COST EFFICIENCY AND CAPITAL STRUCTURE IN FARMS AND COOPERATIVES

by

LEVI ALAN RUSSELL

B.S., Kansas State University, 2009

AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

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Abstract

U.S. farm profitability is near historic highs. This fact raises many questions related to the economics of production agriculture. Three questions are examined in this dissertation. First, should farmers use a different benchmark for farm profitability? To answer this question, a benchmark of farm profitability is developed that adds balance sheet information to an established benchmark which uses only income statement data. The second and third questions focus on cooperatives since farmers rely on efficient cooperative management to maximize their return on investment in the cooperative and their own farm profitability. How should cooperatives allocate earnings to farmers? To answer this question, a model is developed to inform boards of directors regarding optimal equity allocation decisions. Finally, do cooperatives face agency costs? To answer this question, a variable cost model is estimated to examine the indirect costs of leverage.

The first essay used data from Kansas farms to determine the effects of the use of debt on cost efficiency. A nonparametric cost efficiency model was used to examine these effects. Results indicated that farms which were more specialized, had higher capital costs, and used more equity to finance assets experienced larger increases in efficiency when the use of debt was included in the analysis.

The second essay used information on effective tax rates and empirically-estimated risk aversion coefficients in a portfolio model to determine the effects of different tax rates on the distribution of earnings. Results indicated that even a large deviation in current effective tax rates is not likely to affect the optimal share of allocated earnings. However, member risk preferences had an economically significant effect on the optimal share of allocated earnings, suggesting that board members focus on understanding member risk preferences.

The third essay used data from U.S. agricultural cooperatives to determine the presence of agency costs due to the use of debt. A variable cost function was estimated to generate an index of variable cost efficiency which was used to determine the indirect costs of leverage. A negative relationship between debt and variable cost efficiency was found, indicating that agency costs were present for agricultural cooperatives.

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Dedication

To Lana.

Chapter 1 - Introduction

Currently, U.S. net farm income is near historic highs (Figure 1.1). Due in part to historically high prices from high demand and favorable policy combined with ever-improving technology, the agricultural sector is highly successful. While these "good times" are certainly welcome, they raise many interesting questions for farmers and the cooperatives they own. Three such questions will be examined in this dissertation.

Should farmers use a different benchmark for farm profitability? The first essay examines issues related to external benchmarks extension services use to provide financial information vital for sound business planning. Traditionally, a cost efficiency benchmark that includes enterprise outputs, input prices, and input quantities is used to build a frontier of least-cost producing farms. Other farms can then be compared to those on the frontier to determine how to improve their input or enterprise mixes in order to improve efficiency.

As useful as this benchmark is, it misses an important part of business planning: the use of leverage. Since farms do not typically have access to large equity markets, they rely on debt financing as an external funding source for assets. The first essay incorporates measures of liquidity and solvency in this benchmark in order to determine the characteristics of farms that may benefit from adding this benchmark to its financial analysis toolkit.

In addition to the use of leverage, farmers invest in agricultural cooperatives to lower the cost of inputs, increase revenue from outputs, and gain access at a low cost to fixed investments to improve profitability. As with any other profit center, farmers expect a return on their investment in cooperatives. In order to provide this return, cooperatives must effectively manage the structure of their equity.

How should cooperatives allocate earnings to farmers? The second essay examines an important issue in cooperative finance. Cooperatives, like farms, do not have access to large equity markets and thus depend on debt as an external source of funds. Further, cooperative equity is subject to special legal rules and different taxation rules than most corporations. The returns from an investment in a cooperative are either taxed at the rate paid by the farmer or at the corporate rate. The topic of the second essay is an examination of the effect of taxation on cooperative equity. In order to properly understand the role of special legal rules and tax policy on cooperatives, a look at the history of the development of the treatment of cooperatives in U.S. policy is important.

Cooperatives have long enjoyed favorable legislation that enhances their ability to aid farmers in supplying their operations, as well as marketing and processing their production. Perhaps most significantly is the Capper-Volstead Act of 1922. This act primarily served to exempt cooperatives from certain portions of antitrust laws such as the Sherman Antitrust Act of 1890 and the Clayton Antitrust Act of 1914. The goal of these acts was to prevent private monopolies from arising and to limit the ability of producers of goods and services to influence prices.

Guth (1982) provides an in-depth discussion of the political issues that drove the passage of the Capper-Volstead Act. Small, local cooperatives had been quite popular, but it was the large dairy cooperatives that had the most political power. This power was concentrated in large cities like Chicago and New York. Clashes between opposing interest groups attempting to pass legislation in their favor lead to a push for national legislation for cooperatives. Legislators questioned whether cooperatives should be exempted from federal antitrust legislation and felt pressure from consumers and processors to reject the legislation. However, influence from cooperative proponents like Aaron Sapiro made the case for the advantages of cooperatives.

In the end, Senator Arthur Capper and Representative Andrew Volstead were key in passing the legislation. The bill passed both houses, taking on the "Walsh" amendment which clarified that the Act did not allow cooperatives to form monopolies. President Harding signed the bill into law in 1922. Guth notes: "Farmer cooperatives were freed from most (if not all) of the provisions of the Sherman and Clayton acts; the USDA has sole original jurisdiction over violations and would actively (if sympathetically) monitor cooperative behavior; decisions would be based on pricing behavior, not market shares; consumers, middlemen, and public officials would lodge complaints (especially against the dairymen); and, overall the act opened a greatly expanded field for cooperative activity."

Robotka (1959) evaluated the regulatory and legal impacts on the Capper-Volstead act over the period 1929 – 1959. He notes that while the Capper-Volstead Act had been neither challenged nor affirmed in the Supreme Court, its ability stand up to scrutiny had improved since the late 1920s. His perspective (which is also consistent with Guth's later analysis) that cooperatives were still subject to most antitrust legislation in accordance with the letter of the Capper-Volstead Act. His opinion was that cooperatives were being treated fairly according to the law in terms of regulation and litigation.

Varney (2010) discusses the modern interpretation of the Capper-Volstead Act. The Act "authorizes the Secretary of Agriculture to bring administrative action against an association that 'monopolizes or restrains trade … to such an extent that the price of any agricultural product is unduly enhanced.'" It has been established that cooperatives are not allowed to engage in predatory practices defined under Section 2 of the Sherman

Antitrust Act or to collude with other non-cooperative firms. Varney indicates that current court cases continue to define the scope of the Act. These definitions include recent cases brought against the United Egg Producers Inc., the United Potato Growers of America Inc., and United Potato Growers of Idaho Inc. for allegedly limiting their production in an attempt to raise prices. Debate exists as to cooperatives' immunity regarding these charges under the Act.

In addition to the legal ramifications of Capper-Volstead, there are important economic reasons for forming cooperatives. A major advance in the economic theory of cooperatives was developed by Edwin G. Nourse. He developed what was termed the Competitive Yardstick School. In his 1922 article, Nourse expressed his distaste for consumer and labor cooperatives, accusing them of desiring to overthrow the capitalist system. His view of agricultural cooperatives differed because he saw in them a genuine desire to improve their competitive position within the system. Nourse saw two main objectives for the agricultural cooperative: the provision of the means of adopting technology that requires a large capital investment and the improvement of bargaining power for producer members.

Both of these objectives really are reflected in the benefits of an agricultural cooperative. In Nourse's view, benefits both the producers and consumers. The producer benefits by having the profits that would have gone to downstream firms returned to them. The consumer benefits from the increased competition the cooperative provides. This is the competitive yardstick function of the agricultural cooperative.

To achieve this competitive yardstick, Nourse argued that the size of the cooperative should match its trading partner. Nourse's perspective on the scale of the cooperative differed from that of Aaron Sapiro, another pioneer in cooperative theory, in that he felt it should match that of its trading partner. That is, the size of the cooperative selling a product, like milk, should be of similar size relative to its trading partner, like a creamery.

Do cooperatives face agency costs? The third essay examines a second issue that affects the ability of cooperatives to maximize the return to their members: the management of indirect costs related to the use of leverage. As noted above, debt is typically the only source of external funds for cooperatives. While leverage can benefit the cooperative by lowering the overall cost of financing assets, thereby allowing the firm to take advantage of economies of scale, indirect costs from incomplete contracts, illiquid asset markets, or high cash flow risk on the part of the borrower may drive up the overall cost of using debt. The third essay examines the impact of the use of debt financing on variable cost efficiency.

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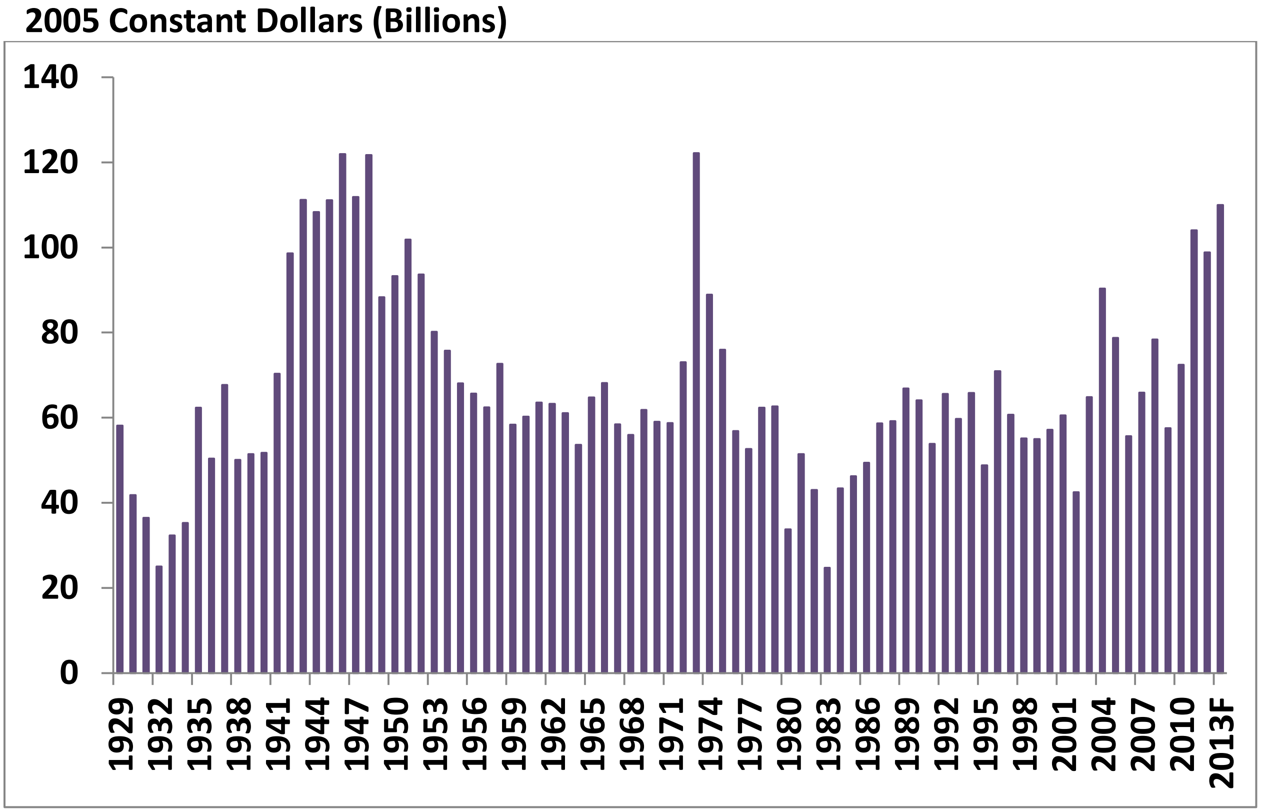

Figure 1.1 Inflation Adjusted U.S. Net Farm Income (USDA)

Chapter 2 - The Impact of Liquidity and Solvency on Cost Efficiency

2.1 Introduction

Finance and production theory have largely developed separately, as if the economic problems associated with them can be easily separated. However, farmers and other economic decision makers in agriculture must integrate these two types of decisions in order to efficiently operate a modern agricultural firm or farm. Liquidity and solvency measures are especially significant because debt is used for operating needs and is an important part of farm capital structure and farm growth strategies. Farm operators must make decisions about the usage of debt, that is, whether and to what degree the operator will finance short- or long-run inputs with debt.

As indicated in the literature, it is important to include analysis of debt to gain an understanding of the economic issues farms face. The issue of credit constraints is particularly relevant in the wake of the 2008 financial crisis and economic downturn. Briggeman et al. (2009), Briggeman & Akers (2010), and Ciaian et al. (2012) found that the availability of and access to credit significantly impacts the profitability of farms and rural businesses. Färe et al. (1990) studied the profit of rice farms in California given expenditure constraints on variable costs using a linear programming framework. Even government payments can have an impact on farmers' financing costs. Kropp & Whitaker (2011) found that decoupled direct payments to farmers significantly lower operating costs through lower interest rates.

While it is clear that liquidity and solvency measures are important in many types of farm level analysis, cost efficiency models typically do not include these measures. That is, efficiency models tend to only incorporate production-related and input price variables. To the best of our knowledge, only one study has incorporated debt and asset constraints into a cost-minimizing data envelopment analysis (hereafter, DEA). Whittaker and Morehart (1991) constructed a best-practice cost efficiency frontier with financial variables and found that these variables significantly impacted cost efficiency estimates. As a result, a primary contribution of this study is to extend the work of Whittaker and Morehart. This will be accomplished by incorporating liquidity and solvency measures in a different cost efficiency model and conducting additional regression analysis to more fully understand the impact of financial variables on cost efficiency scores.

