From diversification to specialization: reassessing farm risk

by

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B.S., Kansas State University, 2024

A THESIS

submitted in partial fulfillment of the requirements for the degree

MASTER OF SCIENCE

Department of Agricultural Economics
College of Agriculture

KANSAS STATE UNIVERSITY
Manhattan, Kansas

2026

Approved by:

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Abstract

Historically, diversification has been viewed as a key strategy for reducing farm financial risk and stabilizing year-to-year variability in net farm income. However, since the mid-1990s, consolidation spurred by enterprise specialization has been a defining trend for the U.S. farm sector. This raises an important question. To what degree has specialization overtaken diversification as a means of risk reduction? Using Kansas Farm Management Association data from 1973 to 2024, one-year rolling regression models estimated for 10-year periods of data were used to examine the evolving relationship between specialization and farm financial performance. The analysis accounts for regional differences and evaluates the effects of specialization alongside other key factors, including economies of scale, financial leverage, operator age, expense efficiency, and government payments.

Results indicate that farms have increasingly specialized over time and that greater specialization is associated with higher returns, improved financial efficiency, and lower variability in income. Larger farms also tend to generate higher and less volatile returns. Expense efficiency emerges as the most important factor affecting financial risk and performance over the 51-year period, though its relative influence declines in recent years. Government payments increasingly contribute to farm profitability but appear less effective more recently as a risk-reduction tool than in earlier periods of the analysis. Overall, the findings suggest that specialization and consolidation have contributed to improved financial performance and stability in modern production agriculture.

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Acknowledgements

The completion of this thesis project and paper is not merely the final graduation requirement of my master's education, but rather a culmination of my educational career. The contents of this paper are merely a reflection of the people that have led and walked with me along the way through all walks of life. I would like to preface this paper by acknowledging a handful of those people that have had an extraordinary impact on my educational and professional career.

First and foremost, I would be remiss if I did not acknowledge our Lord and Savior, Jesus Christ. My faith has been a constant source of strength, guiding me through the stress and long hours of this journey.

My parents, Mike and Jodi, whose unwavering support in every endeavor of mine has meant the world. Their constant push to be the best version of myself and to never back away from a challenge has been one of the largest motivators in my life. I also owe a big shout out to my siblings Davis, Wyatt, and John. I am excited to see what you all accomplish. Additionally, I would like to thank my fiancé, Paige, whose constant support helped carry me through this process; and whose exceptional proofreading skills significantly improved what you are about to read.

Dr. Joe Parcell, my major professor, has made an immeasurable contribution to my academic journey. From my undergraduate years to taking me under his wing during my graduate studies, the experiences he has provided have been invaluable. I am truly grateful for his guidance and mentorship. In addition, Dr. Logan Britton, whom I attribute as the reason for me pursuing post graduate work. Last but not certainly not least, I owe huge thanks to the mentorship of Luc Valentin over the last three years.

Chapter 1 - Introduction

1.1 Motivation

For decades, volatile markets, extreme weather conditions, trade distortions, and increasing farmland asset values have characterized the farm sector. These and other economic forces have incentivized some operations to consolidate, and the surviving firms have grown larger. These dynamics all affect a farm's risk profile and its approach to risk-taking.

To mitigate financial risk, farms have options. As one mitigation strategy, diversification refers to an operator embedding multiple enterprises and their respective revenue streams into a single business. Pursuing a portfolio of enterprises effectively insulates the business from shocks (e.g., low prices, poor yields) experienced by one enterprise. In Kansas, farms often diversify by producing row crops and raising livestock. These revenue streams complement each other well. Row crops are often used as inputs for livestock operations, and market relationships sometimes have a financial risk benefit to operators who participate in both livestock and crop markets. For example, USDA Economic Research Service data indicates that since 1973 the annual ratio of U.S. livestock revenues to crop revenues has ranged from a high of 1.22 to a low of 0.69 (Economic Research Service, 2026). Other approaches to diversification include growing or raising multiple crops or animal species, farming irrigated and non-irrigated acres, investing in the stock market instead of reinvesting profits back into the farm operation, and maintaining an off-farm job or business. Any of these diversification strategies should mitigate the financial risk a farm operator assumes.

Although revenue diversification seems appealing in concept, its effect depends on the economies of scale an operation possesses in any one, or collection of, farm income streams (Purdy, Langemeier, & Featherstone, 1997). Examining economies of scale and scope and their effects on farm risk and financial performance over time helps to explain changes in farm structure. Considering data from 1985 to 1994, Purdy, Langemeier, and Featherstone (1997) found that scale increases financial performance for Kansas farms. They also found that diversification decreases financial performance variability (decreased risk) and increases financial performance. They noted that the results varied across different enterprise mixes (i.e., diversification structures).

Despite diversification traditionally being viewed as a risk mitigation strategy, production agriculture has persistently trended toward greater enterprise specialization and larger farms. The current research examines how farm structural relationships have evolved by using data from the Kansas Farm Management Association (KFMA), a farm management service operated in partnership with Kansas State University. The analysis draws on farm-level records from 1973 to 2024 to measure how farms have expanded, how the farm risk-return structure has changed, and how operators have positioned their businesses along the diversification-specialization spectrum.

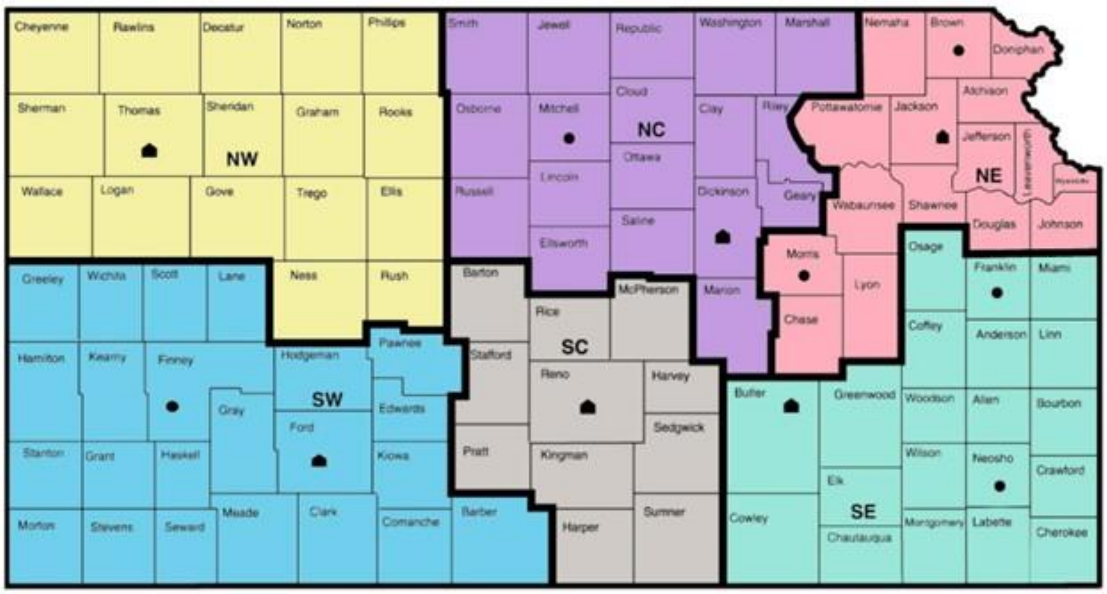
Using the KFMA dataset allows for capturing farm-level adjustments across more than 50 years of economic cycles, including recessions, droughts, and agricultural market fluctuations. Three financial performance measures are evaluated: operating cash flow coefficient of variation, operating cash flow, and return on equity. These measures are analyzed using 10-year rolling ordinary least squares (OLS) regressions, producing 43 model estimates that track how the effects of key variables have evolved.

By examining the roles of enterprise specialization, farm scale, and leverage on financial performance, this study provides insight into how management decisions influence farm financial outcomes. Ultimately, the analysis seeks to explain the economic forces underlying agriculture’s structural transformation during the past 50 years.

1.2 Kansas Agriculture

Throughout the state, Kansas has diverse agricultural production activities and climatic conditions. Recognizing these differences, KFMA divides its data reporting and programming to serve farms in the six regions shown in Figure 1.1. These regions have meaningful variations in precipitation, agricultural production, and farm management practices.

Figure 1.1: KFMA Regional Associations

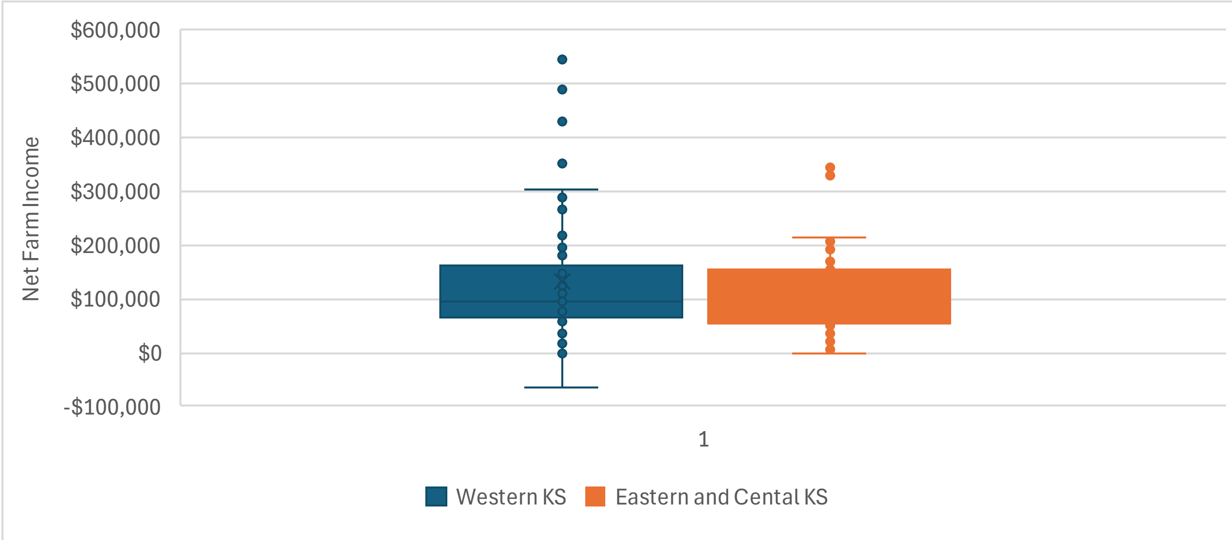


Western Kansas is semi-arid. It averages 17 inches to 19 inches of precipitation annually. Predominant crops produced in this region are dryland wheat, grain sorghum, and corn. The region also has a high concentration of cattle feedlots, which benefit from the semi-arid climate and proximity to feed grains. Because much of western Kansas sits above the Ogallala Aquifer, farms use groundwater to irrigate corn and other crops including triticale, sunflowers, soybeans, and alfalfa. However, the limited groundwater supply has led to water use restrictions. As a result, crops grown in western Kansas depend highly on precipitation and record variable yields from year to year.

In contrast, eastern Kansas has a more temperate climate and averages 30 inches to 40 inches of precipitation per year. The higher amount of rainfall makes this region better suited for cattle grazing rather than large-scale cattle feeding, which occurs in western Kansas. Typically, calves from the eastern region's cow-calf grazing operations are transported to feedlots out of the region. Crop production in eastern Kansas primarily consists of dryland corn, soybeans, and wheat. Buyers for these crop commodities include biofuel producers, oilseed crushing plants, poultry and swine feed mills, and export markets. Compared with western Kansas, the more consistent and favorable growing conditions in eastern Kansas generally result in less year-to-year production variability and more stable returns over time. The region also has more favorable conditions, including weather, population density, and product demand, to support specialty crop production and agritourism.

Figure 1.2 displays variability in inflation-adjusted annual net farm income for the state's two western regions compared with its four eastern and central regions. The box and whisker chart plots average annual net farm income. The wider spread of points and whiskers in the western Kansas data implies that farms in this region have averaged variable net farm income. The tighter points and shorter whiskers for farms in central and eastern Kansas indicate less net farm income variability in these regions.

Figure 1.2: Average Regional Variability in Net Farm Income, 1973-2024



Because of regional differences and variances in farm and operating environment characteristics (e.g., weather, cropping pattern changes, outside investments, demand drivers, changes in water rights and other policies), this analysis considers how a particular KFMA farm compares relative to the average farm in its region (Nivens, Kastens, and Dhuyvetter, 2002). To do this, each region has an average farm estimated, and differences between each farm observation and the regional representative farm are computed.

Chapter 2 - Literature Review

The current research builds on the 1997 study titled "Financial Performance, Risk, and Specialization" by Purdy, Langemeier, and Featherstone. For a group of Kansas farms, Purdy et al. measured the effects of risk, economies of scale, and economies of scope on farm financial performance in response to the "industrialization of agriculture." At the time, the authors noted that the food and agricultural supply chain had begun to adopt strategies comparable with modern industrial manufacturing. This shift changed the overall approach farms took to the business of agriculture, and the trends toward specialization and consolidation continue today.

Purdy et al. (1997) use the mean and variance of return on assets (ROA) to measure farm financial performance. Explanatory variables include operator age, percentage of operated land owned by the operator, operating expense ratio, debt-to-equity ratio, debt-to-asset ratio, farm specialization (i.e., farm scope), and total acreage operated (i.e., farm size). They found farm size was positively related to financial efficiency, proving the law of economies of scale. However, the relationship between economies of scope and financial performance was not as conclusive. They found specializing in livestock production reduced financial performance variability, but the same wasn't true for crop specialization. However, they showed farms that specialized in crops, swine, or dairy all reported higher financial performance. They postulated the cause of swine and dairy's positive effect on mean financial performance was likely due to relative economies of scale not captured in the study. Crop production's effect is likely due to the increased risk-return ratio as suggested by the increased crop farm ROA volatility.

Using data for a set of Kansas farms similar to those observed by Purdy, Featherstone, and Langemeier (1997), Nivens, Kastens, and Dhuyvetter (2002) used spatial analysis to compare a farm's management practices with its neighbors' practices. They define good management as the ability to persistently earn profits that are greater than profits earned by other farms in the same area. They separate the samples of farms into different geographic regions, create regional "average farms," and specify variables as relative to the average farm in the region. This allows for making comparisons across regions rather than specifying the model to capture cause-effect tendencies that vary due to geographic-specific factors (i.e., weather, demand, production practice). This allows Nivens et al. to better compare farms between regions as the good farms in each region would be better than their peers regardless of exogenous factors. The authors quantified whether crop marketing success increased a farm's profitability relative to its neighbors. They concluded that the best way to differentiate an individual from neighbors was to more intensively manage input costs, agronomic practices (less tillage), and yields. The effect of trying to gain an advantage in marketing wasn't as strong.

Helmers, Langemeier, and Shaik (2005) examine whether diversification between crop and livestock enterprises improves farm efficiency using a non-parametric linear programming approach applied to KFMA data. Their analysis decomposes overall efficiency into scope and scale efficiency components to evaluate the impact of diversification across farm types. The results indicate specialized farms tend to exhibit higher levels of efficiency than diversified farms. For example, farms specializing exclusively in wheat or beef had the highest efficiency scores. Farms operating multiple enterprises showed lower overall efficiency. The authors find that differences in efficiency were largely driven by scope, not scale, effects, suggesting that diversification across enterprises may introduce inefficiencies rather than cost advantages. Overall, the findings challenge the commonly held assumption that diversification improves farm performance. Instead, they provide evidence that specialization may offer efficiency advantages in agricultural production systems.

Chapter 3 - Methods

3.1 Measures of Analysis

This analysis delves into the effect of multiple measures (e.g., diversification, size, leverage) on Kansas farm financial performance from 1973 to 2024. This five-decade timespan is broken into multiple periods for analysis; the period length is denoted with *n* in the following variable specifications. Three measures of financial performance are analyzed: operating cash flow coefficient of variation, operating cash flow, and return on equity. All variables used in the analysis are either directly computed from inflation-adjusted values or adjusted for inflation using the Consumer Price Index (Federal Reserve Bank of St. Louis, n.d.).

