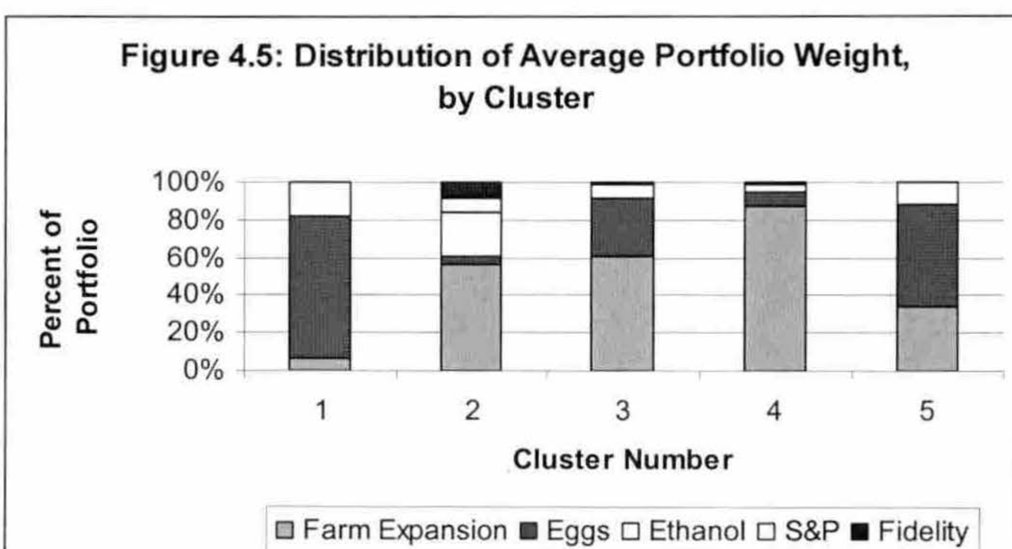


Figure 4.5 illustrates the distribution of average portfolio weights for each cluster.



The farm characteristics of each cluster given in Table 4.3 and their respective portfolio weights in each asset revealed a lot of key differences between clusters. Cluster 4 has an average of 88% of its optimal portfolio in farm expansion, the largest percent of any cluster. Cluster 4 also boasts the biggest 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 Figures 4.4d-e indicate, 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. They are primarily livestock and diversified commodity producers, which may be an indication of why they post the lowest average corn and soybean yields in 2003. 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.

As Figure 4.5 illustrates, Clusters 1 and 4 consistently differ the most in terms of their average optimal portfolio weights across a majority of the asset classes. In order to determine if Clusters 1 and 4 differ significantly in terms of average farm characteristics contained in

Table 4.3, pair-wise t-tests testing for differences in their mean values while accounting for sample size and standard deviation were conducted. The t-test results are illustrated in Table 4.4.

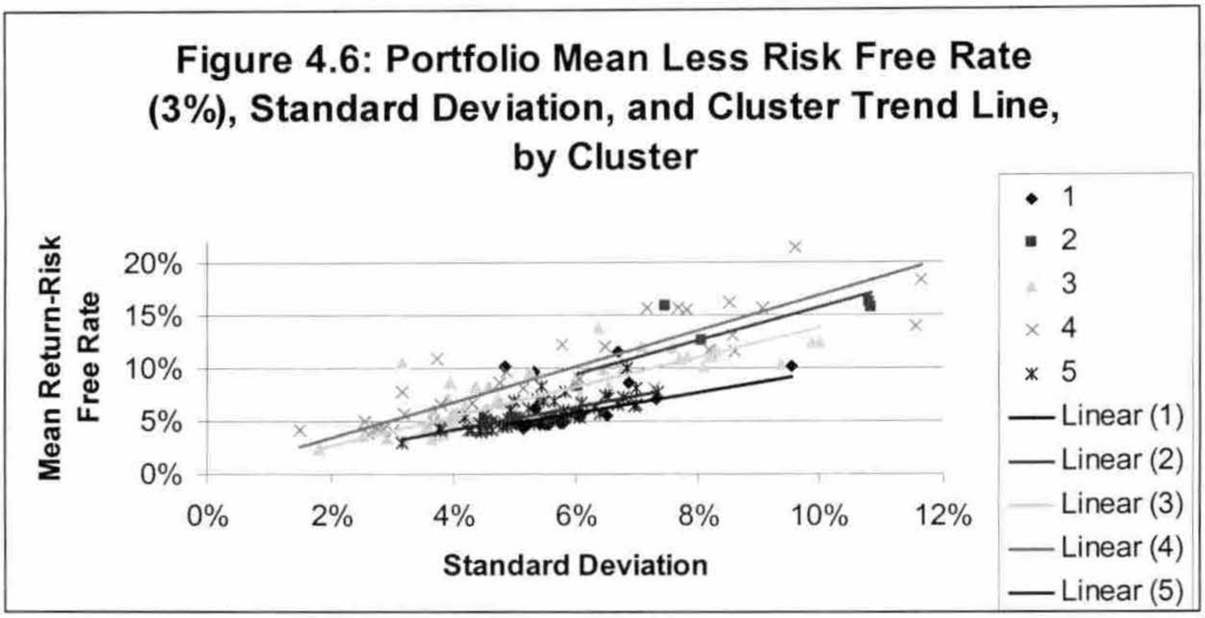
Table 4.4: t-Tests of Difference in Means for Clusters 1 and 4