Of the studies that have examined the impact of liquidity and/or solvency measures on cost efficiency models, most have done so after estimating the efficiency models. Many DEA studies are conducted in conjunction with limited dependent models to inform the researcher of the relationships between the variables of interest. For example, Rowland et al. (1998) found that the most cost efficient Kansas hog producers tended to have lower debt-to-asset ratios and utilized fewer and older buildings and equipment to keep their costs low. Lambert and Bayda (2005) created a set of debt-to-asset ratios based on length of debt terms and asset life and examined their impact on technical and scale efficiency scores. For technical efficiency, they found that the intermediate-term debt-to-asset ratio had a positive correlation, while the short-term debt-to-asset ratio had a negative correlation. Only the intermediate-term ratio was found to be significantly related to scale efficiency scores. More recently, the results from Alarcon (2007) suggest that the pressure exerted by financial institutions on farms with higher debt loads encourages efficient production behavior. Specifically, farms which are better able to control their costs have more access to credit because they do not present as great a default risk to the creditor.

The purpose of this paper is to construct and utilize a conceptual framework which allows the incorporation of debt ratios into the cost efficiency DEA for farm analysis. The model developed is used to determine the impact of liquidity and solvency on cost efficiency and to determine farm characteristics that drive the impacts debt ratios have on cost efficiency. The present work adds to the literature by directly incorporating debt ratios into the estimation of cost efficiency and through the use of a Tobit regression analysis to determine the characteristics of farms more likely to experience an improvement in efficiency with the inclusion of debt ratios. This work differs from that of Whittaker and Morehart (1991) in that it uses a different DEA framework and expands the analysis by using Tobit regressions. To illustrate these findings, a sample of Kansas farms are utilized to show that farms that are deemed inefficient with standard DEA models are actually efficient when incorporating liquidity and solvency ratios.

2.2 Methods

This study is conducted in two stages. The first stage uses two DEA models to examine the cost efficiency of 303 farms in Kansas. The first model is a standard or base DEA model and the second model builds on the base model by including financial or debt variables. The second stage uses Tobit regressions to determine the impact of cost ratios and income shares on the degree to which efficiency improves due to the addition of liquidity and solvency.

In the first stage, the debt ratios are added in a manner consistent with Coelli et al. (2005). That is, the debt ratios are added as undesirable outputs in the DEA program. Coelli et al. (2005) indicate that the auxiliary regression approach can also be used to examine efficiency differences related to variables such as financial ratios (e.g., Alarcon (2007), Lambert and Bayda

(2005), and Rowland et al. (1998)). Adding debt ratios to the DEA model, allows us to more precisely measure how the financial variables move or rotate the frontier[1].

It is not clear if adding the debt ratios will improve cost efficiency. Optimal capital structure of a firm states that the cost of equity is greater than the cost of debt. So, farms could use debt, a lower cost of capital, in a manner that *improves* their cost efficiency. Furthermore, paying interest on debt can lower tax burdens for farms, which would also lower cost structures for farms. However, if a farm adds too much debt and elevates their default risk, a lender will respond by raising debt interest rates, which will raise the cost of capital and *hinder* a farm's cost efficiency.

Agency costs may also impact the relationship between efficiency and debt in farms. These costs arise from a lack of information as to the potential performance of the farm. In order to account for these costs, lenders modify the terms of debt agreements by increasing the interest rate. A farmer may, in order to obtain additional debt financing, be required to pay higher interest rates if his or her operation presents a higher default risk due to an elevated solvency ratio.

To test the impact of debt ratios on cost efficiency, two constant returns to scale DEA models are utilized that follow Färe et al. (1985). To our knowledge, we are the first to add liquidity and solvency ratios to this efficiency model for the analysis of farms. The base model is a standard cost efficiency model that includes five inputs and two outputs. The debt model is similar to the base model, but includes the inverse current ratio (the current ratio is inverted to avoid the problem of division by zero in the case of a farm with no current liabilities) and the

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[1] Caution should be exercised when examining the change in efficiency that occurs when financial ratios are added to the DEA model. In general, adding variables to a DEA model will result in a change in efficiency.

total debt-to-asset ratio as outputs. As discussed above, this inclusion of financial ratios is akin to the inclusion of "environmental" variables by Ferrier and Lovell (1990) and Coelli et al. (2005).

The first DEA model is the *base* model and is developed as follows:

$$Min \;\; w_i{}' x_i^* \tag{1}$$

$$subject\ to \qquad z_i\, x_i \;\leq x_k^* \tag{2}$$

$$z_i\, y_i \geq y_k \tag{3}$$

where w is a vector of input prices, x^* is a vector of inputs that minimizes farm i's cost, x is a vector of actual inputs, z measures the weighting of each farm in forming the frontier, and y is a vector of outputs. Furthermore, it is assumed that w is strictly positive and z, x, and y are greater than or equal to zero. Equation 1 is the objective function, which assumes that each farm will minimize total cost and operates under constant returns to scale. Equation 2 compares the input of each farm to the rest of the farms and equation 3 compares the output of each farm to the rest of the farms. Equations 2 and 3 form the best-practice cost-efficiency frontier for the *base* DEA or the model that does not incorporate financial variables.

The primary contribution of this paper is the addition of financial measures, liquidity and solvency, to the cost efficiency model developed by Färe et al. (1985). This addition accounts for the ability of farmers to control their debt exposure. The *debt* model includes equations 1 through 3 and adds the following liquidity and solvency constraints:

$$z_i l_i \leq l_k \tag{4}$$

$$z_i s_i \leq s_k \tag{5}$$

where l is the inverse current ratio and s is the negative of the debt-to-asset ratio. Both variables are assumed to be less than or equal to zero. The inequality constraint indicates that the addition of debt is undesirable *ceteris paribus*. The intuition of equations 4 and 5 is that if a farm incurs costs to produce more output, but subsequently takes on a larger amount of short- or long-term debt relative to its asset size, the farm may incur higher costs (e.g., interest rate increases) because of added financial risk. Equations 2 through 5 form the best-practice cost-efficiency frontier for the *debt* DEA or the model that does incorporate financial variables.

To identify how cost efficient the i^{th} farm is, two cost efficiency scores are calculated for each farm using the j^{th} DEA *base* and *debt* models. Cost efficiency scores are:

$$CE_i = w_i' x_i^* / w_i{}' x_i \quad (6)$$

where CE is the cost efficiency score and is defined as the ratio of the minimum cost under constant returns to scale to actual cost. CE is strictly positive. A farm is considered efficient if the cost efficiency score is equal to one. That is, if a farm's actual cost is equal to the theoretical minimum cost as defined by model *j*, the farm is on the frontier.

The objective of the second stage is to determine which farm characteristics have a statistically significant impact on the improvement in cost efficiency from the addition of financial ratios to the DEA models. The primary reason for using a Tobit regression rather than simply analyzing the mean values of farm characteristics is that the regression approach accounts for the covariance among the cost ratios and among the income shares when estimating the increase in efficiency. A failure to account for the covariance among the shares may lead to erroneous conclusions, such as an attribution of an improvement in efficiency to one factor when it is actually due to another. The dependent variable (Λ) in the Tobit regression is specified as follows:

$$\Lambda = CE_{Debt} - CE_{Base} \quad (7)$$

where Λ is equal to the difference between the cost efficiency scores. Thus, the Tobit regression analysis will help determine what specific farm characteristics drive cost efficiencies. It is important to note that *none* of the cost efficiency scores in the debt model were lower than those in the base model for any of the farms.

The first Tobit regression analyzes the impact of cost shares on the degree to which cost efficiency will increase with the addition of financial ratios to the DEA model. The cost shares are computed by dividing a given input cost by total input cost. To avoid the problem of singularity, the cost shares are normalized by the largest cost, total capital costs. The resulting Tobit model is as follows:

$$\Lambda = \beta_0 + \beta_1 \left(\frac{LABOR}{K}\right)_i + \beta_2 \left(\frac{CROP}{K}\right)_i + \beta_3 \left(\frac{LVSK}{K}\right)_i + \beta_4 \left(\frac{FUEL}{K}\right)_i + e_i \quad (8)$$

where $\left(\frac{LABOR}{K}\right)$ is the ratio of farm labor cost to capital cost, $\left(\frac{CROP}{K}\right)$ is the crop input (i.e., allocable crop inputs such as fertilizer) to capital ratio, $\left(\frac{LVSK}{K}\right)$ is the livestock input (i.e., allocable livestock inputs such as feed) to capital ratio, $\left(\frac{FUEL}{K}\right)$ is fuel to capital ratio, and e is the error term.

The second Tobit regression analyzes the impact of income shares on the degree to which cost efficiency will increase when financial ratios are added to the DEA model. Income shares are calculated by dividing the revenue of a given enterprise by gross farm income. This Tobit model is:

$$\Lambda = \delta_0 + \delta_1 FDGRN_i + \delta_2 HF_i + \delta_3 OILSD_i + \delta_4 WHEAT_i + \delta_5 BF_i + \delta_6 DY_i + \delta_7 SW_i + \varepsilon_i \quad (9)$$

where $FDGRN$ is the share of total income from feed grain enterprises, HF is the share of total income from hay and forage enterprises, $OILSD$ is the share of total income from oil seed enterprises, $WHEAT$ is the share of total income coming from the wheat enterprise, BF is the share of total income from beef cattle enterprises, DY is the share of total income from dairy enterprises, SW is the share of total income from swine enterprises, and ε is the error term. Note that government payments, crop insurance proceeds, and other miscellaneous income are omitted from equation (9) above to avoid singularity. These items are included in the DEA estimation.

The third Tobit regression analyzes the impact of operator age, farm size, specialization, and farm type on the degree to which cost efficiency will increase when financial ratios are added to the DEA model.

This Tobit model is:

$$\Lambda = \gamma_0 + \gamma_1 AGE_i + \varphi_1 AGE_i^2 + \gamma_2 GFI_i + \varphi_2 GFI_i^2 + \gamma_3 HHI_i + \gamma_4 TYPE_i + \zeta_i \quad (10)$$

where AGE is the age of the operator; GFI is the gross income of the farm; HHI is the Herfindahl index of specialization; $TYPE$ is the percentage of labor devoted to crop production, a proxy for farm type; and ζ is the error term. Four iterations of this model were estimated. The first was estimated with φ_1,φ_2, and γ_4 set equal to zero; the second was estimated with $\varphi_1$and φ_2 set equal to zero; the third was estimated with γ_4 set equal to zero; and the fourth estimated all coefficients.

Since the cost efficiency scores are not independent of each other, the error terms in the Tobit regressions are not independently and identically distributed. In order to account for this, the standard errors in these regressions were calculated using a bootstrap procedure with 1000 replications.

2.3 Data

Data were obtained from the Kansas Farm Management Association or KFMA (Langemeier, 2010). KFMA data is unique because it provides a level of disaggregation not readily available in other farm datasets, which is necessary to examine the relationship between production and financial variables. Using one year of data to estimate cost efficiency scores is problematic due to weather variability. Therefore, the variable averages for each of the 303 farms with continuous data from 2006 to 2010 are used in the analysis.

Summary statistics for the inputs, outputs, financial ratios, cost shares, and income shares are presented in Table 1.1. Crop inputs consist of seed, fertilizer, herbicide and insecticide, crop marketing and storage, and crop insurance. The livestock input consists of purchased feed, dairy expense, veterinarian expense, and livestock marketing and breeding. Fuel is comprised of fuel, auto expense, irrigation energy, and utilities. Labor is represented by the number of workers (hired workers, and unpaid family and operator workers). The capital input includes repairs; machine hire; general farm insurance; property taxes; organization fees, publications, and travel expenses; conservation expense; interest; cash farm rent; and an interest charge on net worth (Langemeier 2010). Labor price is obtained by dividing labor cost by the number of workers. Implicit input quantities for the crop input, livestock input, fuel, and capital are computed by dividing the respective input costs by USDA input price indices.

Outputs include crop and livestock. Implicit crop and livestock quantities are computed by dividing crop income and livestock income by Kansas crop price and livestock price indices created using price indices from USDA-NASS. The primary sources of crop income are feed grains (e.g., corn and grain sorghum), hay and forages, oilseeds (e.g., soybeans and sunflowers), wheat, government payments, and crop insurance proceeds while the primary sources of livestock income are beef, dairy, and swine production.

2.4 Results

The results offer insights into the relationships between farm characteristics and cost efficiency when debt ratios are considered. The first stage results of the analysis are found in Table 2.2. In the base DEA model, four farms are efficient (i.e., they lie on the frontier, mathematically: $CE = 1$), while nineteen are efficient in the debt DEA model. This increase in the number of farms on the best-practice frontier implies that some farms are better at managing cost when financing decisions are considered in the analysis. It is worth noting that the four efficient farms in the base model are also efficient in the debt model. Given that there are so few efficient farms, it is difficult to discuss the statistical significance of the differences between farm characteristics of the efficient farms for the base and debt models.

Cost efficiency levels improve when debt is included in the DEA model. The average efficiency score in the base model is 65.67% while the average for the debt model is 70.45%. A paired t-test shows that these means are significantly different. According to the base model, the average farm could reduce its costs by 34.33% and maintain its current output if it was cost efficient. For the debt model, the average farm need only reduce its costs by 29.55% in order to be efficient. These results are consistent with those found in the Whittaker and Morehart (1991) study.

Our findings assume that farms manage their debt effectively. Twenty-nine percent of the farms have improved efficiency scores in the debt model *vis-à-vis* the base model. Our results confirm that not accounting for financial variables seriously underestimates a farm’s cost efficiency. These results suggest to producers that adequate time should be spent managing their use of debt and that simply focusing on the production aspects of the business can result in reduced cost efficiency.

To better understand the improvements in efficiency scores, the improvements in efficiency were broken down into quartiles based on the cost efficiency score in the base model. An analysis of these quartiles for the base and debt models is shown in Table 2.3. An improvement is defined as the difference between the efficiency score in the debt model and the efficiency score in the base model. The base model efficiency scores are divided into quartiles with quartile 1 being the top 25% of farms. Efficiency and improvement are negatively correlated; that is, more of the farms in the lower efficiency quartiles have an improvement in efficiency and *vice versa*. Further, larger average improvements are realized for the lower efficiency farms. In contrast to Rowland et al. (1998), our analysis shows that farms with higher cost efficiency were less liquid and and more solvent. This result is consistent with Alarcon (2007) and Lambert and Bayda (2005).