3.1.1 Operating Cash Flow Variable Definition

The first dependent variable is operating cash flow (CF), defined as annual (*t*) net farm income with depreciation expense added back for farm *f*. This metric's average across period (k) is the base value for the explanatory variable used in the operating cash flow model to analyze overall financial performance.

(1) $\text{Operating Cash Flow}_{tf} = \text{Net Farm Income}_{tf} + \text{Depreciation}_{tf}$,

Due to changes in the KFMA dataset's depreciation definition and specification starting in 1991 — managerial depreciation replaced tax depreciation — depreciation expense had to be removed from the analysis to avoid biasing coefficients via a variable specification change. This adjustment allows for consistently reflecting cash a farm has available to deploy after paying all operating, overhead, and interest costs.

3.1.2 Risk Measure Variable Definition

CF risk is defined in this study by variation in CF shown in equation (1). However, due to the differing farm scales present in the data, using CF variation as a variable could lead to misleading results. The variation would depend highly on the farm's revenue potential and ultimately would bias the results by giving more weight to explanatory variables that best explain farm size. Thus, a variable for risk relative to a farm's revenue potential — a coefficient of variation (CV) — is computed. CV measures and compares farm risk as a dependent variable in El Benni, Finger, and Mann (2012) and an independent variable in Jetté-Nantel et al. (2011).

(2) Coefficient of $\text{Variation}_{\text{kf}}$: $\frac{\text{Standard deviation of cash flow}_{kf}}{\text{Average cash flow}_{kf}}$

For any period (k), the CF average and standard deviation are represented for farm f as,

(3) Average Operating Cash $\text{Flow}_{\text{kf}} = \sum_{k=t-n}^{n} \text{Operating Cash flow}_{kf} /$ n, or

(4) Standard Deviation of Operating Cash Flow_{kf} =

$$\sqrt{\frac{1}{n-1}\sum_{k}^{n}(\mathit{Operating}\ \text{cash flow}_{kf} - \overline{\text{Operating cash flow}_{kf}}\ )^2}$$

3.1.3 Return on Equity Variable Definition

The third measure, return on equity (ROE), measures financial efficiency. It provides insight into how efficiently a given operation utilizes owned capital to generate returns and evolve the farm business. It is calculated using the same CF measure defined in equation (1) resulting in cost-basis, not true, return on equity. For each period k, average ROE is calculated for each farm f using its average operating cash flow (CF), as described in equation (3), and average equity, which is calculated using the same procedure. ROE is expressed as,

(5) Average ROE_{kf}: $\frac{\text{Average operating cash flow}_{kf}}{\text{Average equity}_{kf}}$

3.1.4 Explanatory Variable Definitions

This analysis aims to examine farm enterprise diversification using the Herfindahl–Hirschman Index (HHI), a common measure of concentration (Lindbloom et al. 2022; Sharma P., 2025). The HHI for farm f in period k is measured as the sum of squared revenue shares of enterprise *i*. This measure and ROE use the same methodology. Each revenue stream's average revenue is calculated using equation (3), and then, the share of each average revenue stream is taken relative to total revenue. Each of these average revenue stream shares (the number of revenue streams denoted by *m*) for period *k* is then utilized in computing equation (6) rather than taking the average HHI of each individual year in the period.

$$(6) \quad \mathrm{HHI}_{kf} = \sum_{k=\mathrm{t-n}}^{m} \text{Revenue share}_{ik}^{2}$$

This creates an index from 1 to 1/m. An HHI value of 1 indicates the farm generates all revenue from one enterprise (i.e., perfectly specialized). A value of 1/m indicates a farm generates revenue evenly throughout each enterprise (i.e., perfectly diversified).

Scale is measured as average assets over any period *k*. Assets are scaled to $100,000 to ease the interpretation of coefficients in the modeling. The average assets in the period are calculated using equation (3) and then scaled back to $100,000s.

$$(7) \quad \text{Assets}_{kf} = \frac{\text{Average Assets}_{\mathrm{kf}}}{100{,}000}$$

To capture managerial efficiency and account for revenues and expenses of financial performance, the expense ratio is included in each model. This variable is also accounted for in accordance with ROE, where the average of each metric of the ratio is averaged like in equation (3) and then summarized into equation (8) to produce the expense ratio for period *k*.

$$(8) \quad \text{Expense Ratio}_{kf} = \frac{\text{Average Farm Expenses}_{\mathrm{kf}}}{\text{Average Value of Farm Production}_{\mathrm{kf}}}$$

Additionally, operator age and government payments are included in the model, consistent with Purdy et al. (1997). Operator age is added as a constant to factor for noise from aggression, risk tolerance, and so forth. Government payments are added to capture the changing nature of government funds distribution throughout the timeline analyzed and measure how the payments have changed in significance to producers. Both variables are defined in the dataset with respect to equation (3).

To account for financial leverage, the final variable specified is the debt-to-asset ratio. It signals how levering farm assets affects financial risk and performance. This ratio is computed similarly to ROE and the expense ratio. The defining terms are summarized in the period using equation (3) and then delineated in the term in equation (9).

$$(9) \quad \text{Debt to Asset}_{\text{kf}} = \frac{\text{Average Liabilities}_{\text{kf}}}{\text{Average Assets}_{\text{kf}}}$$

Once each of the variables are computed for each farm in each period, the results for all farms in a specified region (*r*) are averaged. This creates a regional average farm for each period analyzed. Following this, the differences between each farm's variables and the specified regional averages are taken. The resulting values indicate how a farm performed relative to other farms in its region. This centering adjustment is specified as follows:

$$(10) \quad \widehat{\text{Variable}}_{\text{kfr}} = \text{Variable}_{\text{kfr}} - \overline{\text{Variable}}_{\text{kr}}$$

To interpret the values that compare each farm to the regional average, a value near zero suggests the farm is close to average in the region, a negative value indicates the farm is below average in any given metric relative to other regional farms, and a positive value indicates the opposite.

3.2 Models

This analysis employs 43 regression models for each financial performance metric. Each regression represents the variables specified as the period (*k*) of year *t* and *n* number of years prior. Changes in coefficients will be analyzed to identify industry changes over time and assess whether the previously outlined trends (e.g., specialization and consolidation) have been motivated by the effects shown in these models.

Three models are specified below. A separate model for CV, CF, and ROE as the dependent variables are estimated with otherwise identical right-side parameters also defined previously.

Equation 1 – Operating Cash Flow Coefficient of Variation Model

$$(\widehat{\text{Coef Var}}_{\text{kfr}}) = \beta_{0k} + \beta_{1k}\widehat{\text{HHI}}_{\text{kfr}} + \beta_{2k}\widehat{\text{Assets}}_{\text{kfr}} + \beta_{3k}\widehat{\text{DAR}}_{\text{kfr}} + \beta_{4k}\widehat{\text{Operator Age}}_{\text{kfr}} + \beta_{5k}\widehat{\text{Expense Ratio}}_{\text{kfr}} + \beta_{6k}\widehat{\text{Gov Pay}}_{\text{kfr}}$$

Equation 2 – Operating Cash Flow Model

$$\widehat{\text{Cash Flow}}_{\text{kfr}} = \beta_{0k} + \beta_{1k}\widehat{\text{HHI}}_{\text{kfr}} + \beta_{2k}\widehat{\text{Assets}}_{\text{kfr}} + \beta_{3k}\widehat{\text{DAR}}_{\text{kfr}} + \beta_{4k}\widehat{\text{Operator Age}}_{\text{kfr}} + \beta_{5k}\widehat{\text{Expense Ratio}}_{\text{kfr}} + \beta_{6k}\widehat{\text{Gov Pay}}_{\text{kfr}}$$

Equation 3 - Return on Equity Model

$$\widehat{\text{ROE}}_{\text{kfr}} = \beta_{0k} + \beta_{1k}\widehat{\text{HHI}}_{\text{kfr}} + \beta_{2k}\widehat{\text{Assets}}_{\text{kfr}} + \beta_{3k}\widehat{\text{DAR}}_{\text{kfr}} + \beta_{4k}\widehat{\text{Operator Age}}_{\text{kfr}} + \beta_{5k}\widehat{\text{Expense Ratio}}_{\text{kfr}} + \beta_{6k}\widehat{\text{Gov Pay}}_{\text{kfr}}$$

In these equations, *r* indicates the farm is centered around the regional average, *k* indicates the time period in which the model is specified, and *f* designates the farm specified.

Coefficient β_{1k} is the coefficient value for the HHI term in period *k* (*k* = 1982 – 2024). HHI is expected to have a positive effect on the CV — inherently increasing risk as farms get more specialized. This is consistent with the economies of scope and portfolio risk theory. Over time, this coefficient is expected to decrease in value (move toward zero), meaning that diversification becomes a less effective at managing risk and that farms have become more homogeneous in their enterprise structures. This hypothesis is derived from the shift away from farm enterprise diversification. However, HHI has an expected positive relationship with CF and ROE (Purdy et al., 1997; El Benni et al., 2012). Farms have moved toward specialization over time, and assuming that all farms are profit-maximizing firms, their decisions must be rooted in the idea that greater profits can be expected if they specialize.

Coefficient β_{2k} is the coefficient value for assets or scale in period k. Assets are expected to have a negative impact on the CV and increase in value over time. This hypothesis is drawn from farms growing bigger and larger farms reporting better risk-adjusted returns. As the gap widens between large farms and small farms, this effect is expected to increase in magnitude. Assets are also expected to have a positive impact on CF. As operators invest more, they should expect higher net returns. Assets are similarly expected to have a positive impact on ROE.

Coefficient β_{3t} is the coefficient value for leverage in period k. It is expected to be positive as farms with high leverage inherently take on more financial risk, and it is expected to vary according to interest rates. When interest rates are high, highly leveraged farms will be penalized heavily, but if interest rates are low, farms will not be penalized as harshly. The effect of leverage on CF is expected to be positive as well. As farm leverage increases, higher returns should be expected. A positive effect is also expected for ROE. One reason is in tandem with the previous note that farms should expect higher returns if they leverage their assets, but also, as debt increases, equity declines. Combined, these two points lead to the assumption that ROE will positively benefit.

Coefficient β_{4t} is the coefficient value of operator's age in period k. This is expected to have a negative value because operators who have had longer farming careers are thought to be more experienced, more established, and less aggressive. Those features would decrease the amount of CF risk they accept. However, it is hypothesized that more established farms expect a higher CF, resulting in a positive coefficient in those models. Older operators are expected to have lower ROE because they may have less debt. With less debt and high equity values, ROE will fall. In more recent years, average farm operator age has increased. Given this trend, we assume an amplified magnitude of the coefficient's value.

Coefficient β_{5t} is the coefficient value for the expense ratio in period k. It is expected to have a positive effect on risk. The expense ratio is also expected to negatively impact CF, which will inherently decrease when expenses increase relative to revenue. We make the same assumption for the expense ratio's effect on ROE. It is unclear how this effect will change over time, but changes in this metric's impact will indicate how important it is for operators to manage their expenses relative to average.

Coefficient β_{6t} is the parameter value for government payments. The structure of government payments consistently changed throughout the data sample period. Changes in this parameter may suggest whether participation in these programs has been beneficial. Government payments are expected to have a negative effect on the CV. Additionally, following the same line of thinking, these payments should positive affect CF and ROE. Earlier in the dataset, the effect would be expected to be higher as programs had more of an "opt-in nature." As payments moved toward being extended more on an ad hoc basis, this effect is expected to diminish as all neighboring farms should receive relatively the same number of payments.

Table 3.3.1: Coefficient of Variation Relative Risk Models' Expected Effects

Expected Signs of Coefficients – Coefficient of Variation Models	
Variable	**Sign**
HHI	+
Assets	-
Debt-to-Asset Ratio	+
Operator Age	-
Expense Ratio	+
Government Payments	-

Table 3.3.2: Operating Cash Flow Models' Expected Effects

Expected Signs of Coefficients – Operating Cash Flow Models	
Variable	**Sign**
HHI	+
Assets	+
Debt-to-Asset Ratio	+
Operator Age	+
Expense Ratio	-
Government Payments	+

Table 3.3.3: ROE Models' Expected Effects

Expected Signs of Coefficients – ROE Models	
Variable	**Sign**
HHI	+
Assets	+
Debt-to-Asset Ratio	+
Operator Age	-
Expense Ratio	-
Government Payments	+

3.3 Determining Relative Effects of Parameters

In addition to determining trends for each independent variable of interest as well as their signs, it is also important to note which variables have the greatest effects on each financial performance indicator. Two tests are employed. First, simply analyze the standard error and confidence intervals of the coefficients produced by the models. This will indicate whether the coefficients statistically differ from zero over time and whether the confidence in statistical significance changes over time. This indicates the model's significance and whether the variables themselves at an individual level matter in determining a performance measure's outcome.

The other approach is to rank explanatory variables to determine their relative importance in explaining dependent variable variation. Standardized regression coefficients (standardized betas) are employed (Bring, 1994). These coefficients rescale the estimated regression parameters, so the effects of variables measured in different units can be directly compared by changes of one standard deviation.

The standardized beta for variable $\hat{X}_{kr}$ is defined as

$$(11)\quad \beta^{*}_{xk} = \beta_{xk} * \frac{SD\ (\hat{X}_{kr})}{SD\ (\hat{Y}_{kr})}$$

where β_{xk} is the estimated regression coefficient for a given explanatory variable $\widehat{X_{kr}}$, $\widehat{Y_{kr}}$ is the dependent variable, and SD represents the standard deviation. The resulting standardized coefficient, β^{*}_{xk}, represents the expected change in the dependent variable associated with a one standard deviation change in the explanatory variable.

Because standardized coefficients are expressed in the common unit of standard deviations, they are unit-free and can, therefore, be directly compared across regressors within the same equation. The magnitude of the standardized beta reflects the relative strength of the relationship between each explanatory variable and the dependent variable, conditional on the other variables included in the model.

Using these standardized coefficients, a ranking procedure is implemented to evaluate the relative importance of each explanatory variable compared with other variables in the model's specification. For each year, regressors are ranked according to the absolute magnitude of their standardized betas; larger values indicate greater explanatory importance. This ranking framework allows for identifying variables that contribute most strongly to explaining each financial performance indicator each year. Furthermore, by comparing these rankings across years, it is possible to examine how the relative importance of explanatory factors changes over time, including shifts in average rank and movements in rank positions for each regressor.

Chapter 4 - Data

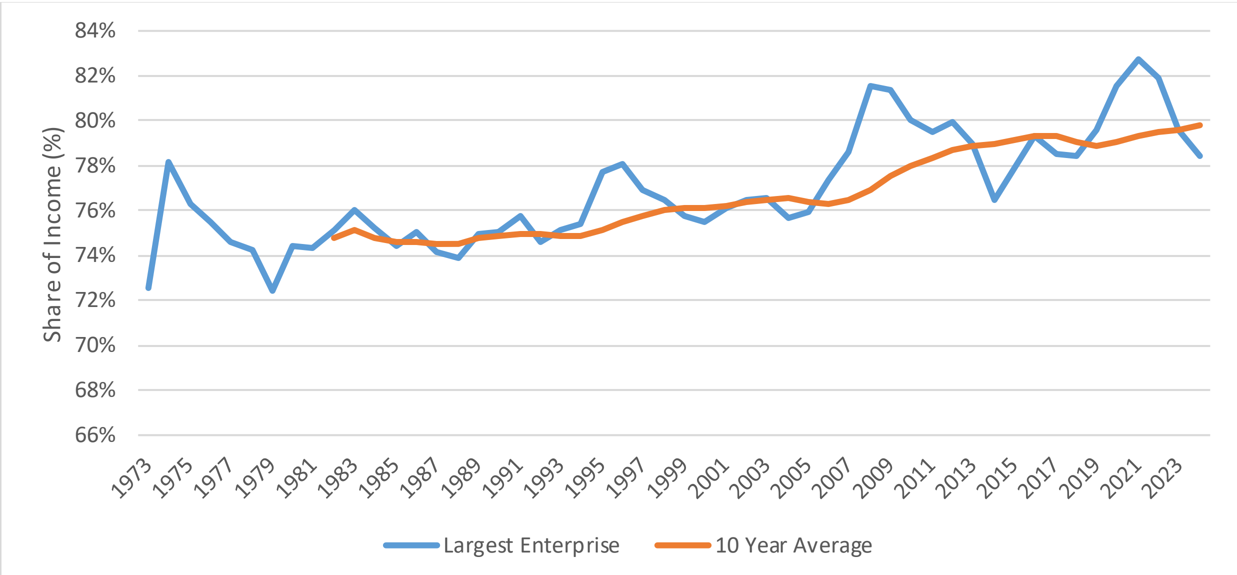
The Kansas Farm Management Association (KFMA) provides member farms across the state with production and financial management services and information to help them make more informed decisions. It offers services such as accounting support, consulting, and estate planning assistance. Founded in 1931, the association is a joint program between the Kansas State University Department of Agricultural Economics and K-State Research & Extension. The partnership grants the department access to data for research and detailed farm-level financial analysis. For each KFMA farm, the dataset includes more than 2,000 variables and metrics calculated each year. Recognizing Kansas' geographic and agricultural diversity, KFMA breaks the state into six regions. Farm-level data can be pooled by region to observe regional changes in farm characteristics. Figure 1.1 shows the counties grouped into the six associations (Kansas State University Department of Agricultural Economics, n.d.).