	Cluster			
Variable	**1**	**4**	**t-Statistic**	
Operators' Average Age	59	52	3.01	***
Farm Size	879	857	0.09	
Percent Rented Acreage	55.21%	52.75%	0.33	
Corn Yield	164.2	172.1	-1.64	**
Soybean Yield	36.8	39.3	-1.53	*
Grain Sales Ratio	0.73	0.77	0.29	
Net Farm Income	52,639	110,412	-3.45	***
Return to Management	-8,077	19,330	-2.40	***
Debt to Asset Ratio	29.51%	18.04%	2.19	***
Net Farm Income Ratio	14.93%	32.00%	-5.77	***
Return on Assets	6.02%	9.33%	-2.96	***
Profit Margin	21.15%	34.64%	-4.76	***
Interest Expense Ratio	6.22%	2.64%	4.34	***
Operating Expense Ratio	35.14%	36.41%	-0.53	
Government Payments Ratio	6.76%	8.53%	-2.47	***
Return on Equity	11.82%	12.20%	-0.13	
Non-farm Income	16,671	14,314	0.43	
Sharpe Ratio	0.99	1.86	-9.37	***
Expected Portfolio Return	8.58%	13.12%	-4.93	***

*Indicates Statistically Different at the 10% Level
**Indicates Statistically Different at the 5% Level
***Indicates Statistically Different at the 1% Level

Of the 17 variables tested, 12 are significantly different between Clusters 1 and 4. This suggests that not only are the optimal investment choices between the clusters different, but the structure of farms between the two clusters are significantly different as well. The operators in cluster 4 are significantly younger than those in cluster 1, and cluster 4's farms are more efficient in terms of profitability and productivity. This is the primary reason cluster 4 chooses mainly farm expansion.

Figure 4.6 illustrates the mean portfolio return less the risk free rate of return of 3% and clusters singled out and a trend line predicting the risk and return tradeoff.



In the above figure, the risk free rate of return is subtracted from the mean portfolio return in order to give the trend line for each cluster 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 inline 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

The multinomial logit model was conducted using the cluster number assigned to each farm and a selected number of the above financial characteristics. 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. Certain clusters do not contain farms in each category described in table 3.1, because of the dynamics of multinomial logit modeling, a dummy variable for farm type could not be included. Mathematically, the model will maximize the probability that a farm lies in a given cluster given their individual characteristics is:

$$\max[\Pr(Y=j)] = \frac{1}{e^{B_0 * \text{constant}} + e^{B_1 * opage} + e^{B_2 * grain} + e^{B_3 * nfir} + e^{B_4 * roe} + e^{B_5 * da} + e^{B_6 * inex} + e^{B_7 * govpmt} + e^{B_8 * nfi}}$$

for $j = 0,1,2,3,4$

Again, a unique value of *B* will be estimated for each cluster, each relative to cluster 1. Table 4.5 contains means for each of the variables by cluster; they are described in Appendix A.

Table 4.5: Mean Values of Variables used in Model, by Cluster

	Cluster Number				
Variable	1	2	3	4	5
Age of Operator	59	43	54	52	55
Grain Sales Ratio	0.73	0.35	0.77	0.77	0.64
Net Farm Income Ratio	0.15	0.18	0.23	0.32	0.16
Return on Equity	0.12	0.18	0.09	0.12	0.09
Debt to Asset Ratio	0.30	0.51	0.22	0.18	0.33
Interest Expense Ratio	0.06	0.05	0.04	0.03	0.06
Government Payments Ratio	0.07	0.07	0.08	0.09	0.08
Non-farm Income	16,671	3,456	9,772	14,314	12,416

Tables 4.6 and 4.7 contain the parameter estimates for each *B* and the marginal effects of the logit model.