Paired t-tests are used to determine the differences in key farm characteristics between farms that did and did not incur an improvement in cost efficiency when financial ratios were added. These paired t-tests are shown in Table 2.4. The largest improvement in cost efficiency across cost shares is found in farms that have significantly lower crop and fuel inputs and significantly higher capital input. Additionally, the results of paired t-tests show that adding financial variables to the DEA model really improve the cost efficiencies for livestock operations. That is, farms with an improved efficiency score had significantly lower feed grain income share, higher beef income share as well as a smaller percentage of their time devoted to crop production. Farms with an improved cost efficiency score had older operators and were more specialized. Furthermore, farms with an improved cost efficiency score had higher liquidity and lower debt levels.

The results of the Tobit regressions bring to light some important results related to capital costs and debt usage. In Table 2.5, the crop/capital and livestock/capital ratios are statistically significant and negatively related to the difference in base and debt DEA model cost efficiency scores. That is, farms with higher crop/capital and livestock/capital ratios tend to have lower improvements in efficiency when liquidity and solvency ratios are added to the cost efficiency estimation. This key finding is supported by the results in Table 2.4. Recall that farms that improved their efficiency had significantly larger capital costs and significantly higher liquidity and lower solvency ratios. These findings imply agency costs may be restricting the usage of debt and driving up capital costs due to increased default risk. Farms that improved cost efficiency with the addition of financial ratios to the base model had higher capital costs because they held more equity.

None of the marginal effects on the income share were statistically significant in the income share regression. Table 2.6 presents the results of this regression. This result implies that the choice of enterprise does not significantly impact the probability of an improvement in efficiency due to debt use planning.

Additional regression analysis was conducted to determine the impact of age, size, specialization, and operation type (livestock or crop farm) on the degree of improvement in efficiency. Results of these regressions are found in Table 2.7.

Assuming a linear relationship between the right-hand side variables and improvement in efficiency, we find that age and specialization are significant and positively related to improvement in efficiency. When square terms are added for the age of operator and farm size variables, only specialization is significantly correlated to improvement in efficiency.

2.5 Conclusions and Implications

This paper provided a conceptual framework that can be used to examine the impact of liquidity and solvency on cost efficiency. This framework was then applied to a sample of Kansas farms. The results of this paper confirmed the importance of including liquidity and solvency measures when estimating cost efficiency. Specifically, the results indicated that including liquidity and solvency ratios in DEA models had a statistically significant impact on improving cost efficiency for some farms.

Adding liquidity and solvency ratios to the DEA analysis improved efficiency scores, especially for low efficiency farms. Less efficient farms, as defined by the lowest quartile cost efficiency estimates, saw significant improvements in their efficiency scores when financial ratios were added. Thus, an analyst may be missing an important part of a given farm's efficiency picture unless debt measures are included in the cost efficiency estimation.

Furthermore, adding liquidity and solvency ratios to the cost efficiency estimation improved efficiency values for farms with different input mixes. When adding financial ratios to cost share analysis, farms with lower crop and fuel input levels and a higher capital input level had a higher efficiency gain than the average farm when liquidity and solvency ratios were added.

A key finding of this paper is that farms that improved their cost efficiency had higher capital costs, higher liquidity ratios, and lower solvency ratios. This finding is confirmed by the Tobit regression results which showed that a farm was less likely to improve if it spent a larger share of its total cost on purchased inputs relative to capital. The combination of these results suggests that farms that improve their efficiency with the addition of financial ratios have more equity. Given the KFMA data does not ask debt or credit usage questions, it is not possible to surmise why these farmers choose to provide more self-financing rather than financing from a lender.

Although income shares were not significantly related to improvements in cost efficiency, we found a significant and positive relationship between specialization and improvements in efficiency. This indicates that while enterprise choice does not impact cost efficiency when debt ratios are added to the model, the choice of the number of enterprises to operate does. There is also evidence that the age of operator is significantly related to improvement in efficiency. Results suggest that the efficiency indices for older operators are impacted to a greater extent by the addition of debt ratios than those for younger operators.

More work is needed to fully understand the finance and production decisions of the farm operation. Often, farm efficiency analyses focus on production and ignore the financial decisions (e.g., Yeager and Langemeier, 2009). However, the present study illustrated that adding debt ratios improves cost efficiency scores.

In sum, the results of this paper suggest that past benchmark performance measures underestimated efficiency. We suggest that financial ratios be included in cost efficiency benchmarks in order to account for the possibility of credit constraints. Further, we have demonstrated that the impact of an inclusion of financial ratios in the cost efficiency estimation varies according to the particular distribution of cost shares and other farm characteristics.

2.6 References

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Table 2.1 Summary Statistics for a Sample of 303 Kansas Farms from 2003 to 2010.

	Mean	Std. Dev.
Inputs		
Crop*	103,561	111,317
Livestock *	38,858	254,567
Fuel*	21,221	16,485
Labor**	1.181	0.573
Capital*	175,367	128,581
Outputs		
Livestock*	72,554	211,626
Crop*	267,509	299,502
Cost Shares		
Crop	0.22	0.103
Livestock	0.057	0.069
Fuel	0.069	0.022
Labor	0.176	0.07
Capital	0.478	0.09
Income Shares***		
Feed Grain (e.g., corn and grains sorghum)	0.177	0.137
Hay and Forage	0.035	0.057
Oilseed (e.g., soybeans and sunflowers)	0.205	0.154
Wheat	0.159	0.145
Beef	0.277	0.23
Dairy	0.002	0.02
Swine	0.001	0.009
Other		
Inverse Current Ratio (Current Liabilities/Current Assets)	0.289	0.308
Total Debt/Asset Ratio	0.269	0.227
Herfindahl Index of Specialization	0.300	0.139
Age of Operator	56.676	10.864
Gross Income	$352,807	$402,038
Percentage of Labor for Crop Production	0.706	0.175

*Units are implicit quantity.

**Unit is number of workers.

***Government payments and crop insurance are omitted.

Table 2.2 Summary Results of the Data Envelopment Analyses.

DEA Model	Cost Efficiency Score = 1	Mean Efficiency Score
Base Model	4	65.67%
Debt Model	19	70.45%

*The efficiency score is the ratio of minimum cost found in the DEA model to actual cost.
Notes: Total number of farms = 303
Twenty-nine percent of farms had higher efficiency in the debt model than in the base model.

Table 2.3 Analysis of Cost Efficiency Quartiles.

Efficiency Quartile*	Number of Farms Improved**	Average Improvement in Cost Efficiency***	Mean Financial Ratios Liquidity[1]	Solvency[2]
1	13	1.38%	0.3307	0.3429
2	20	2.69%	0.2825	0.2808
3	25	6.00%	0.2406	0.2378
4	32	8.93%	0.2431	0.1715

*The 25% of farms with highest cost efficiency make up the first quartile.
**Number of farms which had higher efficiency in the Debt model than in the Base model.
***Average improvement in cost efficiency between the Debt and Base DEA models.
[1]Inverse Current Ratio
[2]Total Debt/Asset Ratio

Table 2.4 Comparison of Mean Values of Farm Characteristics†

		No Improvement in Efficiency	Improvement in Efficiency	Difference
Cost Shares	Labor	0.175	0.178	0.003
	Crop	0.242	0.186	0.056***
	Fuel	0.07	0.062	0.007***
	Livestock	0.06	0.05	0.011
	Capital	0.453	0.524	0.071***
Income Shares	Feed Grain	0.211	0.174	0.038**
	Hay/Forage	0.04	0.033	0.007
	Oilseed	0.219	0.213	0.006
	Wheat	0.161	0.139	0.022
	Beef	0.234	0.318	0.084***
	Dairy	0	0	0
	Swine	0.003	0.001	0.001
Other Characteristics	Gross Income	$367,609	$317,775	$49,833
	Crop Labor	0.72	0.673	0.047**
	Workers	1.183	1.237	0.054
	Herfindahl Index of Specialization	0.289	0.328	0.039**
	Age of Operator	54.62	61.492	6.872***
	Liquidity[1]	0.371	0.045	0.326***
	Solvency[2]	0.33	0.086	0.244***

†Comparison between farms which experienced an improvement in efficiency when financial ratios were added to the DEA with those that did not.

*Significant at the 90% confidence level.

**Significant at the 95% confidence level.

***Significant at the 99% confidence level.

[1]Inverse Current Ratio

[2]Total Debt/Asset Ratio

Note: Results based on paired t-tests.

Table 2.5 Cost Share Tobit Regression Results†

	Marginal Effects	P-Values
Labor/Capital	-0.147	0.121
Crop/Capital	-0.45***	0.000
Livestock/Capital	-0.389**	0.018
Fuel/Capital	-0.597	0.102

*Significant at the 90% level.
**Significant at the 95% level.
***Significant at the 99% level.
†Dependent variable is equal to the difference between the efficiency score in the debt DEA model and the efficiency score in the base DEA model.
Notes:
Labor is hired and unpaid farm labor, crop is primarily seed and fertilizer, livestock is primarily feed, and capital is primarily interest expense and depreciation.
Standard errors were calculated using a bootstrap procedure with 1000 replications.

Table 2.6 Income Share Tobit Regression Results†

	Marginal Effects	P-Values
Feed Grain (e.g., corn and grain sorghum)	-0.145	0.550
Hay and Forage	-0.520	0.289
Oilseeds (e.g., soybeans and sunflowers)	0.130	0.593
Wheat	-0.072	0.781
Beef	0.324	0.101
Dairy	-8.345	0.991
Swine	-0.271	0.999

† Dependent variable is equal to the difference between the efficiency score in the debt DEA model and the efficiency score in the base DEA model.
Note: Standard errors were calculated using a bootstrap procedure with 1000 replications.

Table 2.7 Age, Size, Specialization, and Farm Type Tobit Regression Results†

	Marginal Effects	P-Values	Marginal Effects	P-Values	Marginal Effects	P-Values	Marginal Effects	P-Values
Age	0.00787***	0.000	0.00777***	0.000	0.0013735	0.909	0.0003847	0.974
Age Squared					0.0000554	0.589	6.35E-05	0.533
Gross Farm Income	-3.90E-06	0.520	-2.60E-05	0.667	-4.13E-05	0.626	-3.53E-06	0.969
Gross Farm Income Squared					1.24E-09	0.953	-5.50E-09	0.802
Herfindahl Index of Specialization	0.354***	0.003	0.268**	0.044	0.3516***	0.001	0.2627*	0.036
Crop Labor			-0.133	0.220		0.151	-0.1447	0.211

†Dependent variable is equal to 1 if the debt DEA showed a higher efficiency for a given farm than for the base model and is equal to 0 if the efficiency scores are the same for the two models.
*Significant at the 90% level.
**Significant at the 95% level.
***Significant at the 99% level.
Notes:
Age is the average Age of the operator over the study period.
Standard errors were calculated using a bootstrap procedure with 1000 replications.

Chapter 3 - Cooperative Equity Allocation: A Portfolio Approach

3.1 Introduction

A key issue for cooperatives is the management of the distribution of the firm's earnings. Since the maximization of the return to the member is the primary goal of the cooperative (VanSickle and Ladd, 1983; Sexton, 1986), board members and managers should use tools and information at their disposal to choose the optimal level of retained earnings and earnings allocated to members.

The decision to retain or allocate funds to members involves balancing member preferences for fixed assets provided by the cooperative and cash returns on their investment in the cooperative. Cooperatives must retain sufficient earnings to replace depreciated assets and invest in expansion of the firm. Expansion allows the cooperative to take advantage of economies of scale, a key part of the purpose of its establishment according to the Competitive Yardstick theory. Allocation of earnings to members is also crucial as members will likely prefer to have a portion of their investment paid out to them to invest in their own operations. This comports with the view that cooperatives raise (lower) the net price received (paid) for the members' product (inputs).

Tax rates, to the extent that they have a differential effect on the value of retained and allocated earnings, may also affect the board's decision to allocate or retain earnings. A higher tax rate paid on allocated (retained) earnings reduces the return to the member from allocated (retained) earnings and thus may influence the board to retain (allocate) a larger share of the earnings of the cooperative.

Member risk preferences can influence the board's decision to allocate equity to the extent that returns from retained earnings and allocated earnings are characterized by different risk-return tradeoffs. If returns from allocated (retained) earnings become more risky, *ceteris paribus*, members will prefer a higher percentage of earnings be retained (allocated). The degree to which this effect influences the optimal decision of the board depends on the strength of the members' preference for lower risk. If members are more risk averse, this effect will be stronger than if members were more risk neutral.

This study has two primary objectives. First, we develop a mean-variance portfolio model that explicitly accounts for the effects of income tax rates and member risk preferences on the allocation of equity. Second, we use sensitivity analyses to examine the effects of different tax regimes and farmer risk-preferences on the optimal allocation of cooperative equity.

To understand the problems faced by the board when deciding how much of earnings should be allocated to the membership or retained in the cooperative, it is necessary to understand the sources and possible allocations the board faces. Figure 3.1 provides a diagram of the foregoing discussion.

Cooperative profits come from two possible sources. Members can buy/sell inputs/outputs with the cooperative; this is called patronage income. Non-patronage income primarily comes from nonmembers and/or investments the cooperative has made in federated cooperatives and other ventures. Both patronage and non-patronage profits are split into two categories: allocated and unallocated. An intuitive way to think of this distinction is that allocated earnings are "earmarked" for the member, whereas unallocated equity is not. Also, allocated earnings can be paid in cash, cash patronage refund, or held as equity in the cooperative, retained patronage refund. There are multiple strategies of returning retained patronage refunds or allocated equity to the members (Dahl and Dobson, 1976), but it must be paid to the member in the event of death. Unallocated equity is only paid to the members in the cases of liquidation of the firm.

Though profits from patronage business can be put into retained earnings, this practice is sometimes controversial as it conflicts with traditional cooperative principles (Kenkel, 2012). This is because members want their equity to be returned to them on the cooperative's revolving schedule or upon death. Unallocated equity stays in the firm unless it is liquidated.