4.1 Trends in Agriculture

To evaluate changes in farm consolidation, this analysis uses data from 1973 to 2024 — a 52-year period with multiple financial cycles affecting farm operations. During a long period of analysis such as this one, trends clearly emerge over time. During shorter time periods, one-off events may more heavily bias results and conclusions.

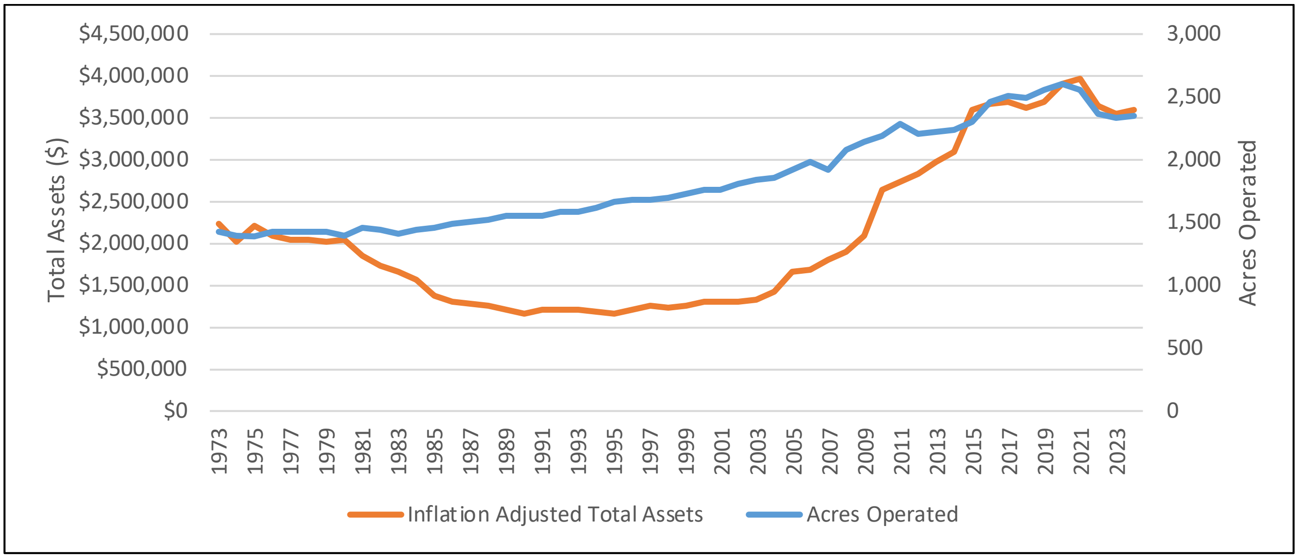
KFMA data allow for monitoring diversification using a few metrics. Figure 4.1.1 shows the extent to which farms have specialized their enterprise portfolios by presenting the average share of farm revenue generated by a farm's largest enterprise (i.e., crop, livestock, or other). To smooth year-to-year exogenous deviations, a 10-year rolling average is also computed. During the past 50 years, specialization on KFMA farms has trended upward by 6- to 8-percentage-points. Note, the vertical axis scale in Figure 4.1.1 is enhanced to highlight this trend. Because this measure is an average for up to 450 farm operations, an 8-percentage-point increase on average indicates many farms increasingly specialized in crops or livestock over time.

Figure 4.1.1: Income Share of Farms' Largest Enterprise, 1973-2024



With respect to measuring farm scale, the coffee shop measure is the number of acres operated. Acres represent a biased metric because not all acres are created equal, especially across eastern to western Kansas and row-crop and beef cow operations. An alternative farm scale measure is total farm assets adjusted for inflation (Figure 4.1.2). Both metrics generally trend upward over time. Note the dip in total assets at the beginning of the 1980s. It potentially displays the farm financial stress sustained during this time as the agricultural economy deteriorated and asset values subsequently eroded.

Figure 4.1.2: Change in Farm Scale, 1973-2024



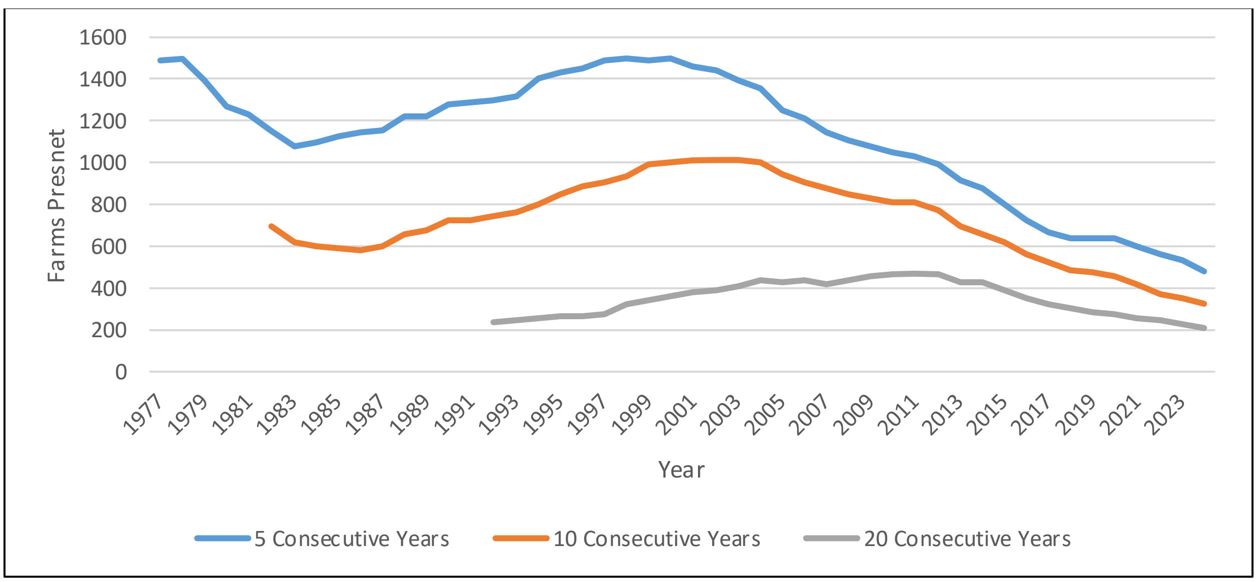
These two visuals suggest KFMA farms have become larger and more specialized. This motivates the theory that producers continually move in the direction of economies of scale and consolidation and away from enterprise diversification.

4.2 Data for Analysis

KFMA supplied data for the analysis. The total number of farms in its dataset has decreased over time due to factors such as farm consolidation and farms choosing to access services from providers other than KFMA. As a result, farms enter and leave the dataset over time — meaning data for individual farms may not be reflected in consecutive years. This is important because to determine a farm's financial risk, multiple years of data are needed to calculate the variance and mean for performance variables over time. Few farms are present in the KFMA dataset across all years (i.e., 1973 to 2024). Analyzing data for these farms alone would result in poor model specification and likely inefficient standard errors and biased coefficients.

To overcome this limitation, KFMA data can be broken into time periods — groups of consecutive years to compare with other periods across time. Periods can be defined as every year available in the data with a set number of years prior (e.g., if 10-year segments are assigned, then data from 1973 to 2024 would yield 43 periods beginning with 1973 to 1982 and ending with 2015 to 2024). A key factor is deciding how many years to include in an analysis period. Shorter periods (e.g., five years) would yield the most observations. However, the data would be influenced by economic cycles experienced during those periods, and variance measures could have wild swings. A 20-year period would smooth out the variation and generate a sample of how a farm performs across cycles, but it also significantly reduces the number of observations (i.e., farms) to analyze. Figure 4.2.1 shows the number of farms with data available in five-, 10-, and 20-year periods. Previous studies, especially those using KFMA data, tend to choose 10-year periods (Nivens, Kastens, Dhuyvetter, 2002; Purdy, Langemeier, & Featherstone, 1997).

Figure 4.2.1: Presence of Farms for Consecutive Years



Overall, the 10-year periods provide enough farm observations to perform the analysis at an aggregate level. However, to perform spatial analysis, sufficient data must be available for all six regions. Tables 4.1, 4.2, and 4.3 summarize the number of farms present by region over consecutive years for a given time. Most regions have satisfactory data for the five- and 10-year periods. The number of observations decreases substantially if using 20-year periods.

Table 4.1: Farms with Data Available for 5 Consecutive Years

	Total	North Central	South Central	Southwest	Northeast	Northwest	Southeast
min	**634**	104	53	16	96	34	144
max	**1497**	246	294	288	293	156	488
avg	**1193**	184	195	113	215	97	323

Table 4.2: Farms with Data Available for 10 Consecutive Years

	Total	North Central	South Central	Southwest	Northeast	Northwest	Southeast
min	**325**	56	33	8	75	17	92
max	**1013**	155	175	104	202	80	344
avg	**724**	120	127	58	144	48	227

Table 4.3: Farms with Data Available for 20 Consecutive Years

	Total	North Central	South Central	Southwest	Northeast	Northwest	Southeast
min	**209**	23	22	6	45	5	63
max	**469**	81	81	39	98	22	193
avg	**348**	60	58	21	72	16	120

Ten-year periods were chosen as the time period length, as supported by literature and data. To ensure data quality, each farm present in the dataset must meet further requirements. If a farm has data errors or missing values for the assets, liabilities, and net farm income variables, it is dropped from the period. The process is then repeated for every period from 1973-1982 to 2015-2024.

To minimize outliers due to data anomalies, the top and bottom 1% of the dependent variables were discarded prior to conducting the regional benchmarking and analysis.

4.3 Summary Statistics

See Figures 4.4, 4.5, and 4.6 for summary statistics. Partial statistics are displayed for each model specification. The tables display data for every 10th period to show overall trends. The means of each variable are at or near zero, indicating the regional average as computed in the regional analysis framework used. Negative values indicate a parameter for the farm is below the regional mean, and positive values indicate a farm's measure is above the regional mean. Each parameter is computed using formulas shared in Chapter 3.1. Additionally, Figures 4.1, 4.2, and 4.3 visualize the trend of each of the dependent variables prior to the regional adjustment. In the results section, each of the raw explanatory variables are visualized in the coefficient trend graphs to ease comparing results to industry trends.

Table 4.4: Summary Statistics for Regionally Adjusted Coefficient of Variation Models

Notes: Mean, SD, Min, and Max are computed on the estimation sample used in each year's regression (within-year trimming of *Coef Var* at the 1% and 99% quantiles, followed by listwise deletion on Region and all model variables, then region-demeaning within year (raw minus region mean). Values rounded to 2 decimals.

Variable	Stat	1984.0	1994.0	2004.0	2014.0	2024.0
N (estimation sample)		471	554	572	500	269
Coef Var	Mean	0.00	-0.00	-0.00	0.00	-0.00
	SD	0.55	0.60	0.84	0.45	0.57
	Min	-0.66	-0.55	-0.82	-0.55	-0.67
	Max	3.39	5.03	6.40	3.43	6.58
HHI	Mean	0.00	0.00	0.00	0.00	0.00
	SD	0.15	0.15	0.17	0.12	0.14
	Min	-0.28	-0.20	-0.32	-0.23	-0.27
	Max	0.36	0.43	0.39	0.39	0.32
Assets	Mean	0.00	0.00	-0.00	-0.00	-0.00
	SD	10.89	9.73	10.24	21.50	41.12
	Min	-21.69	-14.56	-12.59	-31.23	-47.19
	Max	49.78	51.28	87.94	214.35	257.98
Debt to Asset Ratio	Mean	0.00	0.00	-0.00	0.00	0.00
	SD	0.19	0.25	0.24	0.20	0.17
	Min	-0.32	-0.35	-0.32	-0.26	-0.22
	Max	0.76	0.63	0.70	0.71	0.62
Operators Age	Mean	-0.00	-0.00	-0.00	-0.00	-0.00
	SD	9.02	10.31	11.19	10.02	9.83
	Min	-24.89	-23.81	-28.19	-29.66	-33.82
	Max	20.89	29.52	30.08	29.85	20.41
Expense Ratio	Mean	0.00	-0.00	-0.00	0.00	0.00
	SD	0.12	0.12	0.17	0.20	0.23
	Min	-0.35	-0.33	-0.44	-0.43	-0.33
	Max	0.29	0.27	0.96	1.54	1.80
Gov Pay	Mean	0.00	0.00	-0.00	0.00	-0.00
	SD	12,293.12	30,879.05	34,110.35	29,609.01	51,236.59
	Min	-28,147.64	-75,686.20	-57,986.24	-60,110.24	-92,332.87
	Max	58,208.13	113,465.20	218,194.11	232,890.64	348,535.66

Note: Relative to average implies the regional adjustment has been performed in accordance with Chapter 3.2, forcing the average for each of the parameters to be at or near zero, below average value to be negative, and above average to be positive.

Table 4.5: Summary Statistics for Regionally Adjusted Operating Cash Flow Models

Notes: Mean, SD, Min, and Max are computed on the estimation sample used in each year's regression (within-year trimming of *Cash Flow* at the 1% and 99% quantiles, followed by listwise deletion on Region and all model variables, then region-demeaning within year (raw minus region mean). Values rounded to 2 decimals.

Variable	Stat	1984	1994	2004	2014	2024
N (estimation sample)		471	554	572	500	269
Cash Flow	Mean	-0.00	-0.00	0.00	-0.00	0.00
	SD	100,287.55	93,777.31	87,633.28	177,427.18	237,275.99
	Min	-150,323.05	-140,553.17	-109,693.39	-304,716.34	-302,641.17
	Max	380,297.48	346,467.22	341,754.30	685,408.52	1,307,106.08
HHI	Mean	0.00	-0.00	-0.00	0.00	-0.00
	SD	0.15	0.15	0.17	0.12	0.14
	Min	-0.27	-0.20	-0.33	-0.23	-0.27
	Max	0.36	0.43	0.39	0.39	0.32
Assets	Mean	-0.00	-0.00	-0.00	-0.00	0.00
	SD	10.50	9.50	9.02	15.87	34.37
	Min	-21.54	-14.56	-12.02	-24.08	-42.57
	Max	47.07	51.28	49.51	106.01	189.42
Debt to Asset Ratio	Mean	-0.00	-0.00	0.00	0.00	-0.00
	SD	0.19	0.25	0.24	0.19	0.17
	Min	-0.34	-0.35	-0.31	-0.25	-0.22
	Max	0.76	0.63	0.69	0.71	0.63
Operators Age	Mean	-0.00	0.00	0.00	-0.00	-0.00
	SD	9.00	10.34	11.15	10.02	9.85
	Min	-24.99	-23.95	-28.19	-29.69	-33.98
	Max	20.87	29.52	30.11	29.86	20.06
Expense Ratio	Mean	0.00	0.00	-0.00	0.00	-0.00
	SD	0.12	0.12	0.17	0.20	0.23
	Min	-0.36	-0.33	-0.44	-0.43	-0.33
	Max	0.29	0.27	0.96	1.54	1.79
Gov Pay	Mean	0.00	0.00	-0.00	-0.00	-0.00
	SD	12,516.31	30,900.04	31,701.06	27,498.95	44,618.69
	Min	-28,323.39	-75,686.20	-57,986.24	-55,439.10	-79,514.54
	Max	58,359.44	114,770.93	220,135.20	237,561.77	214,947.08

Note: Relative to average implies the regional adjustment has been performed in accordance with Chapter 3.2, forcing the average for each of the parameters to be at or near zero, below average value to be negative, and above average to be positive.