Table 4.6: 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**

Table 4.6, Continued
*Significant at the 10% Level
**Significant at the 5% Level
***Significant at the 1% Level

Table 4.7: 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

Overall, the model does an adequate job of predicting a farm's cluster based on the explanatory variables, given the level of the pseudo R^2 and absolute value of the log likelihood function. 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 parameter es timates cannot be directly interpreted. In order to look at the respective probabilities; one must convert the parameter estimates to marginal effects. The marginal effects of each explanatory variable in each cluster are displayed in Table 4.7.

The marginal effects measure the change in probability of a farm being assigned to a cluster given a change in one of the explanatory variables. For example, if the operator's age were to increase by one percent, the probability of the farm being assigned to Cluster 1 increases by 0.965% and the probability of the farm being assigned to Cluster 4 decreases by 0.55%. The marginal effects for each explanatory variable sum to zero across the five clusters, indicating that the probability is exhaustive. For example, if we add all of the marginal effects of the intercept (-0.393, 0.089, 0.321, 0.111, and -0.129) they will sum to zero.

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 4.8 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.

Table 4.8: 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

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 4.5 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 inline 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.

Clusters 1 and 5 are most dependent on government payments; their marginal effect with respect to the government payments ratio is positive, indicating that farms that are more dependent on government payments are most likely to be assigned to 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.

5.0 CONCLUSIONS AND FUTURE RESEARCH

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 view of a producer is the need for farmers to add value to their basic commodities in order to stabilize farm incomes. From the standpoint of non-farmer investors, relatively inexpensive inputs in the form of raw agricultural commodities have been a major factor in starting value-added businesses. The government's willingness to subsidize value-added agricultural businesses in order to stimulate rural development is also a major factor in the growth of value-added agriculture.

Investment in farm expansion has traditionally been viewed as the only means for producers to retain their competitiveness in the face of a constantly changing world agricultural market. These expansions in farm size allowed producers to obtain increased economies of scale and/or scope due to decreasing labor/output and increasing capital/labor, which in turn, decreases a producer's average costs as output increases. There has been little empirical evidence that average costs rise as output increases in American agriculture, indicating that diseconomies of scale are rare. However, physical constraints such as the lack of available land and capital may limit the extent to which a farm can expand.

Investment in value-added agricultural businesses and equities by Iowa agricultural producers were evaluated as investment alternatives to farm expansion. Investment in value-added agricultural businesses may seem enticing to producers due to negative covariance with farm returns, which provides them with additional income when commodity prices are relatively low. Producers may also benefit from the additional marketing channel for crops that they provide. These businesses are relatively more familiar to agricultural producers because the value-added businesses evaluated use a producer's raw inputs, giving them a feeling of inside information about how the investments perform. Finally, value-added agricultural investments may seem enticing to them if the business is located in proximity to the farm because the producer can literally see the investment on a regular basis; if the business stimulates the local economy, the producer may gain additional utility.

Stock investments to farmers may also seem enticing due to the long-term appreciation and short-term benefits they provide. Since these investments are not closely tied to their commodity outputs, the correlation between stock returns and farm expansion may be unclear. These investments are also the most liquid among farm expansion and investment in value-added agricultural businesses.

Overall throughout the time period, investment in farm expansion has been a good investment, with an overwhelming majority of producers finding it efficient to expand their farms. 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 choose not to add them to their portfolios. 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).

Unlike previous studies, this research individually optimized a portfolio for every farm present in the dataset. Four of the investment choices, the value-added and stock investments, were identical to all producers. However, one investment choice-- farm expansion -- was unique for each farm due to differing farm returns for each individual throughout the time period. This unique investment available to each producer also yields an equally unique E-V frontier for each producer who invests a portion of his portfolio in farm expansion.

In order to explain differences in investment patterns among the producers and to describe which characteristics of their farm induced them to invest in farm expansion, producers with similar investment patterns were identified via k-means clustering. The results of the clustering yielded groups of producers who have similar maximized Sharpe ratios, and hence, similar risk and return tradeoffs within clusters. The clusters with the steepest E-V frontier slopes posted the highest farm returns, and since the farm returns were the mutually exclusive investment, this is inline with economic intuition. This indicates that those producers with the greatest returns to farm expansion will hold optimized portfolios with higher expected returns for a given level of risk.

In order to predict these clusters, and hence their risk and return tradeoffs, a multinomial logit model was used to quantify the effect that individual farm characteristics had on which cluster the farm was placed in.

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.

The major drawback of this study was the lack of data. The results in this study would be more valid if data on individual farms for a longer time period were available. Also, more detailed data on each producer's family, attitude towards risk, and information on the inclusion of stock or value-added agricultural investments in a current portfolio, would strengthen the models. Further research in this area should first focus on obtaining this data and identifying a farmer's actual willingness to invest in value-added agriculture. This could be evaluated by surveying producers about their views of asset alternatives to farm expansion and current investment holdings.

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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