Note that the diagram focuses on non-section 521 cooperatives. The reason is that most farmer cooperatives operate as non-section 521. Furthermore, section 521 cooperatives can allocate non-patronage earnings to its members however doing so can lead to legal issues. Namely, allocating non-patronage earnings to members under section 521 code means all non-members must be treated similarly as members.

Taxation of cooperatives is different from taxation of investor-owned firms (Figure 3.1). Members pay taxes on "qualified" earnings, whether the member receives them as cash patronage refunds or earnings allocated to them and held on the cooperative's balance sheet. Cooperatives pay federal taxes according to the C corporation tables on all non-qualified earnings as well as any earnings from non-member sources. To manage the effects of taxation on member returns, the board must be conscious of the effective tax rates of their members and of the cooperative itself. This is a key part of effective management of a cooperative's equity.

Another responsibility of the cooperative board is to align business practices with the risk preferences of members. Particularly important in this regard is the members' investment of equity in the cooperative. Cooperative net worth has grown rapidly in recent years. Total U.S. cooperative net worth grew from $20.57 billion in 2006 to $31.3 billion in 2011, an average yearly increase of 9% (USDA). This increase is amplified by the decline in the number of cooperatives from 2,675 in 2006 to 2,285 in 2011, an average yearly decrease of 3% per year. Taken together, the average cooperative's net worth has increased from $7.45 million in 2006 to $12.21 million in 2011. Given these increases in member investment, and the associated increase responsibility of the board to manage this equity in accordance with member preferences, the present study will examine the effect of member risk preferences on the allocation of equity.

3.2 Literature Review

This section discusses the relevant research regarding cooperative finance issues. It is divided into 4 subsections: performance and productivity of cooperatives, general capital issues, debt-specific issues, and equity revolvement and patronage refund policies.

3.2.1 Capital Issues

Capital issues are important to cooperatives because of the unique challenges they face in regard to raising equity. Adding further complications is the "one member, one vote" regime. Large producers, who conduct a significant amount of patronage business and therefore generate a lot of equity for the cooperative, may be disenfranchised from using cooperatives because the "one member, one vote" limits their ability to control the firm. The reason is because a producer's control is not tied to their investment or patronage with the firm. Further, because of their mission to serve members, attracting nonmember investment is difficult because the returns are typically low compared to a potential investor's opportunity cost on the stock market.

Chaddad, Cook, and Heckelei (2005) determine whether physical capital investment is constrained by availability of finance for cooperatives. Findings suggest that cash flow and the marginal profitability of capital are positively related to investment. Size, credit risk, and leverage significantly impact capital investment which implies that managers can alleviate capital constraints by pursuing a growth strategy while maintaining a conservative capital structure (that is, holding less debt as a percentage of total assets).

Further, investment constraints are brought about by free rider, horizon, and portfolio problems. A major problem is that cooperatives distribute benefits according to patronage rather than equity holdings and do not allow transfer of benefits. The authors suggest that these restrictions on residual claims should be re-evaluated to ensure profitability.

Parcell, Featherstone, and Barton (1998) use an expected utility model to determine the optimal financial leverage of a cooperative. Sensitivity analyses were conducted using a stochastic interest rate and a range of risk-aversion levels. The authors found that using more equity reduced the probability of loss but sacrificed profitability. Strategies that can reduce the probability of loss and increase profitability include increasing return on local assets, using debt financing with a low interest rate, and reducing business or financial risk. The study concludes that a decrease in the ratio of equity to assets from 68.7% to 51.8% would increase the probability of the return on equity falling below 0% from 9.09% to 14.29% in Midwestern agricultural cooperatives.

Barton et al (2011) summarized the results of a survey of cooperative leaders which was intended to determine issues cooperatives face in financing their operations. The survey indicated that "financing and managing the asset growth needed to meet member needs and keeping equity proportional to usage" are critical issues for cooperative managers.

3.2.2 Patronage Refunds and Equity Revolvement

Part of the unique structure of cooperatives is their responsibility to return the patronage of their members. Additionally, the equity retained in the firm must be returned to the members in some fashion. These responsibilities typically fall on the board of directors that may or may not be equipped to determine the best patronage refund and equity revolvement policies. This has lead economists to consider patronage refunds and equity revolvement at length. This section will discuss the literature related to these topics.

VanSickle and Ladd (1983), using a maximization of after-tax member benefits approach, find that cooperatives should pay roughly 70% of their patronage refunds to members in cash. The legal minimum cash patronage refund is 20%. Further, cooperatives should pay the maximum allowable dividend on common stock if one is paid. Analysis of the leverage ratio (ratio of total debt to total assets) yields optimum values between 0.39 and 0.69.

Dahl and Dobson (1976) use data from Wisconsin farm supply cooperatives and a cost minimization model to determine the least-cost financial structure. The results suggest that cooperatives should use less capital from retained patronage funds and more from permanent equity (such as preferred and common stock). Using less retained patronage to finance the business indicates that cash patronage refunds could increase. This increase would most likely be attractive to members because it would lower the net price paid on inputs.

Dahl and Dobson suggest a dynamic strategy for financial restructuring. The cooperative should take on more long-term debt and subsequently issue more common stock (that would need to be purchased by members). The benefit to the member of adding more common stock to their portfolio would be attractive dividends and the long-term competitiveness of the cooperative.

Royer and Shihipar (1997) used a present value framework to determine the optimal rate of cash patronage refunds based on member age. Based on collective choice analysis using a median voter rule, cooperatives will most likely pay the 20% minimum cash patronage refund and retain the other 80% in a revolving fund. This is because a producer will prefer a higher cash patronage refund only in the early years of operation. The authors compared a 20% cash patronage refund to a 45% cash patronage refund. They found that up to 14 years of operation, a farmer would receive a higher present value of after-tax cash flows from a 45% cash patronage refund plan. After 14 years of operation, the 20% cash patronage refund plan has a higher present value of after-tax cash flows. However, many cooperatives pay more than this amount. The authors suggested that this may be a result of negative cash flows experienced by younger members thanks to tax obligations under the minimum cash patronage refund.

Beierlein and Schrader (1978) used a simulation based on average data from three Indiana supply and marketing cooperatives thought to represent a typical cooperative to examine the effect of changes in capital structure on the value of a cooperative to its member patrons. The cooperative was assumed to sell or purchase inputs or outputs at prices comparable to investor-owned firms. Three policy options were included in the analysis: a limited-length revolving fund, alternative minimum cash patronage fund amounts, and the payment of a required return on all capital contributed by members. These factors are thought to impact the level of patron benefits. The authors found that required returns on patron equity and increased minimum cash patronage refunds, thought typically to be favorable to members, actually result in lower patron benefits under the assumed conditions. Required returns on patron equity are undesirable from the standpoint of total patron benefits because the increase in dividend payments was more than offset by a reduction in cash refunds. Increased minimum cash patronage refunds reduced overall patron benefits because the increased cash payments reduced the growth rate of patronage. Since cooperative returns exceeded farm returns, the higher growth rate of retained patronage was preferred to higher cash payments.

Corman and Fulton (1990) use a simulation approach to compare benefits to members under three alternative equity revolvement policies. The nonsystematic revolvement policy is simply an ad hoc policy. Members receive their equity investment when they exit the cooperative or when they die. The percentage equities redemption plan allows members to redeem a percentage of their equity each year. The value of equity that can be redeemed is determined by the year's beginning equity. The revolving fund redeems equity after it has reached a certain age in the order it was retained. Results indicate that slower member growth gives higher returns for current members but slows asset growth. Larger cooperatives may be less profitable, reducing the advantage of growth. The percentage equities redemption plan is preferable to the revolving fund because it generates comparable growth rates to the revolving fund while providing greater returns to members. Additionally, gross margin significantly impacts member growth and well-being.

Knoeber and Baumer (1983) use an expected utility framework to study the farmer's preference for retained patronage refunds. Rates of return on cooperative and farm equity, their variances and covariances, and the expected future share of patronage refunds retained and its variance significantly impact the percentage of patronage refunds retained in the cooperative. Finally, the authors determine the impact of the expected rate of return on cooperative equity on the share of equity invested in the cooperative. As the model predicted, an increase in the expected rate of return was positively related with the share of equity invested in the cooperative.

The present work examines the effects of tax rates and farmer risk preferences on the cooperative board's decision to allocate equity to specific members. We use a standard two-period expected utility model similar to Knoeber and Baumer (1983) and sensitivity analyses to determine the robustness of these effects. Effective tax rates from 2006 to 2010 and empirically-determined farmer risk preferences from Parcell, Featherstone, and Barton (1998) are used in the analysis.

Though a significant amount of research has been conducted regarding optimal equity allocation, taxes have not been treated as a variable of interest. For example, Royer and Shihipar (1997) explicitly state that while taxes are included in their model of patron preferences, the tax rate was treated as neutral to the results of the analysis and was chosen arbitrarily. The primary contribution of this essay is an analysis of the effect of effective tax rates on the optimal share of allocated earnings.

3.3 Theoretical Model

As shown in Figure 3.1, which is similar to Boland (2013), the disbursal of cooperative earnings can be complicated. Earnings from patronage of the firm by members who are treated differently from income earned from non-members. All earnings, whether from members or non-members, are then either earmarked specifically to individual members or put into a general equity fund. Allocated earnings are either distributed or retained in a fund, according to current laws and the board's estimation of the members' preferences. Finally, patronage earnings allocated to members are considered qualified earnings, meaning that the members pay taxes on these earnings. All other earnings are non-qualified, indicating that the cooperative pays taxes.

To simplify this complex decision, assumptions regarding cooperative equity are necessary. Boards of directors and cooperative managers are assumed to be perfect agents of the farmer-members with perfect knowledge of the members' preferences as to the management of the assets of the cooperatives. The preferences of the members dictate the decisions of the managers and board members. This assumption is reasonable for two reasons. First, cooperative boards are made up of the members themselves. Monitoring costs are likely to be low when the members serving on the board are part of the general network of producers in the area. Second, members likely have a high opportunity cost of investing in the cooperative. Funds invested in the cooperative could be used to finance projects on the members' own operation. Since cooperative boards are charged with managing the cooperative's equity, the board will likely align policy with members' preferences.

We assume that all earnings that are designated as unallocated will be reinvested in the cooperative as retained earnings. Therefore, this income will be categorized as non-qualified earnings and taxed at the cooperative level. By law, non-qualified earnings are taxed at the cooperative level, at least in the short term.

Further, all remaining earnings will be allocated to the farmer and therefore taxed at the farmer level. All qualified earnings will be paid as 100% cash patronage refund. This allows us to focus on the short term impact of taxes on patronage distribution policy, and avoid the complexity associated with discounting future cash flows from retained patronage refunds. Still, the model does all for inferences of the impact of retaining patronage refunds on the optimal equity allocation decision.

Using the assumptions discussed above, we employ a two-period portfolio model to analyze the effect of tax rates and member risk preferences on equity allocation. The after-tax return on member investment (R_{minv}) is decomposed into the return on qualified earnings (R_{QE}) and the return on nonqualified earnings (R_{NQE}). The return on qualified earnings, by virtue of the 100% cash refund assumption, is approximated by the member's return on assets. This is a reasonable proxy for the return on qualified earnings because the opportunity cost of investment in the cooperative is the member's return on assets. Therefore, it is assumed that the cash patronage refunds will be invested in the member's operation if they were not invested in the cooperative.

Given the return on non-qualified earnings is equal to the cooperative's retained earnings, the return on cooperative assets is a reasonable proxy for return on non-qualified earnings. Thus, after-tax member investment can be decomposed into after-tax return on qualified earnings (the member's return on the assets of their own operation) and after-tax return on non-qualified earnings (the return on the cooperative's assets).

The after-tax return on member investment can be describe as follows:

$$R_{minv} = R_a T_f + R_u T_c \quad (1)$$

where

$$T_f = (1 - t_f), \quad (2)$$

$$T_c = (1 - t_c), \quad (3)$$

and t_f and t_c are effective farm and cooperative income tax rates, respectively.