Table 4.6: Summary Statistics for Regionally Adjusted Cost Basis Return on Equity Models

Notes: Mean, SD, Min, and Max are computed on the estimation sample used in each year's regression (within-year trimming of *ROE* at the 1% and 99% quantiles, followed by listwise deletion on Region and all model variables, then region-demeaning within year (raw minus region mean). Values rounded to 2 decimals.

Variable	Stat	1984	1994	2004	2014	2024
N (estimation sample)		471	554	572	500	269
ROE	Mean	-0.00	0.00	0.00	-0.00	-0.00
	SD	0.09	0.17	0.18	0.10	0.07
	Min	-0.13	-0.20	-0.16	-0.14	-0.11
	Max	0.42	1.22	1.21	0.42	0.29
HHI	Mean	0.00	-0.00	-0.00	0.00	-0.00
	SD	0.15	0.15	0.17	0.12	0.14
	Min	-0.27	-0.20	-0.32	-0.23	-0.27
	Max	0.36	0.43	0.39	0.38	0.32
Assets	Mean	0.00	-0.00	0.00	-0.00	0.00
	SD	10.79	10.18	10.24	21.48	41.01
	Min	-21.54	-14.26	-12.56	-31.23	-47.81
	Max	49.77	66.24	87.96	214.35	257.98
Debt to Asset Ratio	Mean	-0.00	-0.00	0.00	0.00	-0.00
	SD	0.18	0.24	0.23	0.19	0.16
	Min	-0.34	-0.35	-0.31	-0.24	-0.21
	Max	0.57	0.63	0.69	0.62	0.49
Operators Age	Mean	0.00	-0.00	0.00	0.00	-0.00
	SD	8.98	10.16	11.19	9.93	9.72
	Min	-25.15	-23.89	-28.49	-29.91	-33.71
	Max	20.96	27.21	30.29	29.82	20.41
Expense Ratio	Mean	0.00	-0.00	-0.00	0.00	0.00
	SD	0.12	0.12	0.17	0.20	0.23
	Min	-0.36	-0.33	-0.44	-0.43	-0.33
	Max	0.30	0.30	0.96	1.54	1.80
Gov Pay	Mean	-0.00	-0.00	-0.00	-0.00	-0.00
	SD	12,451.56	31,375.82	33,816.54	29,667.55	50,954.93
	Min	-27,591.77	-76,394.96	-57,720.65	-60,110.24	-92,332.87
	Max	58,354.06	112,852.58	218,975.69	232,890.64	348,535.66

Note: Relative to average implies the regional adjustment has been performed in accordance with Chapter 3.2, forcing the average for each of the parameters to be at or near zero, below average value to be negative, and above average to be positive.

Figure 4.1: Unadjusted (Raw) Average Coefficient of Variation Variable Trend

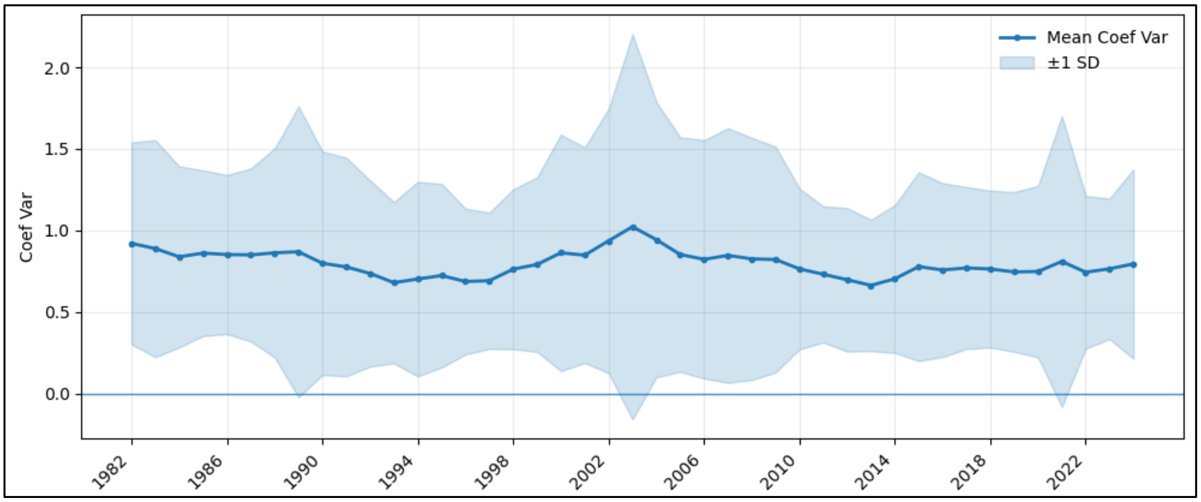


Figure 4.2: Unadjusted (Raw) Average Operating Cash Flow Variable Trend

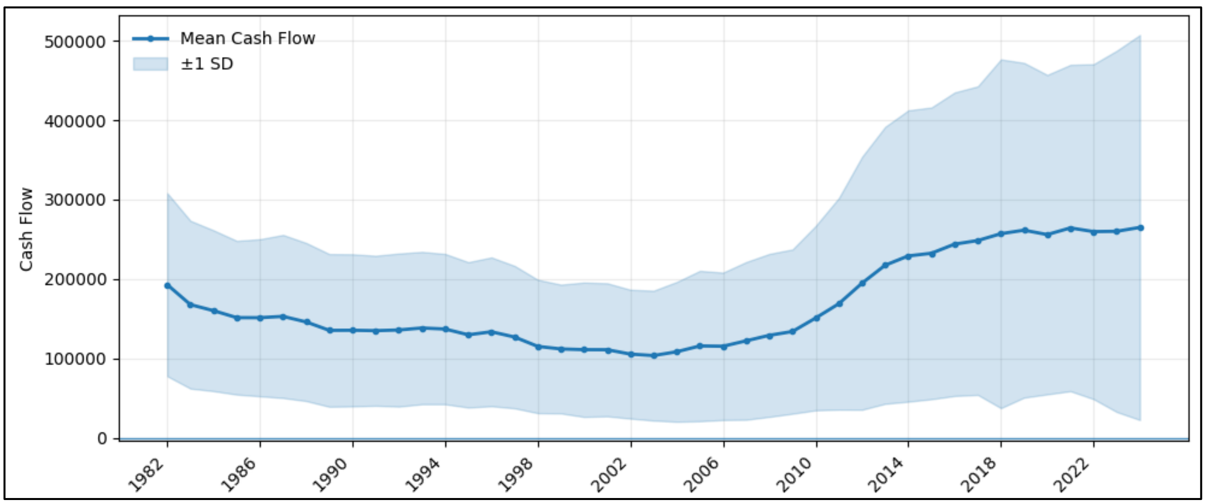
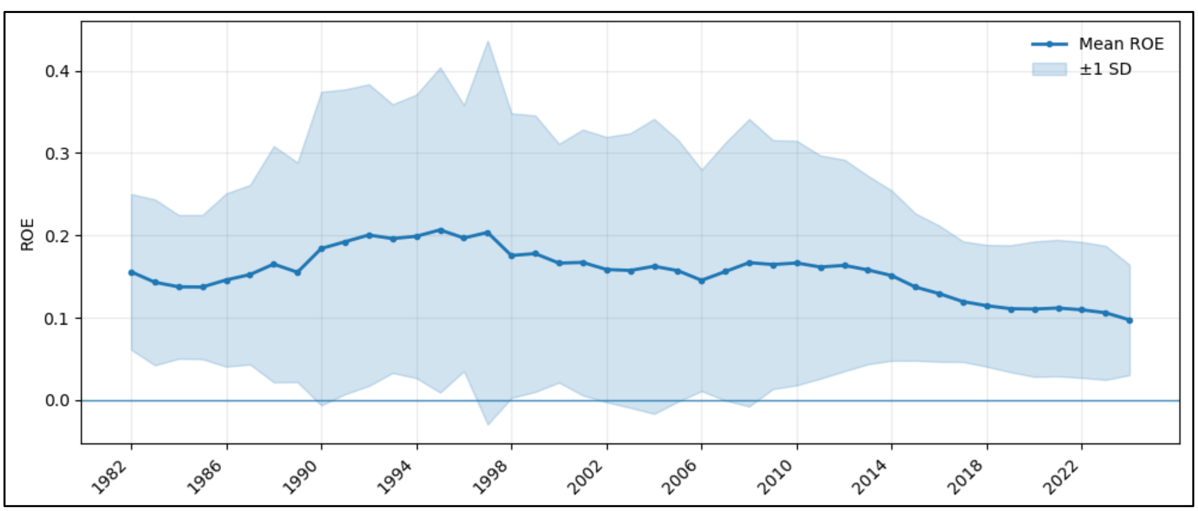


Figure 4.3: Unadjusted (Raw) Average Cost Basis Return on Equity Variable Trend



Chapter 5 - Results

The results that follow are organized by the dependent variable measured. They start with the CV models measuring financial risk, are followed by the CF models measuring financial performance, and conclude with the ROE models measuring financial efficiency. Each subchapter provides coefficients of the variables in question by period, bound by a 95% confidence interval and tracked through each period in the set. Then, variable significance ranking diagnostics show which variables have the largest effects and which effects have strengthened or weakened in relative significance through time.

Models were estimated in Python with coding completed in Google Collaboratory. The ordinary least squares estimator was used. Due to concerns about errors being correlated across farm operations, robust models were estimated with the HC1 heteroskedasticity-consistent covariance estimator (MacKinnon and White, 1985).

Prior to model estimation, the top and bottom 1% of outliers were removed from the data as determined by the top and bottom 1% of the dependent variable. This was completed before the regional difference calculation.

For each of the three model specifications (i.e., CV, CF, and ROE), 43 models were estimated. Each model reflected data for a 10-year period. Graphical representation conveys the size and trend of each coefficient, and confidence bands communicate the statistical significance of each time-varying coefficient. This results in each graphed point representing a coefficient value for the period with the period's last year being the year defined in the x-axis. These visuals also report the average, non-regionally adjusted value in each period for each explanatory variable, banded by its standard deviation. This is meant to compare the coefficient trend to the raw value trend present throughout the dataset.

Each subsection reports an *R-square* value for the 43 time periods analyzed to more simply visualize changes in coefficient values and significance. We then estimate the model's F-statistic each year, invert the noncentral F distribution to obtain a confidence interval, and transform that interval into a confidence interval for the *R-square*. These values are computed in confidence interval bands around each *R-square* trend.

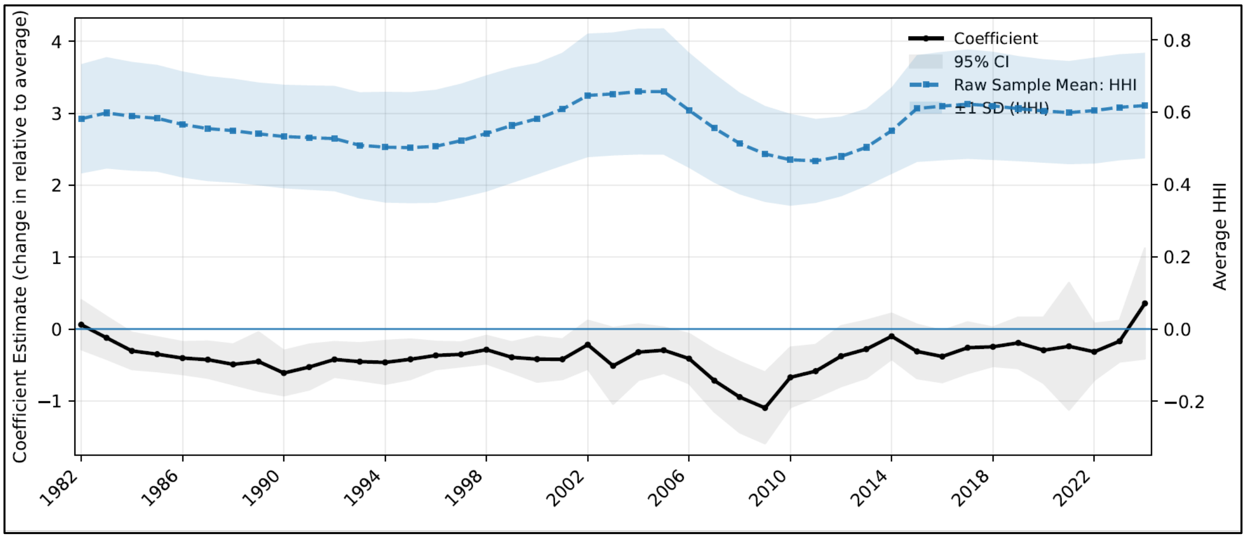
5.1 Coefficient of Variation Model Results

The coefficient of variation (CV) models determine farm financial risk. The relative impact of HHI on relative CV is presented in Figure 5.1. A 1-percentage-point increase in relative HHI has a negative effect on relative CV. For example, the model for the period ending in 2008 indicates that a 1-percentage-point increase in HHI relative to the average decreases relative CV by approximately 1 percentage point relative to average.

This result is opposite the hypothesized effect. It suggests that increased enterprise specialization (i.e., higher HHI) is associated with lower relative CV. Most coefficient estimates are statistically different from zero as the 95% confidence interval bands largely do not include zero. However, the magnitude has neared zero in more recent years, and significance of the coefficient has declined as the bands now include zero. This is possibly due to farms within a region becoming more homogeneous in enterprise structure, making smaller differences in HHI across farms and having a muted impact on relative CV.

Overall, the results suggest that the observed shift toward enterprise specialization may be justified from a financial risk perspective, despite the initial hypothesis that specialization would increase the CV.

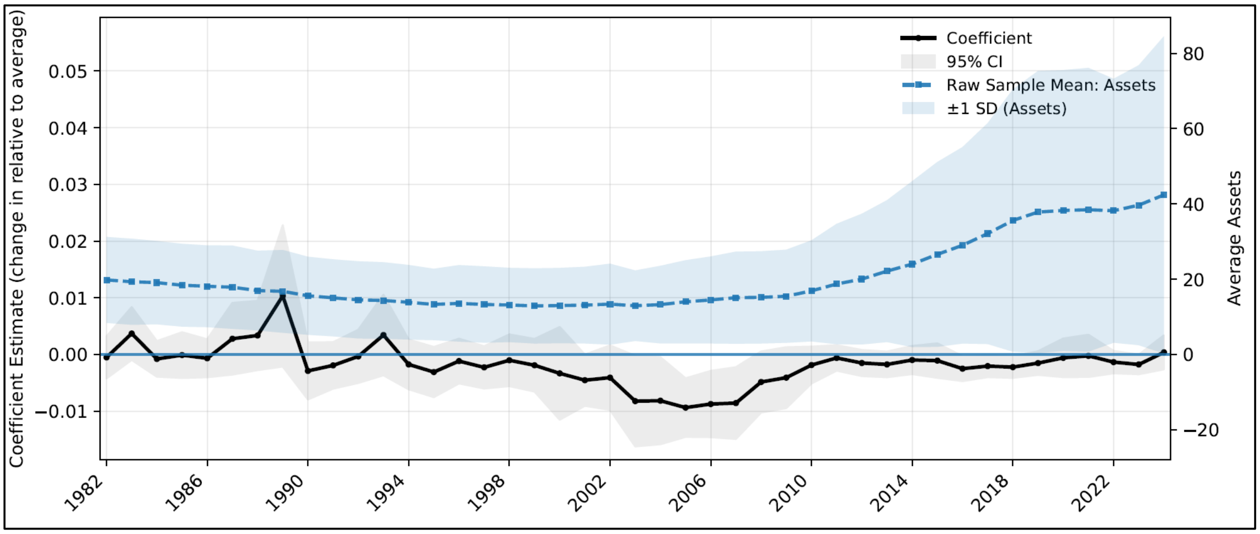
Figure 5.1: Percentage Change in Relative-to-Average Coefficient of Variation from a 1-Percentage Point Change in the Relative-to-Average HHI and Raw Average of Variable
(shaded areas represent 95% confidence intervals)



The asset coefficient represents the effect of a $100,000 change in assets compared to the average on the change in relative CV. As an example, for the period ending in 2006, a $100,000 increase in relative assets leads to a 1 percentage point decrease in CV relative to average. The asset coefficient is largely statistically insignificant across the sample period, except for a short window in the early 2000s when the coefficient is negative and statistically significant.

During this period, the negative coefficient is consistent with the economic theory of economies of scale, indicating that an increase in farm assets leads to a decrease in relative CV. However, the lack of statistical significance across most of the timeline was not expected. This suggests factors other than scale play a larger role in determining a farm's relative financial risk.

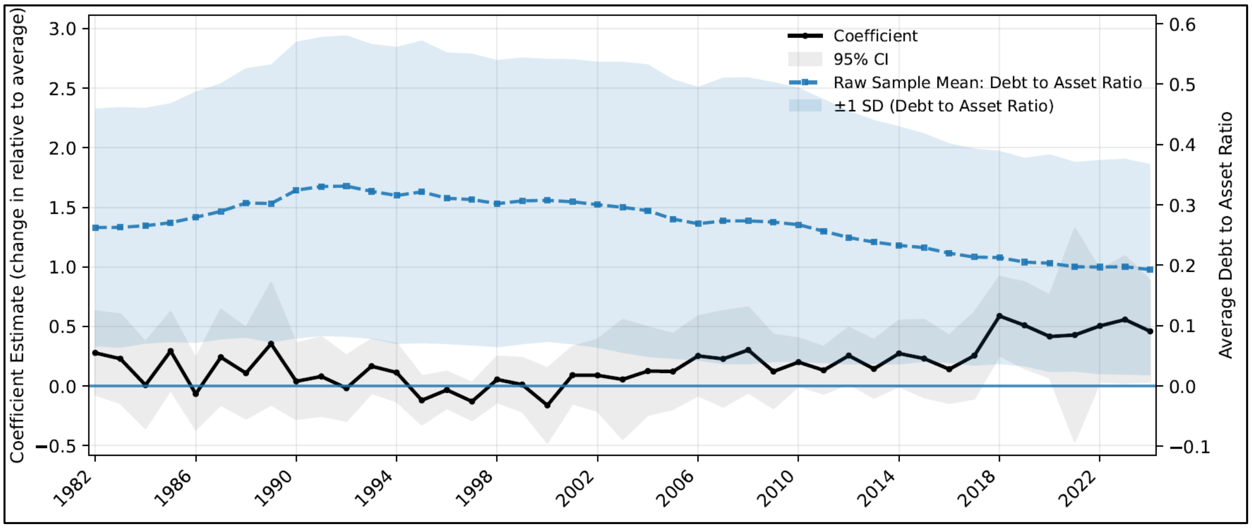
Figure 5.2: Percentage Change in Relative-to-Average Coefficient of Variation from a $100,000 Change in Relative to Average Assets and Raw Average of Variable (shaded areas represent 95% confidence intervals)



Since 2000, a 1-percentage-point change in relative-to-average leverage has had a positive relationship with relative CV (Figure 5.3). This indicates that as relative leverage increases, relative financial risk also increases. For example, in the period ending in 2022, the estimated coefficient suggests that a 1-percentage-point increase in leverage relative to average results in a 0.5-percentage-point increase in CV relative to average.

This result is consistent with expectations. Farms with debt assume higher financial risk. The coefficient is largely insignificant throughout time — outside of a few significant periods. Overall, the positive and increasing trend suggests that managing farm debt and leverage is increasingly important for controlling financial risk.

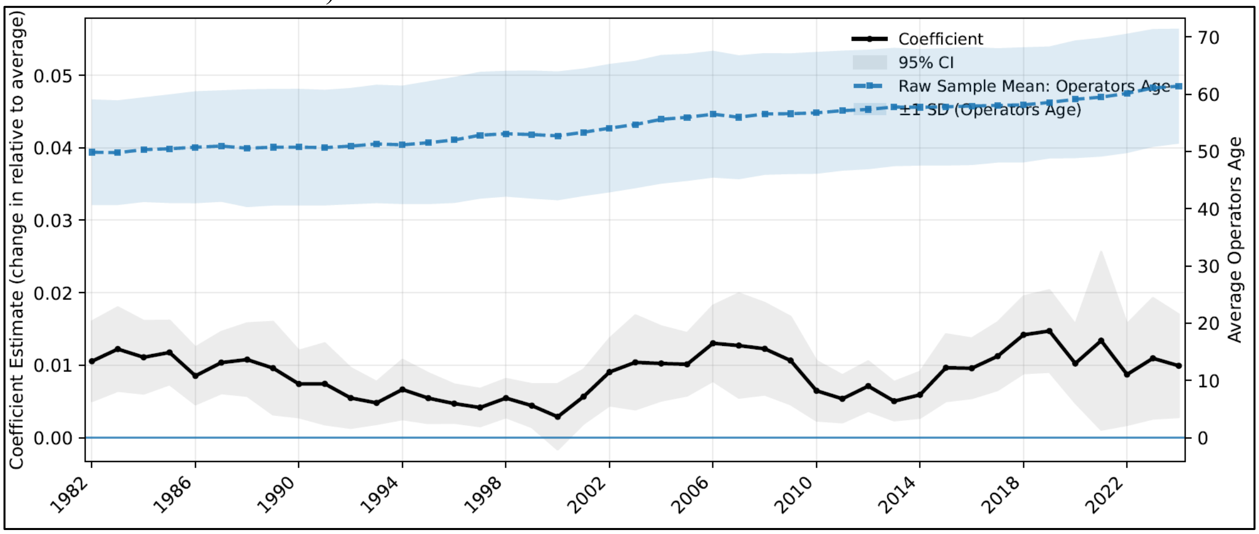
Figure 5.3: Percentage Change in Relative-to-Average Coefficient of Variation from a 1-Percentage-Point Change in Relative-to-Average, Cost-Basis Debt-to-Asset (Leverage) Ratio and Raw Average of Variable (shaded areas represent 95% confidence intervals)



A one-year change in relative-to-average operator age has a positive and statistically significant relationship with relative CV throughout the study period (Figure 5.4). This indicates that older operators experience higher relative financial risk, which is opposite of the expected relationship. Older business owners are generally assumed to be more risk-averse and, therefore, expected to maintain lower financial risk levels. That said, older operators tend to have greater equity to absorb financial risk and may accept higher financial risk if it means they can make decisions based on personal choice more so than business choice.

One potential concern with this finding is that the operator age variable may be capturing a time trend effect rather than purely managerial behavior. In this case, the positive coefficient may reflect that farming has become relatively riskier since the early 2000s, which was a period marked by significant changes in government farm programs.

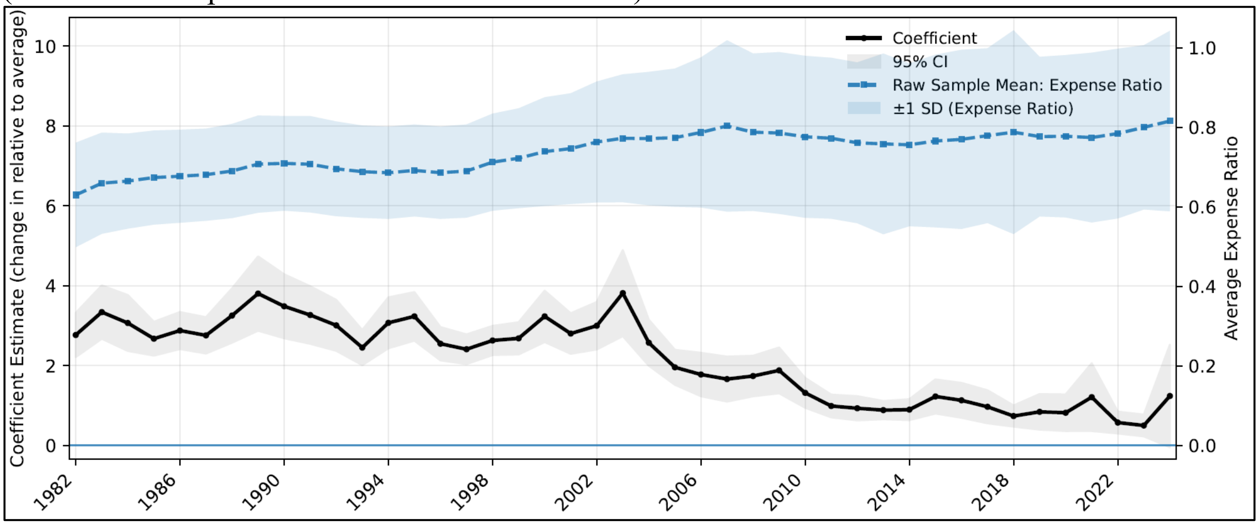
Figure 5.4: **Percentage Change in Relative-to-Average Coefficient of Variation from a One1-Year Change in Operator Age and Raw Average of Variable** (shaded areas represent 95% confidence intervals)



Relative-to-average expense-to-revenue ratio coefficients are presented in Figure 5.5. The coefficient is positive and statistically significant throughout the study period, indicating that a 1-percentage-point increase in the relative-to-average expense-to-revenue ratio results in a higher relative CV. For example, in the period ending in 2005, a 1-percentage-point increase in the relative expense-to-revenue ratio results in a 2-percentage-point increase in relative CV.

This result is consistent with expectations. However, the coefficient's absolute magnitude has declined since the mid-1990s, suggesting that the relative expense-to-revenue ratio may be less influential today than in earlier periods. Despite this decline, the results clearly indicate that managing the expense-to-revenue ratio remains an important determinant of a farm's operating cash flow risk. This point adds to the findings by Nivens, Kastens, and Dhuyvetter (2002) that cost-conscious managers generate higher and more consistent profits.

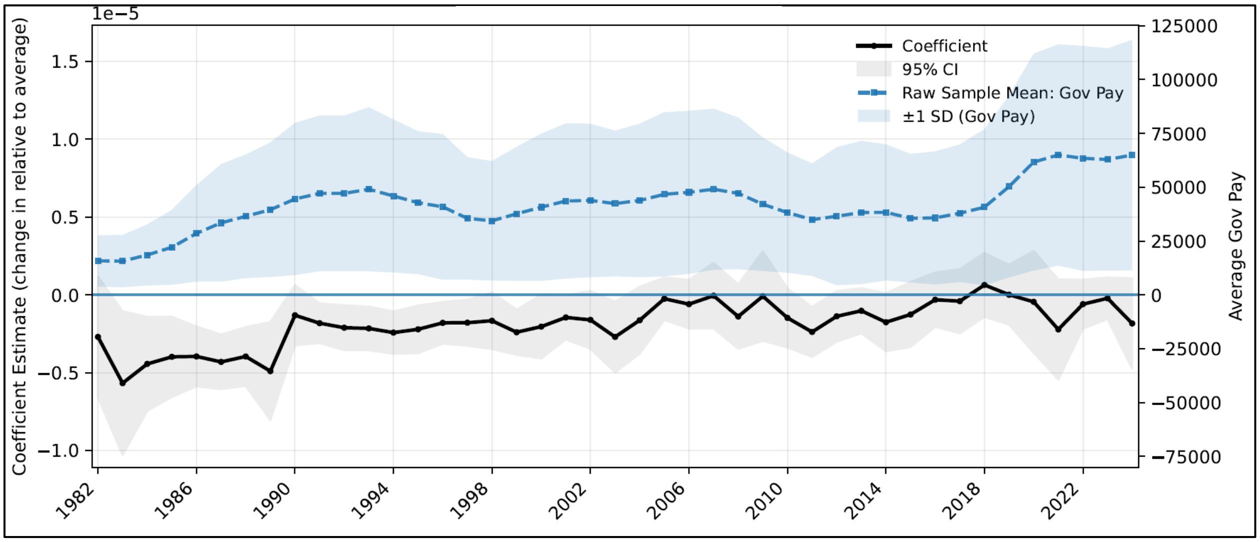
Figure 5.5: Percentage Change in Relative-to-Average Coefficient of Variation from a 1-Percentage-Point Change in the Expense-to-Revenue Ratio and Raw Average of Variable (shaded areas represent 95% confidence intervals)



The relative-to-average government payment coefficients are presented in Figure 5.6. The negative coefficient indicates that farms receiving relatively higher government payments experience lower relative CV. This result is consistent with expectations. Government payments intend to provide income support that reduces cash flow variability and lowers financial risk.

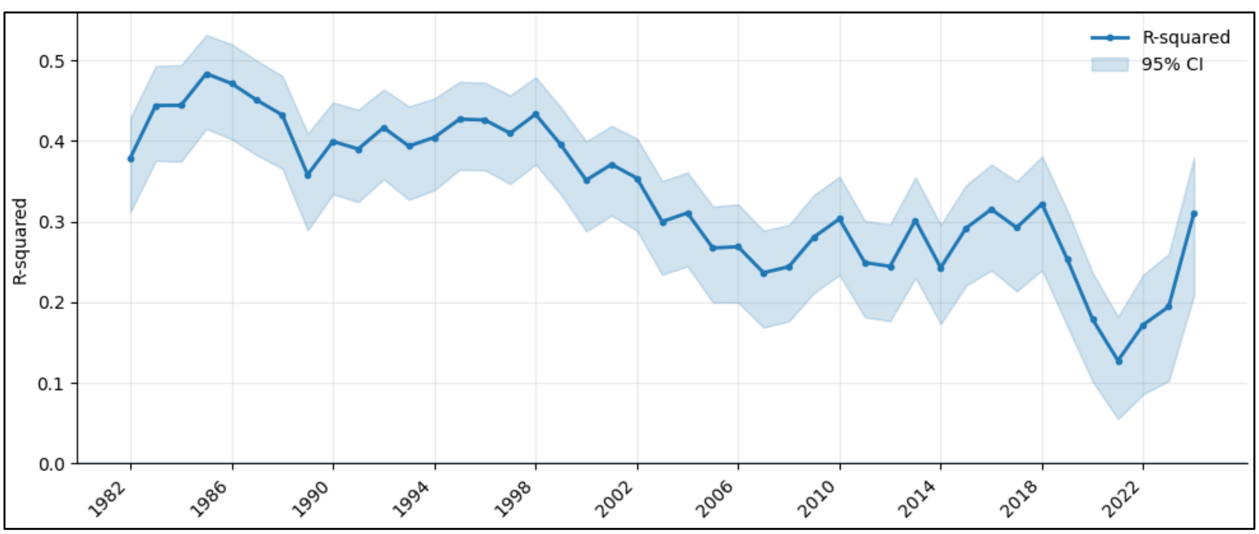
However, the coefficient is not statistically significant during the final 20 years of the study, suggesting that government payments may play a smaller role in stabilizing relative CV in more recent periods. This finding is consistent with the change in farm policy occurring in 1996 under the Freedom to Farm Act and is further supported by recent farm policy focused on ad hoc payments allocated on an as-needed basis.

Figure 5.6: Percentage Change in Relative-to-Average Coefficient of Variation from a Dollar Change in the Amount of Government Payments Received Relative to Average and Raw Average of Variable (shaded areas represent 95% confidence intervals)



The R-square trend indicates how well this model's specification explained variation in the dependent variable. The declining value in later years traces and correlates back to the widening standard errors and confidence interval in each of the variables described above.

Figure 5.7: R-Square Trend Relative to Average Coefficient of Variation Models



Next, the standardized beta ranking sequence is presented in Figure 5.8 and Table 5.1. The table indicates ranking by absolute value or total effect of the variables; displayed first is the average rank over the entire timeline. The second column displays the average rank in the first 20 periods of the timeline, and the third column displays the average rank in the last 20 periods of the timeline. To show how variable importance has changed, the fourth column is the difference between the second and third columns. The figure shows the same trends by visualizing the absolute value of the standardized coefficients.