Since T_f and T_c are deterministic, we can write the expected rate of return on this portfolio as

$$E(R_{minv}) = \omega E(R_a) T_f + (1 - \omega) E(R_u) T_c \quad (4)$$

where ω is the initial-period share of the cooperative's equity allocated to qualified earnings. The variance of $E(R_{minv})$ is

$$\sigma_p^2 = \omega^2 T_f^2 \sigma_a^2 + (1 - \omega)^2 T_c^2 \sigma_{u^2}^2 + 2\omega(1 - \omega) T_f T_c Cov_{R_a R_u}. \quad (5)$$

The board selects ω so that the utility of the next period's equity, E_1, is maximized. It is assumed that the utility function exhibits constant relative risk aversion and is specified as

$$v(E_1) = A - e^{-\lambda E_1} \quad (6)$$

where A is a constant that restricts the range of the function, and λ, which is positive, is the coefficient of absolute risk aversion (Pratt 1964). Since E_1 is assumed to be a normally-distributed random variable, the certainty equivalent z is

$$z = E(E_1) - \frac{\lambda}{2}\sigma^2_{E_1}. \tag{7}$$

According to Freund (1956), maximizing z is equivalent to maximizing expected utility. Since $E(E_1)$ is equal to $E_0[1 + E(R_{minv})]$, and $\sigma^2_{E_1}$ is equal to $E_0^2\sigma^2_{minv}$, the maximization problem is

$$\underset{\omega}{\text{Max}}\ z = E_0[1 + E(R_{minv})] - \frac{\lambda}{2}W_0^2\sigma^2_{R_{minv}} \tag{8}$$

$$s.t. 0 \le \omega \le 1.$$

The constraint on ω ensures that there are no short sales. Using equations 4 and 5 and noting the restriction on ω in equation 8, the first order condition is

$$\frac{\partial z}{\partial \omega} = E_0\left[E\left(R_{QE}\right) - E\left(R_{NQE}\right)\right] - \lambda E_0^2\left[\omega\sigma^2_{R_{QE}}T_f^2 - (1-\omega)\sigma^2_{R_{NQE}}T_c^2 + (1-2\omega)CovR_{QE}R_{NQE}T_fT_c\right] = 0 \tag{9}$$

Solving for the optimal portfolio allocation gives

$$\omega^* = \left. E\left(R_{QE}\right) - E(R_{NQE}) \middle/ \lambda E_0\left(\sigma^2_{R_{QE}}T_f^2 + \sigma^2_{R_{NQE}}T_c^2 - CovR_{QE}R_{NQE}T_fT_c\right)\right. \tag{10}$$

Finally, we find the following comparative statics:

$$\frac{\partial \omega^*}{\partial \lambda} = \frac{E_0^2[\omega\sigma^2_{R_{QE}}T_f^2 - (1-\omega)\sigma^2_{R_{NQE}}T_c^2 + (1-2\omega)Cov_{R_{QE}R_{NQE}}T_fT_c}{\frac{\partial^2 z}{\partial \omega^2}} \lesseqgtr 0, \tag{11}$$

$$\frac{\partial \omega^*}{\partial T_f} = \frac{-E_0E(R_{QE}) + 2T_f\lambda E_0^2[\omega\sigma^2_{R_{QE}} + (1-2\omega)Cov_{R_{QE}R_{NQE}}T_c]}{\frac{\partial^2 z}{\partial \omega^2}} \lesseqgtr 0, \tag{12}$$

$$\frac{\partial \omega^*}{\partial T_c} = \frac{E_0E(R_{NQE}) + 2T_C\lambda E_0^2[-(1-\omega)\sigma^2_{R_{NQE}} + (1-2\omega)Cov_{R_{QE}R_{NQE}}T_f]}{\frac{\partial^2 z}{\partial \omega^2}} \lesseqgtr 0 \tag{13}$$

Equation 11 shows the effect of risk aversion on the optimal share of qualified earnings. Intuitively, the sign of this derivative is dependent on the variances and covariance of the return on qualified and non-qualified earnings. We expect that a higher variance of returns on qualified earnings will tend to make this derivative negative, while a higher variance of returns on non-qualified earnings will tend to make it positive. A positive (negative) sign on equation 11 indicates that more (less) risk-averse members prefer a larger (smaller) share of qualified earnings.

Equations 12 and 13 depict the effect of personal and corporate taxation on the optimal allocation of earnings, respectively. The signs of these derivatives are uncertain and depend on the expected returns and variances on qualified and non-qualified earnings, the covariance of the rates of return on qualified and non-qualified earnings, and the farm and cooperative income tax rates. These comparative statics also illustrate that the impact of one tax rate on the optimal allocation is affected by the other. This is because the comparative statics in equations 12 and 13 are functions of both tax rates. A positive (negative) sign on equation 12 indicates that a lower (higher) effective tax rate on farm profits would increase (decrease) the optimal share of qualified earnings. A positive (negative) sign on equation 13 indicates that a lower (higher) effective tax rate on cooperative profits would increase (decrease) the optimal share of qualified earnings.

Recalling the definitions given in equations 2 and 3, we expect that equation 12 will generally be positive and equation 13 will generally be negative. All other things equal, an increase in farm tax rates will likely decrease the share of net income allocated as qualified earnings. Conversely, an increase in cooperative income tax rates will likely increase the share of net income allocated as qualified earnings. Both of these effects are due to their direct effect on after-tax returns on member investment. Sensitivity analyses described in the next section will examine the relationships described in equations 11, 12, and 13.

3.4 Sensitivity Analysis

To examine the effects of member risk preferences and tax rates on the optimal share of qualified earnings, we use empirically-estimated farmer risk preferences and data on farm and cooperative income and tax rates. Empirically-estimated farmer risk preference information is taken from Parcell et al (1998) in the form of relative risk aversion coefficients used in that study. Seven tax scenarios are chosen to illustrate the effect of changes in tax policy on the decision to allocate profits as qualified earnings.

Financial statement data on Kansas farms and cooperatives from 2005 to 2010 from the Kansas Farm Management Association and CoBank are used to estimate effective tax rates and rates of return on equity for farms and cooperatives, respectively. Returns and their variances can be found in Table 3.1 and tax rates can be found in Table 3.2. Cooperative returns were both higher and less variable than the farm returns.

The covariance between average returns in the six years of data was roughly zero. Since we did not have access to data that would allow a more robust calculation of the covariance, we selected three covariance values of -0.01, 0, and 0.01. Since cooperative assets are financed, ultimately, by debt or the equity farmers invest in the cooperatives, a positive covariance may be likely. This is because success at the farm level would drive success at the cooperative level. However, for some large cooperatives that are invested in other enterprises not related to production agriculture, it is somewhat likely that the covariance of returns between the cooperative and its constituent farmers would be negative.

Support for this low to zero covariance is found in Knoeber and Baumer (1983). They examined the relationship between covariance of farm and cooperative returns and the share of earnings allocated to members. The covariance was not statistically significantly related to the share of patronage refunds retained by cooperatives thus was not a significant factor in determining the board’s policy. This indicates that the covariance between the two returns is small.

Approximations of actual returns and variances were used to generate the two scenarios in Table 3.3. The first scenario assumes that farm returns exceed cooperative returns. An example of this would be a case where the cooperative experienced losses in capturing carry in the grain market or mismanaging farm supply inputs to the extent that they experienced a loss in profit. The second scenario assumes that cooperative returns are higher than farm returns. According to the data, this is the more likely scenario on average.

To determine the effects of changes in the effective tax rates paid by farms and cooperatives on the optimal share of profits allocated to members, seven tax rate scenarios were examined. The first used actual data from the KFMA and CoBank. Deviations in the tax rates of 5, 10, and 20 percent were calculated to create the other six scenarios. These rates were chosen to illustrate a range of possible changes to effective tax rates. The 5% deviations could occur as a result of incremental changes in the tax code while the 10% and 20% deviations represent swings in profitability or large purchases of fixed assets. Overall, effective farm tax rates were higher than cooperative tax rates.

Results in Table 3.4 indicate that, using actual returns from KFMA and CoBank, earnings allocated to members should be low. This is expected since cooperative returns are both higher and less variable than farm returns.

Further, the certainty equivalent is 6.9% which indicates that the farmer would be indifferent between a return of 6.9% with no risk and the risky return from the portfolio of cooperative and farm assets. The certainty equivalent gives board members an idea of what return they should provide their members to ensure that members continue to invest in the cooperative.

Regardless of whether the cooperative returns were higher and more variable than the farm returns or lower and less variable, the average optimal share of allocated earnings is roughly 46%. Since the tax rates (see Table 3. 2) are higher for cooperatives than for farms, this result is reasonable. When pre-tax cooperative returns are higher and more variable, the higher tax rate reduces this return and creates an incentive for a larger share of qualified earnings. When pre-tax farm returns are higher and more variable, the higher risk of farm returns ensures that the majority of earnings are retained as non-qualified earnings.

Since the share of qualified earnings is roughly equal between the two returns scenarios, the certainty equivalent does not change drastically. The value of the certainty equivalent falls between 3.8% and 4.0% in all cases in Table 3.4. This indicates that members would be indifferent between riskless returns of 3.8% - 4.0% and a portfolio of cooperative and farm assets like those indicated in the table. Under these scenarios, cooperative boards should look to provide a return above this level to ensure continued investment in the cooperative.

The tax rates used in this analysis do not have a significant impact on the share of qualified earnings or the certainty equivalent. Table 3.5 shows the changes in shares of qualified earnings and certainty equivalents due to changes in effective tax rates for farms and cooperatives. For each doubling of the change in tax rates, the effect on the share of qualified earnings and certainty equivalents roughly doubles. However, even the largest changes in tax rates (40%) produce changes in qualified earnings of less than 2% and changes in certainty equivalent of 0.1%. The results of this analysis indicate that realistic changes in effective tax rates will not significantly affect the share of qualified earnings.

To further examine the effects of risk aversion on the optimal allocation of net income to members, we specify the following measure of the effect of risk aversion on ω^*:

$$\delta = |\omega^*_{4.5} - \omega^*_{1.0}| \quad (14)$$

where δ is the difference between the optimal allocation of net income as qualified earnings under the assumption of the highest risk aversion and the optimal allocation under the assumption of the most risk-neutral preferences. Higher values of δ indicate a larger impact of risk aversion on optimal net income allocation to qualified earnings. This value is computed for each tax regime. This allows us to determine the effects of risk preferences on the optimal allocation.

Similar to equation 14 above, we specify the following equation to examine the effects of risk aversion on the certainty equivalent:

$$\Omega = |CE_{4.5} - CE_{1.0}| \quad (15)$$

where Ω is the difference between the certainty equivalent under the assumption of the highest risk aversion and the certainty equivalent under the assumption of the most risk-neutral preferences. Higher values of Ω indicate a larger impact of risk aversion on optimal net income allocation. As above, this value is computed for each tax regime and determines the effects of risk preferences on the certainty equivalent.

Table 3.6 shows values of δ and Ω for each of the tax scenarios. All values in the table have the expected sign. The certainty equivalent is larger for the least risk averse than the most risk averse producers in all cases. Changes in the certainty equivalent are uniform within each group of assumed returns. Further, these changes are smallest in the case of actual returns and largest in the case of the high returns and high variance of returns for cooperatives. This indicates that when cooperatives are more profitable and more consistently so, risk aversion among members is not as important a factor as the case of both high and highly variable returns for either farms or cooperatives.

Additionally, the magnitude of the optimal share of qualified earnings was consistent within each group of assumed returns. This indicates that realistic changes in tax rates do not affect optimal qualified earnings as much as the pre-tax returns and variances of returns.

3.5 Conclusions

The complexity of the distribution of earnings in agricultural cooperatives is due not only to the unique rules under which a cooperative operates, but also to the differential tax treatment of its different classes of equity and the need to consider member risk preferences when distributing returns between qualified and non-qualified earnings. Through simplifying assumptions, we developed a portfolio model of the board’s decision to either retain net income in the firm as non-qualified earnings (implying that the cooperative would pay taxes on these earnings) or to designate net income as qualified earnings (which places the tax burden on members). We defined cases that were composed of 5 relative risk aversion coefficients, 7 tax scenarios, 3 sets of means and variances of returns on allocated and unallocated equity, and 3 possible covariances of these returns.

The effect of risk aversion was more economically significant than the effect of taxes on the optimal share of qualified earnings. This implies that while boards should be conscious of the differential tax rates paid by members and by the cooperative firm, managing the earnings allocation policy in accordance with member risk preferences is likely to take precedence. Further, there is no evidence of an interaction effect of tax rates and risk aversion.

A key assumption in the analysis is that 100% of qualified earnings were paid in cash. Thus, retaining some qualified earnings as non-qualified earnings would increase the overall return to the farmer in cases where the cooperative return is higher than the farm return. Any funds retained in the cooperative will produce the cooperative's rate of return. These results are inconsistent with the findings of Royer and Shihipar (1997). While their analysis suggests that a 20% cash payment is preferred to a 45% cash payment, our findings suggest that the 45% is optimal.

The above analysis is valid insofar as its assumptions are justified. Barring fundamental changes in laws regarding cooperatives, there are two primary issues that could change the results of this analysis. The assumptions regarding effective tax rates rest on the ability of cooperatives and farms to manage their net income in such a way as to minimize their tax burden. A policy change that has no effect on tax rates, such as a change in depreciation rules, may change the ability of firms to effectively manage net income. Of course, a change in tax rates could also affect the results of this analysis. Finally, a change in policy or other outside factors may affect the risk attitudes of farmers. For example, changes in crop insurance policy may change the risk profile of farms, thus impacting a farmer's appetite for financial or production risk. More work is needed to determine the extent to which these and other factors are likely to change and the impact those changes would have on the conclusions of this analysis.