Based on the graphical and tabular representations of the standardized betas, evidence suggests that the relative expense-to-revenue ratio is the most important determinant of financial risk. Although the expense-to-revenue ratio standardized coefficient declines over time, no other variable has more significance. The change column shows assets and the leverage ratio increased in rank, and relative HHI declined in rank. Government payments, however, had the sharpest decline in rank. Relative operator age moved little in importance over time.

Figure 5.8: Absolute Value of Standardized Betas for Relative-to-Average Coefficient of Variation Models

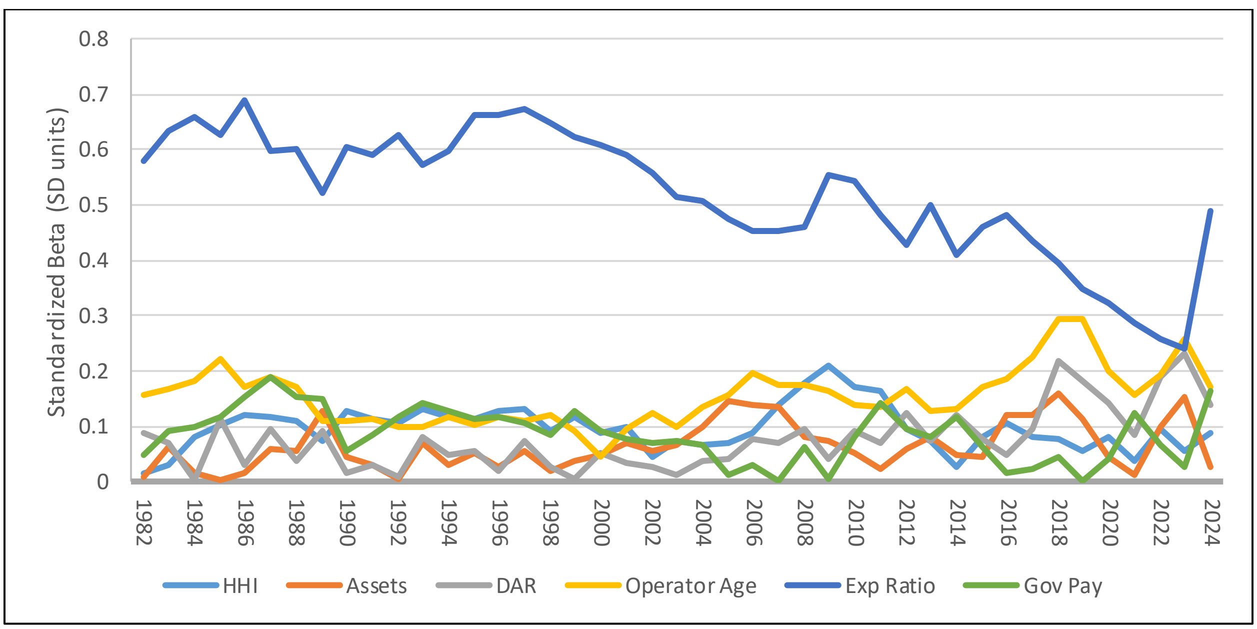


Table 5.1: Standardized Beta Rank Summary for Relative-to-Average Coefficient of Variation Models

Rank Summary by Coefficient - Coef Var				
Coefficient	*Avg Rank*	*First 20 Period Avg*	*Last 20 Period Avg*	*Rank Change*
HHI	3.8	3.5	4.1	-0.6
Assets	4.9	5.5	4.5	1.0
Debt to Asset	4.7	5.1	4.1	1.0
Operator Age	2.6	3.1	2.2	0.9
Expense Ratio	1.0	1.0	1.1	-0.1
Gov Pay	4.0	3.0	5.2	-2.2

The relative-to-average CV model paints an interesting story of changes in agriculture during the past 50 years. The coefficient sign of relative HHI suggests that a farm being more specialized relative to average decreases its relative financial risk. During the first 20 years of the analysis, it had an average rank of 3.5. Additionally, the increasing importance of assets and leverage gives further insight into the consolidation trend and farms using optimal leverage to manage asset growth. Managing expenses relative to revenue is an important factor in managing financial risk.

5.2 Operating Cash Flow Model Results

The CF models capture effects on a farm operation's cash availability. The relative HHI coefficient is generally positive (Figure 5.9), indicating that as farms become more specialized, relative CF increases. For example, for the period that ends in 2000, a 1-percentage-point increase in relative HHI results in an approximate $1,000 increase in relative CF. The coefficient is statistically different from zero across the entire study period.

Although the coefficient fluctuates in cycles, it does not show a sustained trend in either direction over extended periods. That said, note the widening confidence interval bands. The coefficient has become noisier in more recent years.

The positive sign of this coefficient is consistent with expectations and supports previous literature (Purdy et al., 1997). These results further support the trend toward greater enterprise specialization outlined in the introduction and supported in the CV models.

Figure 5.9: Dollar Change in Relative-to-Average Operating Cash Flow from a 1-Percentage-Point Change in the Relative-to-Average HHI and Raw Average of Variable
(shaded areas represent 95% confidence intervals)

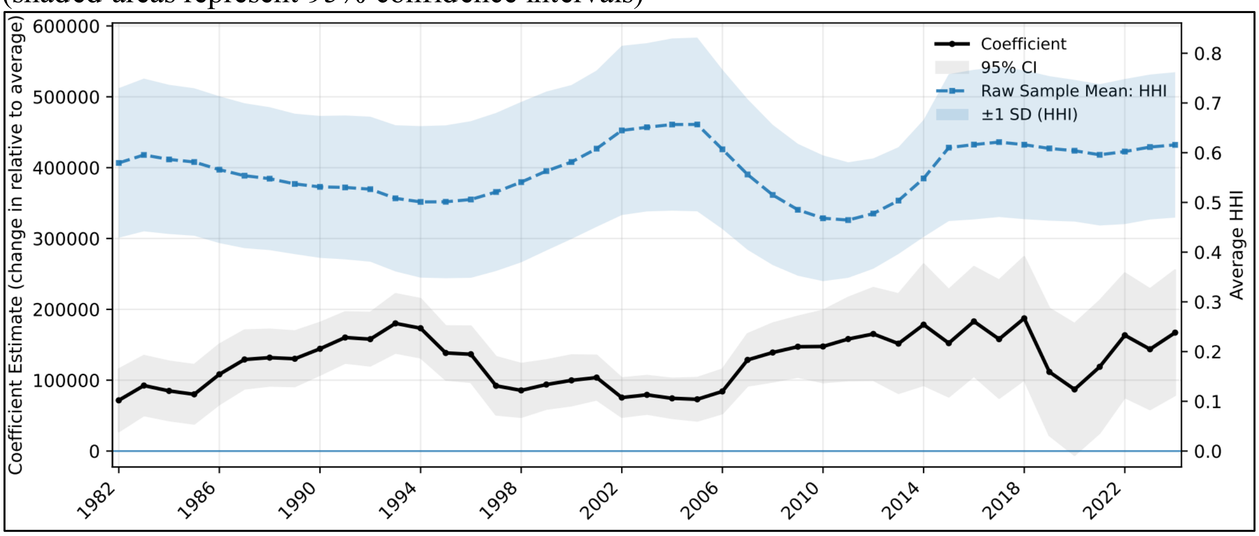
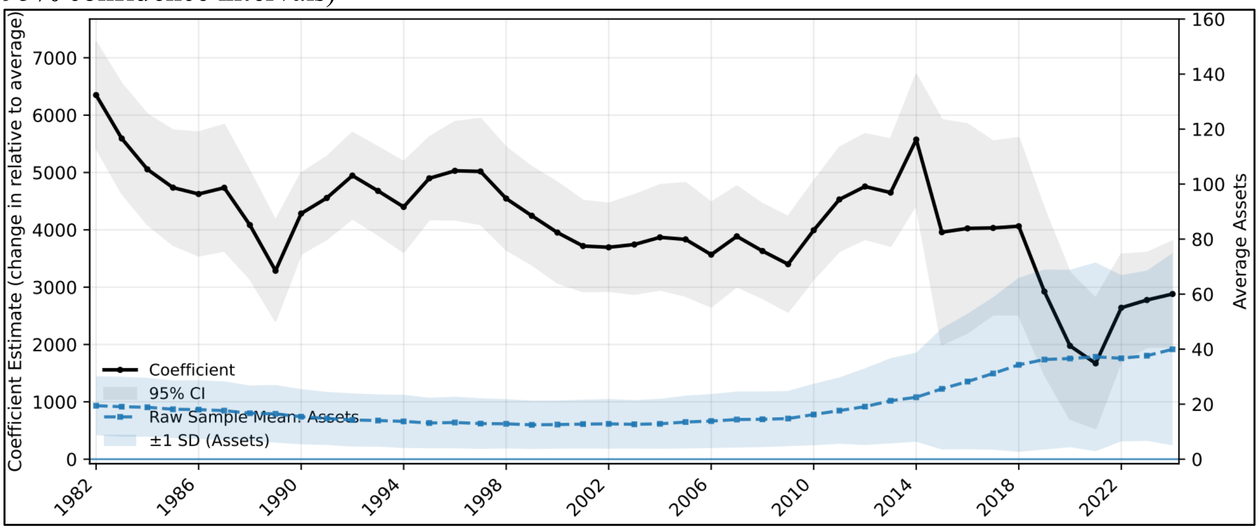


Figure 5.10 illustrates the relative asset (farm scale) coefficient over time. An increase in relative assets has a positive effect on relative CF. Farms with more relative assets tend to generate higher relative CF. For example, in the period ending in 2010, the coefficient indicates a \$100,000 increase in relative assets results in approximately a \$4,000 increase in relative CF.

This result is consistent with the economic principle of economies of scale. The confidence interval bands indicate that the coefficient is consistently statistically significant throughout the study period.

Overall, the coefficient shows a slight downward trend over time, suggesting that farm scale may play a somewhat smaller role in determining relative CF in recent years or farms have become more homogeneous in asset levels.

Figure 5.10**: Dollar Change in Relative-to-Average Operating Cash Flow from a $100,000 Change in Relative-to-Average Assets and Raw Average of Variable** (shaded areas represent 95% confidence intervals)

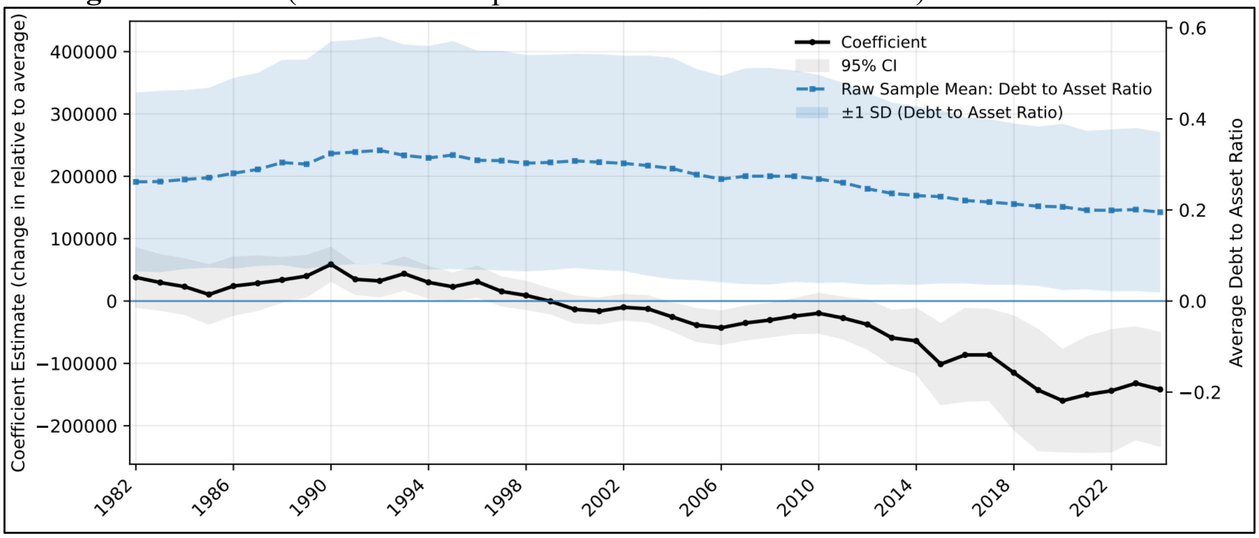


The effect of relative leverage on relative CF provides an informative perspective on changes in Kansas agriculture during the past 50 years (Figure 5.11). The coefficient begins the study period as positive and statistically significant but becomes negative and statistically significant by the end of the sample.

This pattern suggests that higher leverage relative to average was associated with higher CF relative to average during the 1980s and 1990s. The opposite relationship has held since the early 2000s. In other words, leverage historically enhanced returns, but in more recent periods, higher leverage has been associated with lower CF relative to average.

This variable was expected to be strongly influenced by interest rate movements, yet the results do not show clear shifts corresponding to known interest rate cycles. For the past decade, the results indicate that using debt to generate cash flow has not been a good strategy.

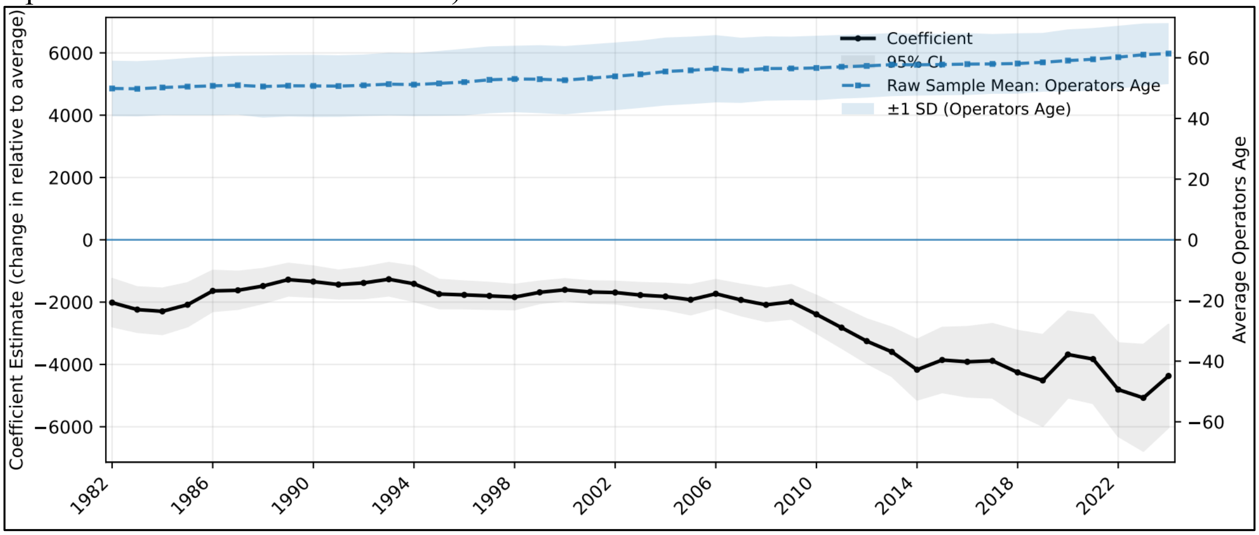
Figure 5.11**: Dollar Change in Relative to Average Operating Cash Flow from a Percentage One-Change in Relative to Average Cost Basis Debt-to–Asset (Leverage) Ratio and Raw Average of Variable** (shaded areas represent 95% confidence intervals)



The effect of relative operator age on relative CF is negative (Figure 5.12). Older operators tend to generate lower relative CF. When considered with the CV model results, this suggests older operators experience higher operating cash flow risk (CV) and lower relative CF.

The coefficient remains relatively stable until around 2010. Then, a noticeable decline begins. This shift coincides with the aging trend observed in the KFMA dataset. It potentially reflects a declining presence of younger operators in the sample and, therefore, less age variation to offset the effect of older operators.

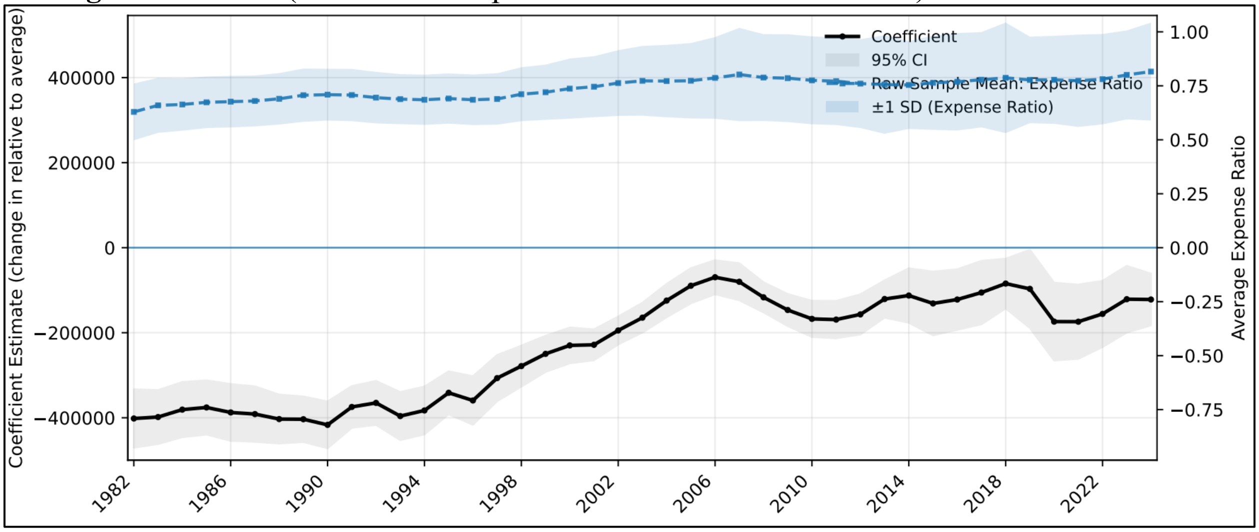
Figure 5.12**: Dollar Change in Relative-to-Average Operating Cash Flow from a One-Year Change in Relative-to-Average Operator Age and Raw Average of Variable** (shaded areas represent 95% confidence intervals)



As shown by Figure 5.13, the relative expense-to-revenue ratio coefficient is negative and statistically significant, and it has a clear declining trend over time (i.e., the coefficient is becoming less negative). An example interpretation is as follows. For the period ending in 2002, a 1-percentage-point increase in the expense-to-revenue ratio relative to average results in approximately a $2,000 decrease in CF relative to average.

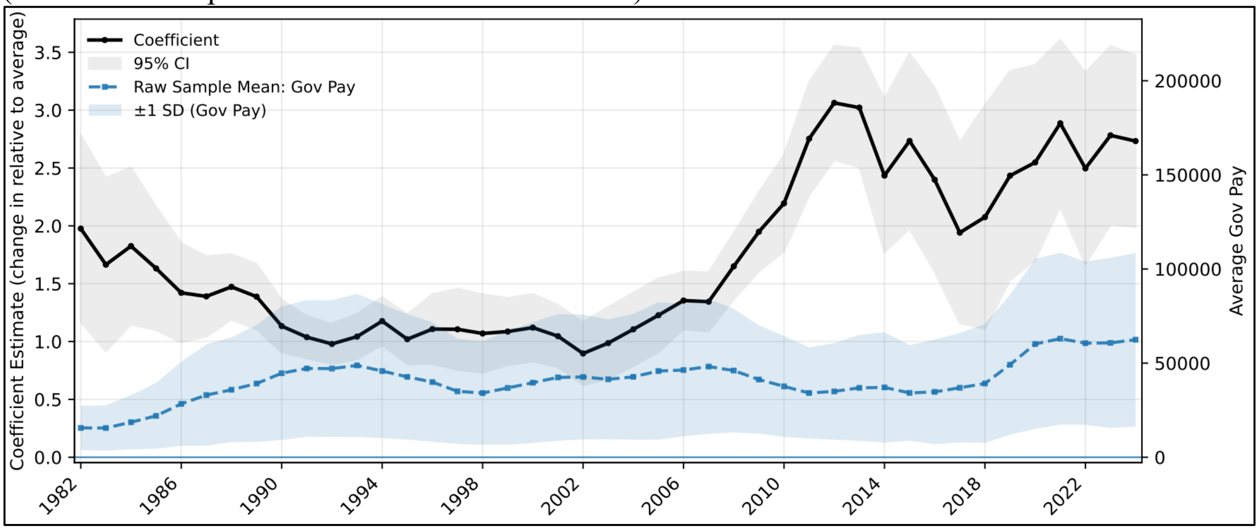
This result is consistent with the relative CV model, indicating that managing expenses relative to revenues remains important, though it may be less influential than in earlier periods. Nivens, Dhuyvetter, and Kastens (2000) concluded similarly with data in 1999. This study's findings are consistent with their findings up to that point, but since 2000, managing expenses relative to revenues has been less effective at generating cash flow.

Figure 5.13**: Dollar Change in Relative-to-Average Operating Cash Flow from a 1-Percentage-Point Change in Relative-to-Average Expense-to-Revenue Ratio and Raw Average of Variable** (shaded areas represent 95% confidence intervals)



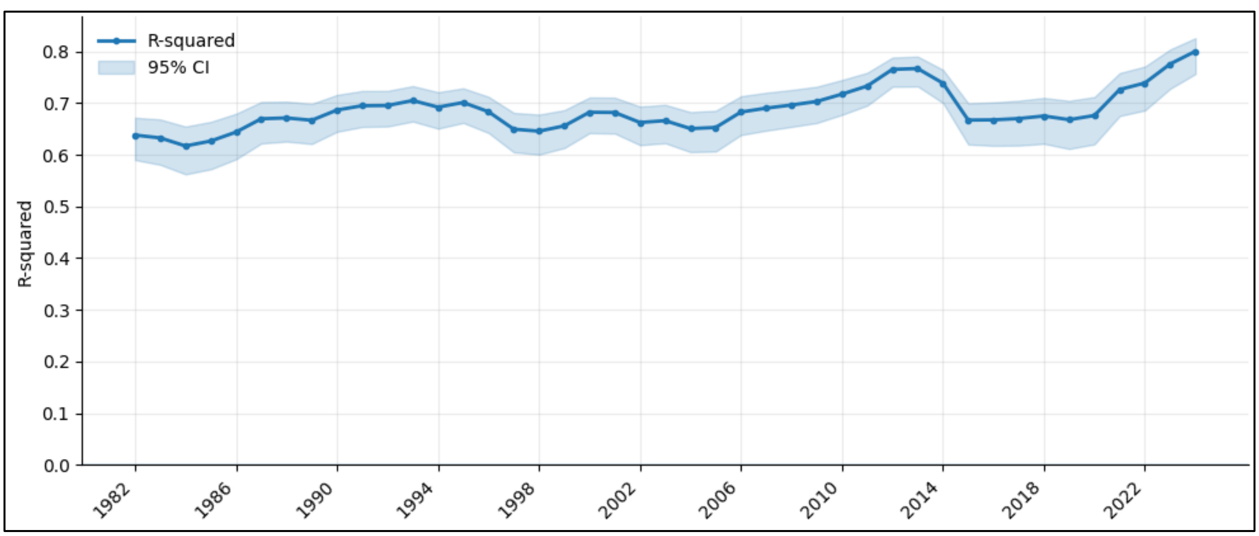
Relative government payments have a positive and statistically significant effect on relative CF, and the magnitude of the coefficient increases over time (Figure 5.14). However, the confidence interval bands widen in later years, indicating greater variability in the estimate. For example, in the period ending in 1998, a $1 increase in government payments relative to average results in approximately a $1 increase in CF relative to average. This result is expected as government payments contribute directly to farm operating cash flow, and as suggested previously, such payments also reduce financial risk.

Figure 5.14**: Dollar Change in Relative-to-Average Operating Cash Flow from a Dollar Change in Relative-to-Average Government Payments and Raw Average of Variable**
(shaded areas represent 95% confidence intervals)



The R-square trend is visualized in Figure 5.15. It stays relatively consistent over time but trends slightly upward, indicating that the model and its combination of variables have gained explanatory power in recent years.

Figure 5.15: R-square Trend for Relative-to-Average Operating Cash Flow Models



The standardized betas of the relative-to-average CF models reflect trends noted throughout this subsection. The standardized beta trends and rank summary are outlined in Figure 5.16 and Table 5.2, respectively. The expense-to-revenue ratio decreased in significance when compared to itself throughout time, and when compared to the other parameters on a standardized platform, this trend is further amplified. The variable's rank dropped an average of 2.3 positions from the first 20 years to the last 20 years. Government payments also show an interesting trend — increasing by 1.6 positions between the first 20 years and last 20 years. Assets and the leverage ratio show little change in ranking between the beginning and ending of the timeline. HHI specialization generally is not a major factor driving CF in recent years.

Figure 5.16: Absolute Value of Standardized Betas for Relative-to-Average Operating Cash Flow Models

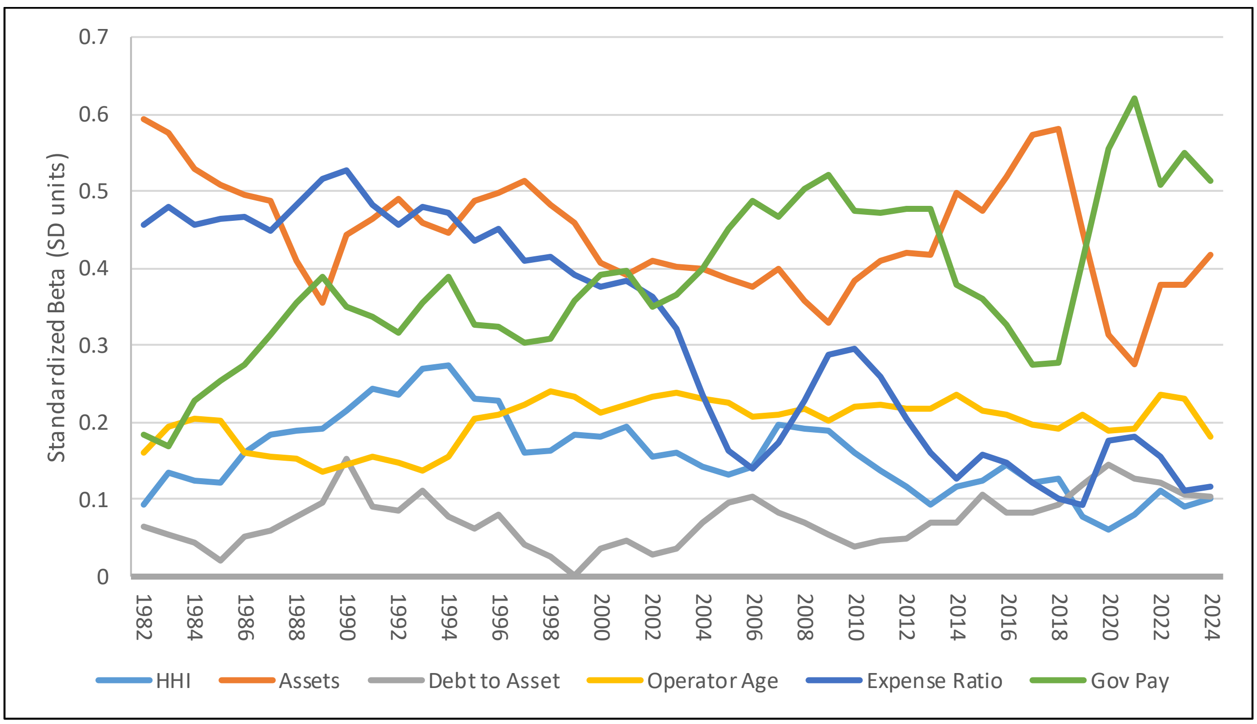


Table 5.2: Standardized Beta Rank Summary for Relative-to-Average Operating Cash Flow Models

Rank Summary by Coefficient - Cash Flow				
Coefficient	*Avg Rank*	*First 20 Period Avg*	*Last 20 Period Avg*	*Rank Change*
HHI	4.8	4.5	5.1	-0.6
Assets	1.5	1.4	1.7	-0.3
Debt to Asset	5.8	6.0	5.7	0.3
Operator Age	3.9	4.5	3.2	1.3
Expense Ratio	2.9	1.8	4.1	-2.3
Gov Pay	2.1	2.9	1.3	1.6

The relative CF models outlined reflect the ability of the farm business to generate cash to cover family living, principal payments, and investments. Most notably, the best CF predictor is farm assets (scale), which would be expected, followed by the expense-to-revenue ratio early in the timeline and then government payments in more recent years. More specialized farms are expected to have higher returns — reinforcing trends seen in Kansas agriculture and beyond. However, when the specialization parameter is compared to other parameters present in the model, it does not contribute a substantial amount to the outcome.

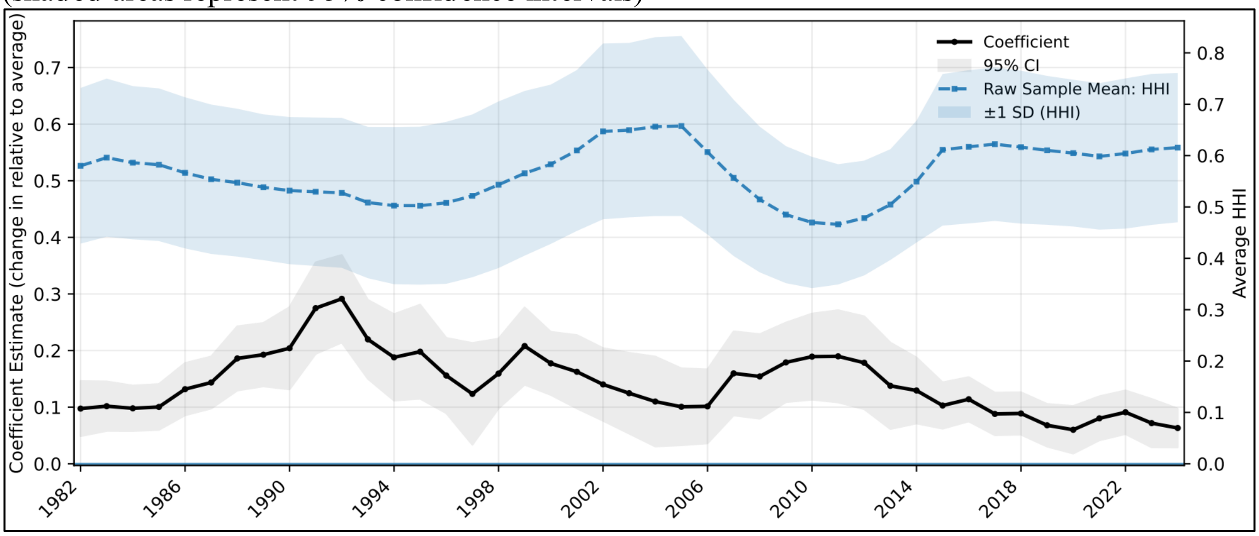
5.3 Return on Equity Model Results

ROE measures how efficiently owners use capital to generate returns. Beginning with the relative HHI coefficient, a positive and statistically significant relationship exists between farms being more specialized relative to average and reporting higher relative ROE (Figure 5.17). More specialized farms experience higher ROE.

The coefficient peaks at 0.29 and gradually declines beginning in the 1990s, reaching 0.06 by the period ending in 2024. This trend suggests that specialization continues to improve

ROE relative to average, but its impact on farm profitability is smaller today than in earlier periods.