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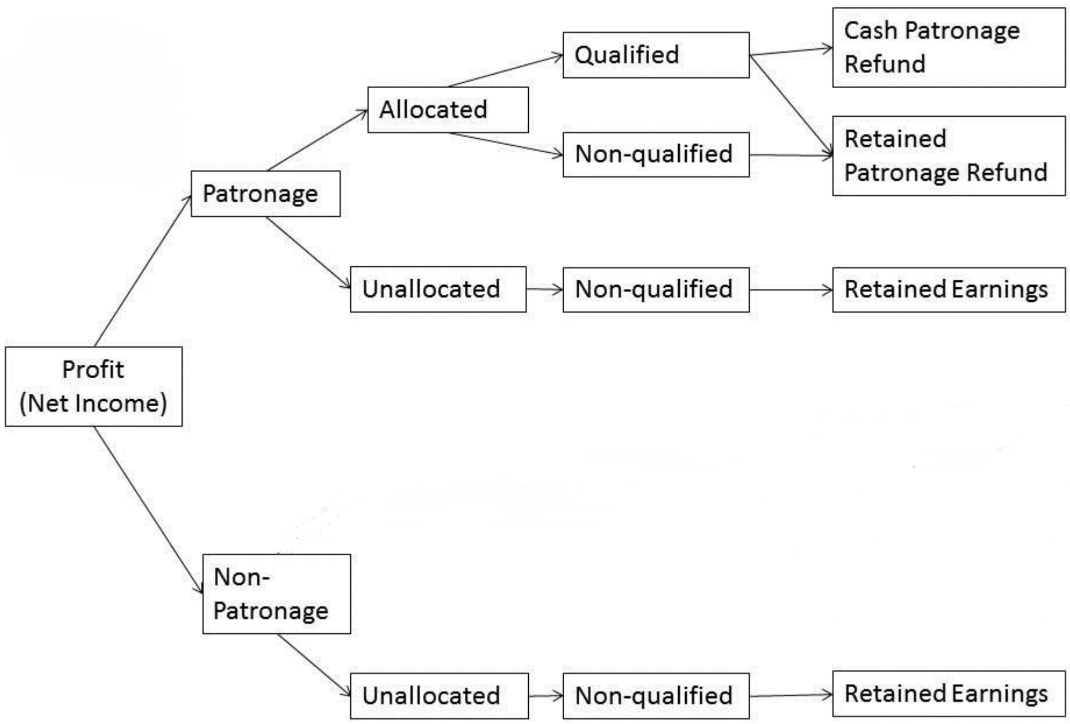

Figure 3.1 Distribution of Non-section 521 Cooperative Earnings

Table 3.1 Average Pre-Tax Returns and Variances of Returns on Assets 2006-2010

	Mean	Variance
Farm Return on Assets	0.036	0.037
Cooperative Return on Assets	0.085	0.007

*Sources: Kansas Farm Management Association and CoBank

Table 3.2 Effective Tax Rates Paid by Kansas Farms and Cooperatives

	Farm	Coop
Actual Effective Tax Rates*	14.1%	7.6%
5% Increase (Decrease) in Farm (Coop) Tax Rates	14.8%	7.2%
5% Increase (Decrease) in Coop (Farm) Tax Rates	13.4%	8.0%
10% Increase (Decrease) in Farm (Coop) Tax Rates	15.5%	6.8%
10% Increase (Decrease) in Coop (Farm) Tax Rates	12.7%	8.4%
20% Increase (Decrease) in Farm (Coop) Tax Rates	16.9%	6.1%
20% Increase (Decrease) in Coop (Farm) Tax Rates	11.3%	9.1%

*Sources: Kansas Farm Management Association and CoBank

Table 3.3 Return and Variance of Return on Assets Used in Sensitivity Analysis

	Return on Qualified Earnings	Return on Non-Qualified Earnings	Variance of Return on Qualified Earnings	Variance of Return on Non-Qualified Earnings
Higher Return and Variance on Qualified Earnings	0.09	0.04	0.05	0.01
Higher Return and Variance on Non-Qualified Earnings	0.04	0.09	0.01	0.05

Table 3.4 Simulation Results: Average Share of Qualified Earnings and Certainty Equivalents

	Actual Returns		High Farm Returns and Variances		High Coop Returns and Variances	
	w*	CE†	w*	CE†	w*	CE†
Actual Tax Rates	0.013	0.069	0.474	0.038	0.469	0.040
5% Increase (Decrease) in Farm (Coop) Tax Rates	0.013	0.069	0.468	0.038	0.465	0.040
5% Increase (Decrease) in Coop (Farm) Tax Rates	0.014	0.068	0.479	0.038	0.474	0.040
10% Increase (Decrease) in Farm (Coop) Tax Rates	0.012	0.069	0.462	0.038	0.461	0.040
10% Increase (Decrease) in Coop (Farm) Tax Rates	0.014	0.068	0.485	0.039	0.478	0.040
20% Increase (Decrease) in Farm (Coop) Tax Rates	0.011	0.070	0.449	0.037	0.454	0.040
20% Increase (Decrease) in Coop (Farm) Tax Rates	0.015	0.067	0.495	0.039	0.486	0.040

*Share of qualified earnings
† Certainty Equivalent

Table 3.3.5 Changes in Average Share of Qualified Earnings and Certainty Equivalents Due to Changes in Taxes

	Actual Returns		High Farm Returns		High Coop Returns	
	Change in w*	Change in CE†	Change in w*	Change in CE†	Change in w*	Change in CE†
5% Increase (Decrease) in Farm (Coop) Tax Rates	-0.001	0.000	-0.006	0.000	-0.004	0.000
5% Increase (Decrease) in Coop (Farm) Tax Rates	0.000	0.000	0.004	0.000	0.004	0.000
10% Increase (Decrease) in Farm (Coop) Tax Rates	-0.001	0.001	-0.011	0.000	-0.008	0.000
10% Increase (Decrease) in Coop (Farm) Tax Rates	0.001	-0.001	0.009	0.001	0.008	0.000
20% Increase (Decrease) in Farm (Coop) Tax Rates	-0.002	0.001	-0.022	-0.001	-0.014	0.000
20% Increase (Decrease) in Coop (Farm) Tax Rates	0.002	-0.001	0.017	0.001	0.015	0.000

*Share of qualified earnings
† Certainty Equivalent

Table 3.6 Summary Statistics for the Effects of Risk Preferences on the Share of Qualified Earnings and the Certainty Equivalent

	Actual Returns		High Farm Returns		High Coop Returns	
	δ*	Ω†	δ*	Ω†	δ*	Ω†
Actual Tax Rates	0.033	-0.012	-0.564	-0.025	0.612	-0.030
5% Increase (Decrease) in Farm (Coop) Tax Rates	0.033	-0.011	-0.555	-0.025	0.615	-0.031
5% Increase (Decrease) in Coop (Farm) Tax Rates	0.034	-0.012	-0.568	-0.026	0.608	-0.030
10% Increase (Decrease) in Farm (Coop) Tax Rates	0.032	-0.012	-0.545	-0.024	0.619	-0.031
10% Increase (Decrease) in Coop (Farm) Tax Rates	0.035	-0.011	-0.573	-0.026	0.605	-0.029
20% Increase (Decrease) in Farm (Coop) Tax Rates	0.031	-0.012	-0.523	-0.023	0.619	-0.032
20% Increase (Decrease) in Coop (Farm) Tax Rates	0.036	-0.012	-0.581	-0.027	0.598	-0.029

*Difference between share of qualified earnings with risk aversion coefficient of 4.5 and the share of qualified earnings with risk aversion coefficient of 1.

† Difference between certainty equivalent with risk aversion coefficient of 4.5 and the certainty equivalent with risk aversion coefficient of 1.

Chapter 4 - Financial Leverage and Input Misallocation in Agricultural Cooperatives: A DEA Approach

4.1 Introduction

The unique nature of the cooperative business presents challenges to managers of agricultural cooperatives in terms of acquiring equity financing. Raising equity can be difficult, as most cooperatives do not allow non-member investors, unlike their for-profit counterparts. Typically, cooperatives obtain equity through mergers (Richards and Manfredo, 2001) or through retained earnings due primarily to profitability (Kenkel et al, 2003). As a result of the limited ability to obtain equity, debt is an important tool for financing the operation and expansion of a cooperative.

Since 1979, the cooperative industry has seen some drastic changes in scale and profitability, while leverage has remained relatively stable. Figure 4.1 shows the decline in the number of agricultural cooperatives in the U.S. from nearly 6,500 in 1979 to just over 2,300 in 2010. Average net income for cooperatives remained generally below $500,000 (all values are in constant 1982 dollars) from 1979 to 2003. From 2003 to 2010, average cooperative income has risen rapidly from just over $330,000 to over $2 million. As shown in Figure 4.2, leverage (measured by the ratio of debt to assets) was fairly constant around 0.6. Average cooperative assets rose steadily from over $1.7 million in 1979 to $18.4 million in 2006. Since 2006, the average value of cooperative assets has risen to $31.2 million.

Some negative effects of the use of leverage in cooperatives are noted in the literature. Leverage can have a negative impact on ROE (Boyd et al, 2007) and was responsible for a significant portion of financial stress in cooperatives in the 1990s (Moller et al, 1996). Recently, there is evidence that debt improves financial performance (McKee, 2008). Parcell et al (1998) offers an explanation for a positive/negative relationship between higher percentages of debt financing and higher returns. That is, if the return on assets is less (more) than the cost of debt, the use of leverage negatively (positively) affects the rate of return on equity.

Another important impact of leverage is the potential for agency costs. Agency costs associated with leverage can result from losses due to incomplete contracts between borrowers and creditors, as well as monitoring and disposal costs borne by the creditor. Creditors charge higher interest rates for those firms that present greater default risks. This increased rate compensates the creditor for the additional default risk it has taken. Agency costs may also cause firms to use assets or inputs that would be sub-optimal to provide collateral for the debt contracts.

An important problem for cooperatives is the optimal use of fixed assets or capacity. Ariyaratne et al. (2006) attempts to determine productivity and assess factors affecting productivity growth using nonparametric and parametric methods. Additionally, input and output biases were calculated by comparing changes in technical change over time. Malmquist productivity indices were used to determine technical change and changes in efficiency. A regression model was used to decompose the effects of productivity into price and input and output bias effects. Between 1992 and 1998, productivity in grain marketing and supply cooperatives in Colorado, Illinois, Kansas, Missouri, Nebraska, Oklahoma, South Dakota, and Texas improved by 6.1%. The authors found that this increase was due to technological improvements rather than pure efficiency or scale change effects and that significant input and output bias existed. The authors suggested that cooperatives could improve performance by more efficiently using inputs and by operating at optimal capacity. Additionally, the inclusion of fertilizer, grain, and chemicals in the firm's product mix would result in increased productivity.

Featherstone and Al-Kheraiji (1995) found evidence of agency costs in a sample of 29 farm supply and marketing cooperatives from 1979 to 1988. They found that the use of leverage increased variable costs and resulted in a decrease in the use of labor inputs suggesting that agency costs exist in farm supply and marketing cooperatives. Additionally, the authors examined the effect of debt financing on changes in total factor productivity and found that debt had an overall positive effect on total factor productivity growth.

The objective of this study is to determine whether and to what extent agency costs exist in farm supply and marketing cooperatives using information on cooperative financial statements from 2005 to 2010. A more complete understanding of the indirect costs of leverage will add to the understanding of cooperative financial structure. An understanding of the indirect costs of leverage is necessary to examine the tradeoffs associated with the use of leverage. The analysis is conducted in two stages: a nonparametric estimation of variable cost efficiency as well as optimal input quantities and a regression of variable cost efficiency on debt and outputs. This two-stage process provides results comparable to Featherstone and Al-Kheraiji (1995).

This work adds to the literature by using a nonparametric estimation of the variable cost function. One advantage of nonparametric estimation is that the curvature of the cost function conforms to economic theory. In addition, recent work by Parman et al (2013) demonstrates the relative superiority of this method in obtaining estimates of economic measures.

4.2 Theory and Methods

Following Kim and Maksimovic (1990), a two-period variable cost model to determine two effects of the use of leverage: differences in capacity between an all-equity firm and a firm that uses debt, and effects on future input use generated by current input use. In the first period, debt and capacity are determined. In the second period, variable inputs are determined. Agency costs are said to exist if the derivative of variable costs with respect to debt is positive. A nonparametric variable cost function is estimated and the effect of debt is examined in an auxiliary regression, consistent with Coelli et al (2005).

In the present work, the variable cost function is defined as:

$$VC = C_v(w, x, c, d, Y) \quad (1)$$

where v indicates that the function is estimated under variable returns to scale, w is a vector of two input prices, x is a vector of two input quantities, c is fixed capacity, d is debt, and Y is a vector of three outputs. As in Featherstone and Al-Kheraiji (1995), we assume that capacity and debt are set in the first period and the quantities of the two variable inputs are chosen in the second period.

To estimate the variable cost function, data envelopment analysis is used to estimate the minimum variable cost of the cooperative firm under variable returns to scale. The model, developed by Färe et al (1985) is as follows:

$$Min\ \ w_i' x_i^* = C_v(w, x, c, Y) \quad (2)$$

$$subject\ to \qquad z_i\, x_i \ \le x_k^* \quad (3)$$

$$z_i c_i \ \le c_k \quad (4)$$

$$z_i d_i \ \le d_k \quad (5)$$

$$z_i\, Y_i \ge Y_k \quad (6)$$

$$\textstyle\sum_i z_i = \ 1 \quad (7)$$

where w is a vector of input prices, x^* is a vector of cost-minimizing inputs for cooperative i, x is a vector of actual variable inputs, z measures the weighting of each firm in forming the frontier, c is fixed capacity, d is debt and y is a vector of outputs. Furthermore, it is assumed that the variables w, x, c, d, and Y are strictly positive and z is greater than or equal to zero.

The theoretical minimum variable cost calculated above is used to calculate the variable cost efficiency score of each cooperative. Taken together, these scores establish the best-practice (i.e. lowest variable cost for a given level of output) frontier and the relationship of each observation to that frontier. Based on the search for relevant literature, this manuscript represents the first calculation of cost efficiency for cooperatives. The variable cost efficiency is defined as:

$$CE_i = w_i' x_i^* / w_i' x_i \qquad (8)$$

where CE is the variable cost efficiency score and the other variables are defined above $CE \in [0,1]$. A firm is considered efficient if the cost efficiency score is equal to one. That is, if a cooperative's actual variable cost is equal to the theoretical minimum variable cost as defined in equation (1), the firm is on the frontier.

Agency costs to the firm from the use of leverage are present if a decline in variable cost efficiency coincides with an increase in debt. While the direct cost of debt is the interest the cooperative pays to the lender, indirect costs (agency costs) may drive up variable costs. Thus, determining the relationship between the level of debt a firm uses and the variable cost efficiency of the cooperative provides evidence as to the presence of agency costs of debt.

In addition to determining the overall effect of debt on the firm, we estimate the impact of agency costs on two subsets of variable cost. To determine whether a firm was over- or under-using in a given variable input, the ratio of the optimal input under variable returns to scale to the actual input quantity is calculated. These ratios are defined as follows:

$$R_L = \frac{x_L^*}{x_L} \qquad (9)$$

$$R_O = \frac{x_O^*}{x_O} \qquad (10)$$

where x_L^* and x_O^* are the optimal quantities of labor and other variable inputs, respectively and x_L and x_O are actual quantities of labor and other variable inputs, respectively.

These values are compared across different values of debt to determine whether different debt levels are associated with shifts in the allocation of inputs. If optimal input ratios move away from 1 as the level of debt changes, there is evidence that agency costs are present. A ratio greater than 1 indicates that the cooperative is likely under-using an input, while a ratio less than 1 indicates likely over-use of an input. A ratio equal to 1 indicates that the cooperative is probably using the optimal amount of an input.

In the second stage, the cost efficiency scores calculated (equation 8) are used to estimate relationships between the previously-mentioned covariates. A Tobit model is used to account for the upper and lower bounds on the cost efficiency scores. This regression estimates the relationships between debt, capacity, output, and cost efficiency. It is specified as follows:

$$CE = \beta_0 + \beta_D D + \beta_C C + \beta_S S + \beta_k \pi_k + \beta_j \gamma_j \qquad (11)$$

where CE is defined as above, D is total debt, C is capacity, S is a vector of two output shares, π is a vector of 5 time dummies, and γ_j is a vector of 8 state dummies.

From these regressions, we are able to determine whether agency costs exist in agricultural cooperatives. Kim and Maksimovic (1990) define the marginal effect of debt on variable cost as an indication of the presence of agency costs. For our purposes, agency costs associated with debt exist when β_D is statistically significant and negative. In order to determine the elasticity values, conditional marginal effects are used. Elasticities are defined as follows:

$$\varepsilon_D \equiv \frac{\partial E[CE|1>CE>0]}{\partial i} \frac{E[i]}{E[CE|1>CE>0]} \qquad (12)$$

where ε_i is the conditional elasticity of variable cost efficiency with respect to i.

4.3 Data

Cost efficiency scores were estimated using financial statement data for farm supply and marketing cooperatives from 2005 to 2010 in 9 states: Iowa, Illinois, Indiana, Kansas, Minnesota, Missouri, Nebraska, Ohio, and Oklahoma. The data are obtained from CoBank and include balance sheet, income statement, and statement of owner's equity. Table 4.1 presents summary statistics for all variables described below.

Similar to Tonsor and Featherstone (2009) and Rowland et al. (1998), overall cost efficiency is estimated using a data envelopment analysis. Two inputs and three outputs are used in the calculation of minimum variable cost. Variable cost is defined as net sales less net income, depreciation, amortization, and lease expense. Labor cost is defined as payroll expense. Other variable cost is defined as variable costs less payroll expense. Debt is defined as the value of total liabilities. The prices of each input are the state-level manufacturing payroll wage and the GDP deflator, respectively. Wage data was taken from the Bureau of Labor Statistics *Employment and Earnings* report and the GDP deflator was taken from the St. Louis Federal Reserve FRED® Economic Data database. Input quantities are determined by dividing both costs by their respective price or price index.

Output variables are defined as marketing revenue, farm supply revenue, and other revenue divided by their respective price indices. The marketing price index is composed of yearly average commodity prices for corn, wheat, soybeans, sorghum, and rice taken from the Bureau of Labor Statistics and is weighted by the state-level production of each commodity. State-level production data were taken from USDA-NASS. The farm supply price index is the average of fertilizer, agricultural chemical, gasoline, and animal feed prices taken from the

Bureau of Labor Statistics. The price index for other revenue is the producer price index for all commodities taken from the Bureau of Labor Statistics.

4.4 Results

The results of the cost efficiency estimation can be found in Table 4.2. Of the 1,975 observations in this analysis, 73 observations defined the frontier. The mean efficiency of 0.73 and median of 0.74 indicate that the distribution is not highly skewed. The mean efficiency also indicates that the average cooperative could reduce its costs 27% while maintaining current production and input mix to move to the frontier. Further, the minimum cost efficiency of 0.26 indicates that the least efficient firm would need to reduce its costs by 74% while maintaining current production and input mix to move to the frontier.

A variable cost efficiency frontier is estimated and a regression analysis is conducted to determine whether agency costs are present in agricultural cooperatives. An examination of the variable cost efficiency frontier is provided in section 4.4.1. Results of the efficiency thirds analysis (4.4.2) and regression analysis (4.4.3) can be found below. We find mixed results with respect to the existence of agency costs in cooperatives.

4.4.1 Variable Cost Efficiency Frontier

The cooperatives that comprise the frontier exhibit interesting characteristics. Nearly all variables in Table 4.3 exhibit a right-skewed distribution. This indicates that the majority of the cooperatives that make up the frontier are smaller in terms of sales, assets, equity, debt, and output than the average. Additionally, nearly all variables have a standard deviation larger than the average, indicating a high degree of variability among the cooperatives that form the frontier.

The average cooperative on the frontier finances a large amount of its assets with debt. The average leverage for cooperatives on the frontier is 59%. This measure is left-skewed, indicating that a majority of the cooperatives finance more than 59% of their assets with debt. Although most measures are highly variable, the standard deviation of leverage is only 15.7% indicating that cooperatives on the frontier have leverage values relatively close to 59%.

Though the most efficient cooperatives finance a large portion of their assets with debt, this does not indicate that agency costs are not present. The most efficient cooperatives are likely to perform well (indicated by high ROE and ROA values) and will likely attract favorable credit terms based on their ability to generate a high return from operations. Thus, more analysis is needed to determine the overall effects of leverage on cooperatives.

4.4.2 Debt and Capacity Model Thirds

In order to determine the effects of debt, fixed capacity, and other financial variables on variable cost efficiency, the data was divided into three groups: low efficiency, middle efficiency, and high efficiency. Full results can be found in Table 4.4.

These results indicate that more efficient cooperatives are larger according to several measures. More efficient cooperatives were larger in terms of both assets and sales, used more debt and capacity, used more of both inputs and produced more of all three outputs. Though both labor and other variable input ratios converged toward 1 on average as cost efficiency increased, the labor input was under-used and the other variable inputs were over-used on average. Further, this analysis does not indicate the presence of agency costs since increases in debt are associated with higher variable cost efficiency.

An interesting finding is that both ROA and ROE decreased as cost efficiency increased. This result indicates that although less cost efficient firms were smaller and had lower sales, these smaller firms were able to obtain high enough sales so as to obtain higher return on assets and equity relative to their larger and more cost efficient counterparts.

To determine the effect of capacity on cost efficiency and optimal input usage, the data were divided into low, middle, and high capacity groups (Table 4.5). Variable cost efficiency increases as capacity increases, indicating that cooperatives are likely using their capacity to effectively increase profitability. This is not consistent with the findings of Featherstone and Al-Kheraiji (1995). They found that cooperatives were overusing capacity and that this overuse was due to suboptimal output allocations. Both sales and ROA increase as capacity increases further confirming that profitability is increased by increasing capacity. These findings suggest that increases in net investment in cooperative assets (Boland 2013) are justified on the basis of profitability.

Other variable cost ratio converged to 1 as variable cost efficiency increased indicating that increases in capacity improved cooperatives' ability to optimally allocate inputs. The labor input ratio converged to 1 from the low to middle capacity groups but diverged farther from 1 between the middle and high capacity groups. This finding is somewhat consistent with that of other variable inputs, but indicates that medium capacity cooperatives may have problems with under-utilization of labor as they increase capacity.

Finally, the data was divided into low, medium, and high debt groups in order to determine the presence of agency costs of debt on cooperatives (Table 4.6). As debt increased, variable cost efficiency decreased from the low to middle efficiency groups but increased from the middle to high efficiency groups. This may indicate the presence of agency costs in smaller cooperatives but increased debt could also be used to cover for poor management. Regression analysis is needed to control for other factors and determine the relationship between variable costs and debt. Though sales increased, the value of assets also increased and ROA decreased, indicating that if they are present, these agency costs of leverage may have a significant effect on cooperative profitability.

Overall, labor was underutilized and the optimal labor input ratio converged to1 as leverage increased. This finding is not consistent with the presence of agency costs. Other variable inputs were over-utilized and converged to optimal as debt increased. Again, this does not indicate the presence of agency costs, but regression analysis is necessary to control for the covariance of explanatory variables.

4.4.3 Regression Analysis

A Tobit regression analysis was conducted to determine the effects of various financial and production variables on variable cost efficiency. The regression analysis adds to the analysis of cost efficiency, leverage, and capacity thirds by accounting for the covariance between the variables. A Tobit model was chosen because variable cost efficiency is bounded between 0 and 1. Unlike the OLS model, the Tobit model restricts predictions within that range. The regression results can be found in Table 4.7 and the associated elasticities of interest in Table 4.8.

The elasticities in Table 4.8 indicate that agency costs and negative effects of the overuse of capacity are evident. Though the thirds analysis above indicates that increases in capacity are associated with increases in efficiency, the regression analysis (which controls for the effects of other variables) indicates the opposite. Regression analysis confirms the existence of agency costs indicated the above section. Ratios of marketing and farm supply outputs to other outputs were significantly positively related to cost efficiency, indicating that cooperatives heavily invested in these enterprises are more cost efficient.

The effect of debt on cost efficiency is statistically significant and negative but inelastic. For a 1% increase in debt, there is a corresponding 0.132% decrease in cost efficiency. This finding indicates that financing assets with debt can have a negative impact on cost efficiency, though the effect is not large.

Overuse of capacity is an issue that may be driven by high profits. As cooperatives increase profitability, their ability to purchase high-value fixed assets increases. This increased incentive to purchase fixed assets, coupled with an increase in the value of other fixed assets (e.g. land) drives up the value of capacity. However, paying higher prices for fixed assets can, as the results indicate, drive up costs relative to output.

4.5 Conclusions

This study determines examines the degree to which agency costs exist in a sample of farm supply and marketing cooperatives from 2005 to 2010. Evidence of agency costs was defined as a decrease in cost efficiency or a divergence of input usage from optimal that coincided with an increase in debt financing. Agency costs can come in the form of disposal costs, monitoring costs, or other costs associated with default risk that the lender passes on to the borrower in the form of covenants and higher interest rates. Our results are consistent with the findings of Featherstone and Al-Kheraiji (1995) regarding the existence of agency costs in the cooperative industry in the 1980s.

Though the analysis of means was not consistent with the regression results, regression is a more powerful tool for summarizing economic relationships as it controls for covariance between regressors. Over the 2005-2010 period, agricultural cooperatives experienced some degree of agency costs, though the elasticities indicate that the effect of debt is not large.

Because of the current low-interest rate environment, agency costs are likely not any more prevalent now than they were in the 2005-2010 period. If interest rates begin to climb, this effect may become more prevalent and may cause some firms to default. Cooperative boards should be conscious of the effect of agency costs and the interplay between the existence of those costs and government policy.

More work is needed to disaggregate the net effect of leverage on variable cost efficiency in order to determine the effects of covenants, interest rates, and scale effects. In addition, future work should examine the relationship between the level and variability of interest rates and agency costs.

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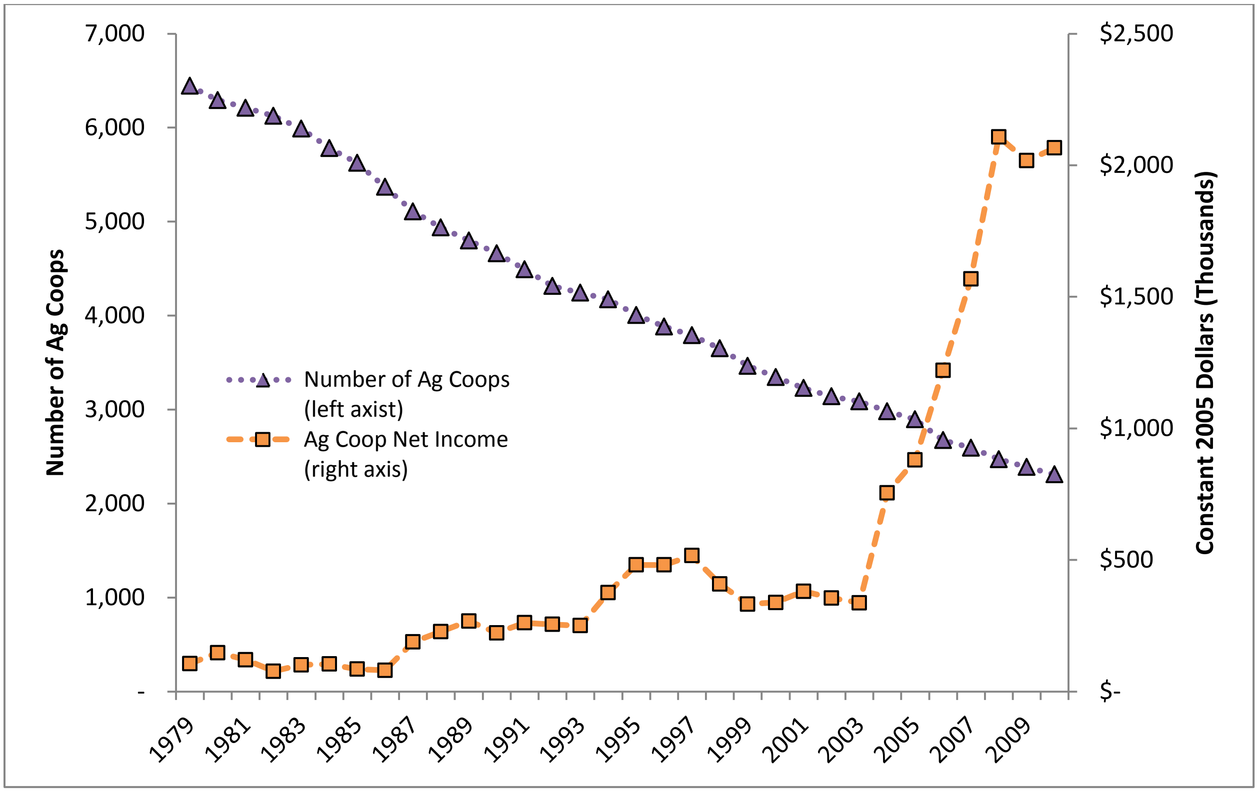

Figure 4.1 Number of Agricultural Cooperatives and Average Net Income Per Cooperative. (USDA)

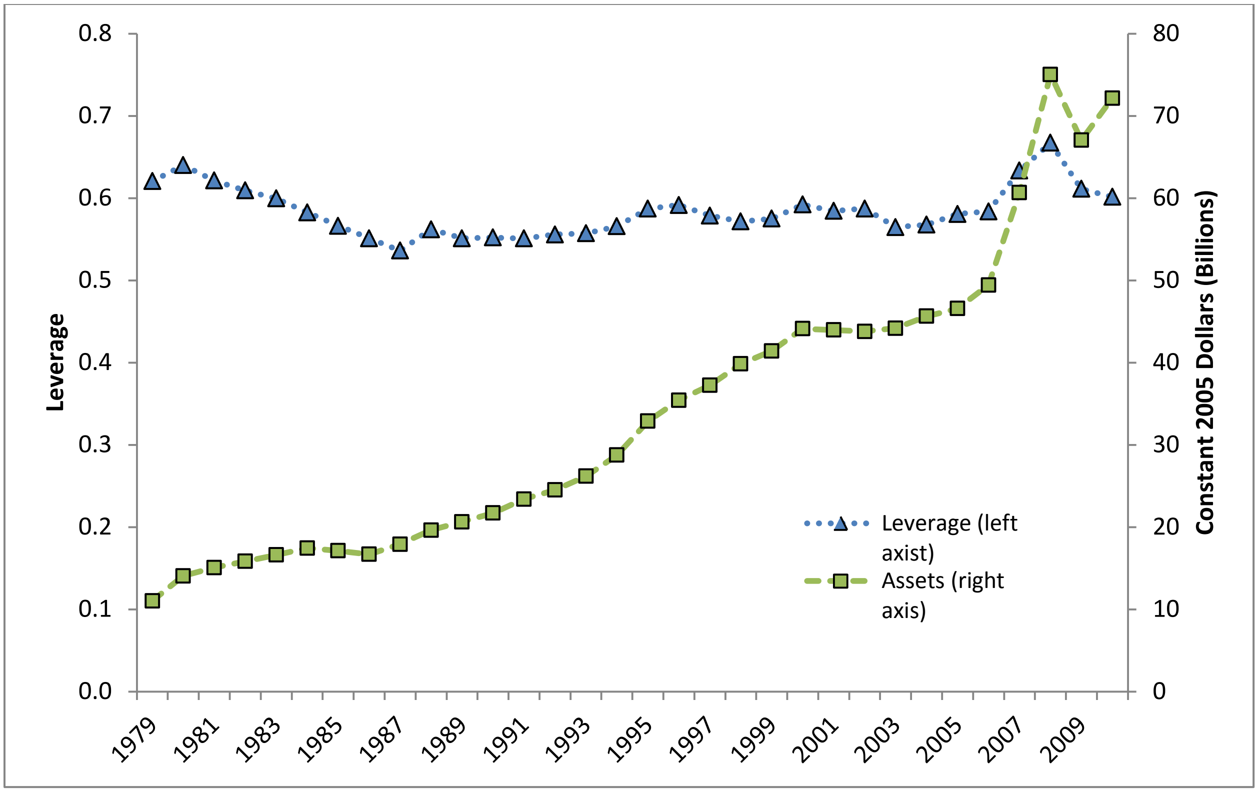

Figure 4.2 Average Cooperative Leverage and Average Cooperative Assets. (USDA)

Table 4.1 Summary Statistics of CoBank Data

	Mean	Median	Standard Deviation
Labor Input	189,132	90,071	250,732
Other Variable Input	627,940	294,780	859,935
Capacity	30,470,635	5,150,227	72,174,851
Debt	$19,357,355	$8,036,907	$30,416,544
Marketing Output	321,200	142,732	490,204
Farm Supply Output	120,171	55,067	175,240
Other Output	81,703	14,344	335,860
Wage	$17.20	$16.88	$1.35
GDP Deflator	106.48	108.59	3.79

Table 4.2 Distribution of Cost Efficiency Scores

	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Firms on Frontier
Cost Efficiency	0.733	0.747	0.151	0.269	1	73

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Table 4.3 Financial Information for Midwestern Agricultural Cooperatives with Variable Cost Efficiency Scores of 1 (n = 73)

	Mean	Median	Standard Deviation
Labor Input	608,335	429,654	593,068
Other Variable Input	1,670,719	959,481	2,012,858
Labor Input Ratio	1.000	1.000	0.000
Other Variable Input Ratio	1.000	1.000	0.000
Sales	$269,872,811	$135,000,000	$335,271,960
Marketing Output	773,786	171,154	1,156,207
Farm Supply Output	258,760	33,276	366,078
Other Output	677,069	100,924	1,281,932
Total Assets	$97,536,501	$70,972,871	$101,170,733
Debt	$65,842,557	$45,555,965	$73,933,265
Equity	$31,693,945	$23,347,317	$30,506,907
Capacity	112,181,145	21,400,000	200,462,295
ROE	0.251	0.201	0.347
ROA	0.075	0.054	0.13
Leverage	0.590	0.620	0.157

Table 4.4 Financial Information for Midwestern Agricultural Cooperatives Divided Into Low, Middle, and High Variable Cost Efficiency Groups*

	Low	Middle	High
Cost Efficiency	0.562	0.744	0.897
Labor Input	103,682	168,729	296,429
Other Variable Input	464,102	598,318	824,784
Labor Input Ratio	1.194	1.163	1.110
Other Variable Input Ratio	0.543	0.729	0.891
Sales	$55,457,878	$74,222,603	$114,898,846
Marketing Output	228,408	308,941	428,266
Farm Supply Output	60,078	118,132	183,421
Other Output	20,619	41,326	183,849
Total Assets	$19,708,933	$27,180,839	$44,126,034
Debt	$13,013,151	$17,419,006	$27,732,719
Equity	$6,695,781	$9,761,833	$16,393,315
Capacity	11,737,958	31,959,732	48,074,130
ROE	0.232	0.218	0.199
ROA	0.064	0.063	0.062
Leverage	0.580	0.537	0.539

*All values are means.

Table 4.5 Financial Information for Midwestern Agricultural Cooperatives Divided Into Low, Middle, and High Capacity Groups*

	Low	Middle	High
Cost Efficiency	0.721	0.726	0.753
Labor Input	55,916	202,012	311,892
Other Variable Input	180,163	630,693	1,080,490
Labor Input Ratio	1.108	1.035	1.324
Other Variable Input Ratio	0.710	0.717	0.733
Sales	$22,457,448	$78,265,298	$144,320,310
Marketing Output	105,571	346,037	515,973
Farm Supply Output	37,668	139,687	184,833
Other Output	20,319	65,425	160,143
Total Assets	$8,414,982	$31,559,891	$51,268,218
Debt	$5,065,911	$20,523,636	$32,739,158
Equity	$3,349,071	$11,036,255	$18,529,060
Capacity	1,216,637	6,053,046	84,260,182
ROE	0.213	0.212	0.224
ROA	0.054	0.056	0.080
Leverage	0.508	0.591	0.560

*All values are means.

Table 4.6 Financial Information for Midwestern Agricultural Cooperatives Divided Into Low, Middle, and High Debt Groups*

	Low	Middle	High
Cost Efficiency	0.717	0.706	0.777
Labor Input	44,973	107,739	415,652
Other Variable Input	130,170	353,626	1,402,875
Labor Input Ratio	1.227	1.129	1.107
Other Variable Input Ratio	0.698	0.693	0.768
Sales	$16,541,878	$44,268,974	$183,527,660
Marketing Output	72,678	196,113	696,025
Farm Supply Output	28,783	70,421	261,401
Other Output	15,055	35,030	195,089
Total Assets	$5,260,043	$15,086,255	$70,612,936
Debt	$2,147,678	$8,657,857	$47,334,052
Equity	$3,112,365	$6,428,398	$23,278,883
Capacity	7,263,088	16,798,105	67,378,778
ROE	0.148	0.216	0.285
ROA	0.070	0.064	0.056
Leverage	0.408	0.590	0.660

*All values are means.

Table 4.7 Tobit Regression Results*

	Coefficient	Standard Error	t	P-Value
Debt	0.002	0.000	24.920	0.000
Capacity	0.003	0.000	7.140	0.000
Marketing Output Share	-0.250	0.011	-22.840	0.000
Farm Supply Output Share	-0.093	0.013	-6.940	0.000
Iowa	0.045	0.009	5.102	0.000
Illinois	0.088	0.009	10.100	0.000
Indiana	0.078	0.013	6.240	0.000
Kansas	0.036	0.008	4.250	0.000
Minnsota	0.036	0.009	4.160	0.000
Missouri	0.004	0.011	0.390	0.698
Nebraska	0.055	0.010	5.470	0.000
Ohio	0.043	0.010	4.190	0.000
2005	0.174	0.007	25.850	0.000
2006	0.102	0.007	15.120	0.000
2007	-0.046	0.007	-6.760	0.000
2008	-0.019	0.007	-27.260	0.000
2009	-0.009	0.006	-1.490	0.136
Constant	0.810	0.013	60.310	0.000

*Dependent variable is the variable cost efficiency score.

Table 4.8 Conditional Elasticities with Respect to Variable Cost Efficiency

	Coefficient	Standard Error	z	P-Value
Debt	-0.132	0.012	-10.680	0.000
Capacity	-0.046	0.010	-4.620	0.000
Marketing Output Share	0.084	0.006	13.230	0.000
Farm Supply Output Share	0.032	0.004	7.080	0.000
Iowa	-0.009	0.002	-4.490	0.000
Illinois	-0.019	0.003	-6.790	0.000
Indiana	-0.025	0.005	-4.770	0.000
Kansas	-0.002	0.000	-3.400	0.001
Minnsota	-0.004	0.001	-3.490	0.000
Missouri	0.000	0.000	-0.370	0.711
Nebraska	-0.005	0.001	-3.900	0.000
Ohio	-0.003	0.001	-3.190	0.000
2005	-0.079	0.007	-10.860	0.000
2006	-0.018	0.002	-7.770	0.000
2007	0.001	0.000	5.920	0.000
2008	0.008	0.001	6.970	0.000
2009	0.001	0.001	1.570	0.117

Chapter 5 - Conclusion

This dissertation is composed of three essays which addressed three questions surrounding the present high-profit state of commercial agriculture. The purpose of the dissertation was to analyze the following questions related to effective capital management of farms and cooperatives: 1) Should farmers use a different benchmark for farm profitability?, 2) How should cooperatives allocate earnings to farmers?, and 3) Do cooperatives face agency costs? Thus, this dissertation had three objectives. The first was to examine the effect of short- and long-term debt financing on the cost efficiency of Kansas farms. The second was to examine the effect of tax rates and member risk preferences on the cooperative's decision to retain profits in the firm or return them to members. The third was to determine the extent of indirect costs of the use of leverage in agricultural cooperatives.

To answer the first question, essay 1, "The Impact of Liquidity and Solvency on Cost Efficiency" developed a conceptual framework for examining the effect of liquidity and solvency on cost efficiency and used data from the Kansas Farm Management Association to estimate cost efficiency for a sample of Kansas farms.

Adding liquidity and solvency ratios to the DEA analysis increased efficiency scores by shifting the cost efficiency frontier up, especially for low efficiency farms. Less efficient farms, as defined by the lowest quartile cost efficiency estimates, saw significant improvements in their efficiency scores when financial ratios were added. Thus, an analyst may be missing an important part of a given farm's efficiency picture unless debt measures are included in the cost efficiency estimation.

Furthermore, adding liquidity and solvency ratios to the cost efficiency estimation improved efficiency values for farms with different input mixes. When adding financial ratios to cost share analysis, farms with lower crop and fuel input levels and a higher capital input level had a higher efficiency gain than the average farm when liquidity and solvency ratios were added.

Although income shares were not significantly related to improvements in cost efficiency, we found a significant and positive relationship between specialization and improvements in efficiency. This indicates that while enterprise choice does not impact cost efficiency when debt ratios are added to the model, the choice of the number of enterprises to operate does. There is also evidence that the age of operator is significantly related to improvement in efficiency. Results suggest that the efficiency indices for older operators are impacted to a greater extent by the addition of debt ratios than those for younger operators. Further, we have demonstrated that the impact of an inclusion of financial ratios in the cost efficiency estimation varies according to the particular distribution of cost shares and other farm characteristics.

To answer the second question, essay 2, “Cooperative Equity Allocation: A Portfolio Approach” used effective tax rates and empirically-determined risk aversion coefficients in an expected utility model to determine the optimal share of net income to allocate to members. The effects of seven tax regimes and five risk aversion levels on the optimal allocation of net income to cooperative members were analyzed using a sensitivity analysis. Results indicated that changes in tax rates had a small impact on optimal share of allocated earnings. Increased risk aversion had the expected effect on allocated earnings. That is, higher levels of risk aversion resulted in higher (lower) optimal share of net income allocated to members when variance of return on allocated equity was relatively low (high).

Our findings indicated that cooperative boards should be conscious of the risk attitudes of their members as their preferences affect the optimal share of net income allocated to members. The effects of risk aversion on the optimal share of allocated equity and the minimum return farmers expect from their cooperative investment far outweighed the effects of any reasonable change in tax rate in the future.

To answer the third question, essay 3, “Financial Leverage and Input Misallocation: A DEA Approach” used data from CoBank to estimate variable cost efficiency. A two-stage model was used that included a math programming model to estimate variable cost efficiency and a Tobit regression of cost efficiency scores on debt, capacity, and other variables.

Results of this estimation were examined for evidence of agency costs. Evidence of agency costs came in the form of decreased cost efficiency or a divergence of input usage from optimal while leverage increased. We find evidence of agency costs of debt in agricultural cooperatives from 2005 to 2010. Agency costs can come in the form of disposal costs, monitoring costs, or other costs associated with default risk that the lender passes on to the borrower in the form of covenants and higher interest rates.

This dissertation examined three questions related to the capital structure of farms and agricultural cooperatives. Cost structure and other firm characteristics were significantly affected by leverage in Kansas farms and Midwestern cooperatives. Risk preferences and agency costs significantly impacted debt and equity management for cooperatives. Future work in these areas will continue to be relevant as the agricultural industry faces challenges and changes such as an increasing world population, changes in federal agricultural policy, and improvements in technology.