Figure 5.17**: Percentage-Point Change in Relative-to-Average Return on Equity from a 1-Percentage Point Change in the Relative-to-Average HHI and Raw Average of Variable** (shaded areas represent 95% confidence intervals)

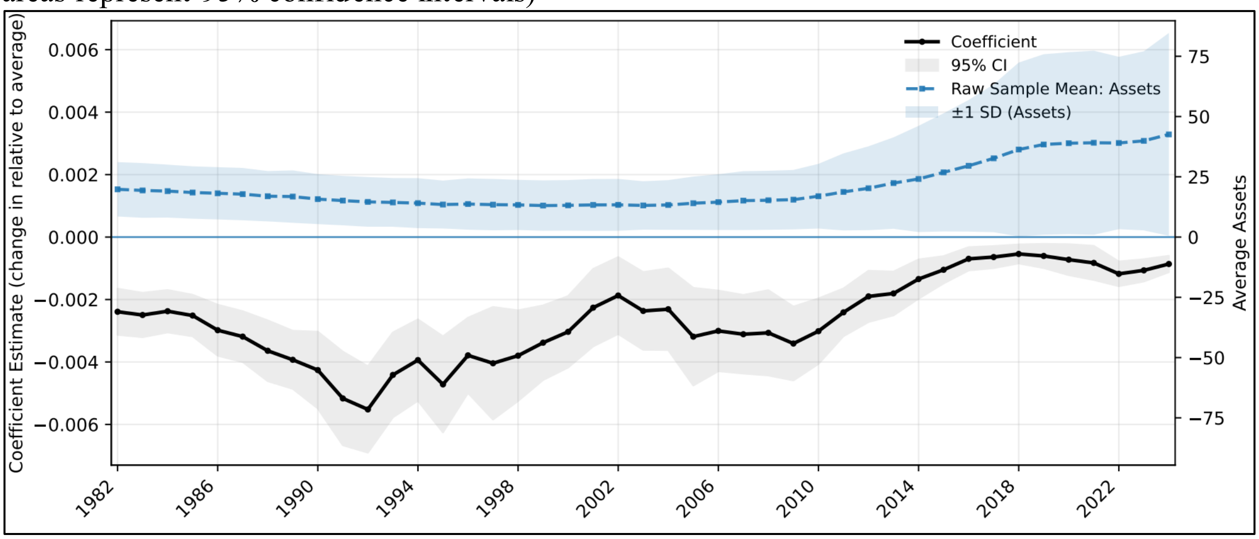


The relative asset (farm scale) coefficient has a negative and statistically significant relationship with relative ROE (Figure 5.18). This indicates that relative ROE declines as farms increase assets relative to average, suggesting lower financial efficiency as farms scale.

The absolute magnitude of the coefficient declined over time, falling from −0.006 in 1992 to approximately −0.001 in 2024. Interpreting the coefficient, a $100,000 increase in assets relative to average results in roughly a 0.55-percentage-point decrease in ROE relative to average in 1992 compared with a 0.1-percentage-point decrease in 2024. This suggests that farms may manage asset growth more strategically today than in the past — possibly because operators have increasingly sophisticated financial management.

This finding is somewhat inconsistent with expectations. Recall that equity = assets − debt, meaning assets and equity are closely related. Several factors may explain this result. For example, farms may add assets with lower income-generating potential, use equity to finance asset purchases so equity grows faster than income, or acquire underutilized or idle assets.

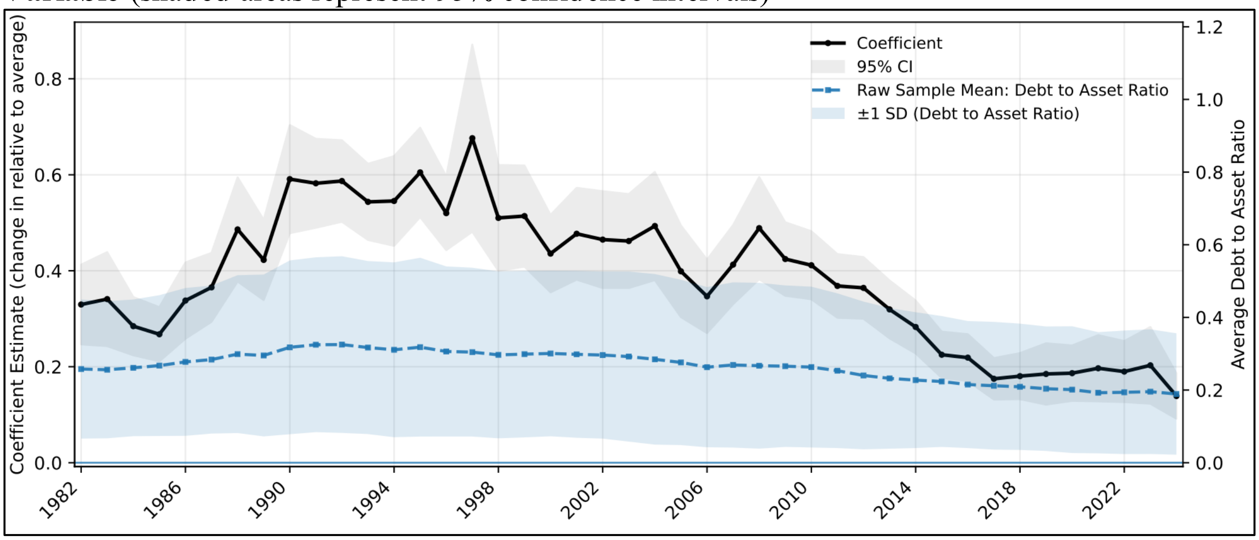
Figure 5.18**: Percentage-Point Change in Relative-to-Average Return on Equity from a $100,000 Change in the Relative-to-Average Assets and Raw Average of Variable** (shaded areas represent 95% confidence intervals)



The relative leverage coefficient indicates that a 1-percentage-point increase in leverage increases relative ROE (Figure 5.19). The coefficient is statistically significant throughout the study period. For example, in the period ending in 2010, a 1-percentage-point increase in relative leverage results in approximately a 0.4-percentage-point increase in relative ROE.

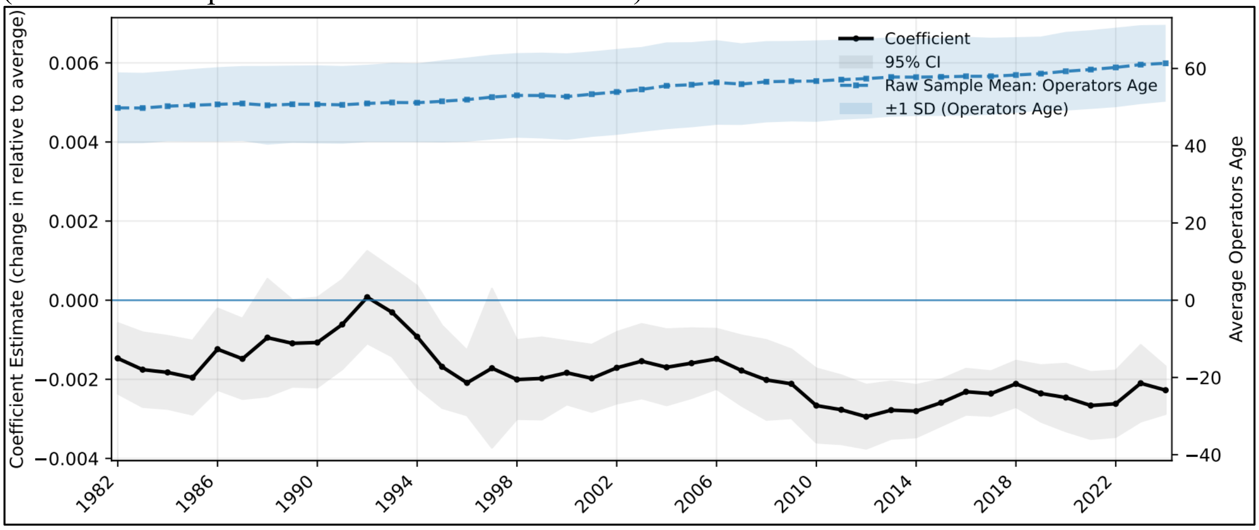
However, the magnitude of the coefficient declines over time, falling from approximately 0.65 in 1997 to about 0.2 in more recent years. Therefore, the strength of this relationship has diminished. This decline is not surprising given the long-term decrease in interest rates, which reduces the risk of leveraging and lowers the marginal impact of debt on returns.

Figure 5.19: Percentage Point Change in Relative-to-Average Return on Equity from a 1-Percentage Change in the Relative-to-Average Debt-to-Asset Ratio and Raw Average of Variable (shaded areas represent 95% confidence intervals)



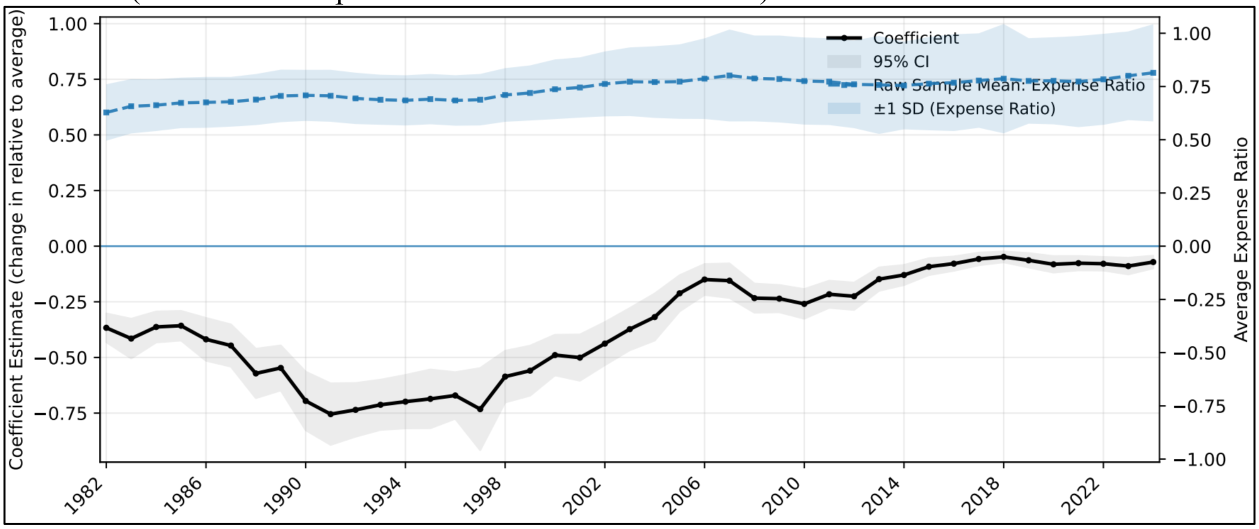
The relative operator age coefficients are mostly associated with negative values throughout the timeline in Figure 5.20. They show more significance in the later years than in earlier years. After the farm financial bubble corresponding with the 1980s, the coefficient has been relatively level since 1996. This indicates older operators are less efficient with ownership stakes in farm businesses.

Figure 5.20: Percentage-Point Change in Relative-to-Average Return on Equity from a One-Year Change in the Relative-to-Average Operator Age and Raw Average of Variable (shaded areas represent 95% confidence intervals)



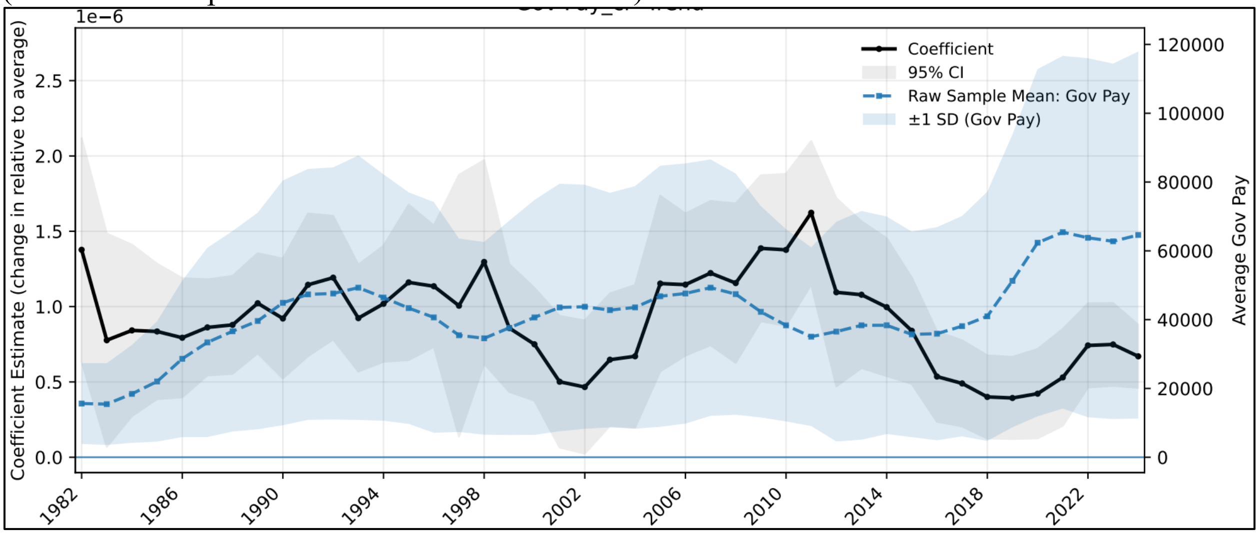
The relative expense-to-revenue ratio coefficient tells a similar story to what it has in the CV and CF specifications. It had a large impact in early years and declined in impact in later years. In the relative ROE models, it has a negative impact throughout the timeline and is consistently statistically significant. The coefficient's absolute value peaked in 1991 at -0.75, trended toward zero, and settled around -0.10 in more recent years. Again, this indicates the importance of managing expenses relative to revenue in the early years to perform well financially, but it has been less impactful in more recent years. This finding for the later years could be due to more homogenous farms existing and each increasingly focused on managing expenses relative to revenues.

Figure 5.21**: Percentage-Point Change in Relative-to-Average Return on Equity from a 1-Percentage Point Change in the Relative-to-Average Expense Ratio and Raw Average of Variable** (shaded areas represent 95% confidence intervals)



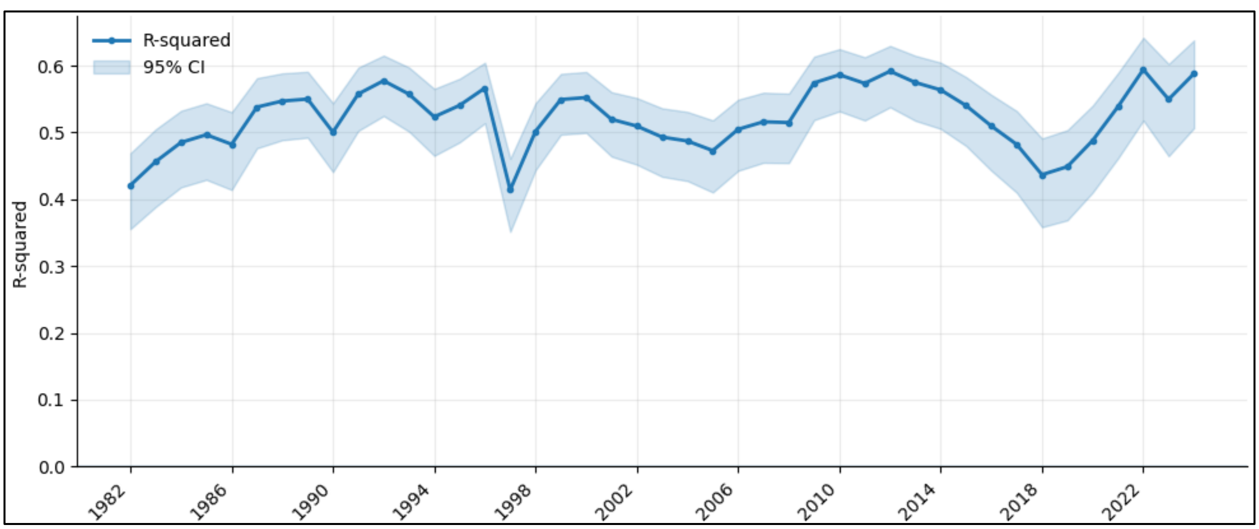
As expected, the relative government payments coefficient displayed in Figure 5.22 has a positive value over time. Additionally, it is statistically significant; note the confidence interval bands not containing zero. The values bounce around over time in what seems to be a cycle. Such cyclical activity indicates that government payments have a more important role in generating higher relative ROE during periods of financial stress, which is expected.

Figure 5.22: Percentage-Point Change in Relative-to-Average Return on Equity from a Dollar Change in the Relative-to-Average Government and Raw Average of Variable (shaded areas represent 95% confidence intervals)



In Figure 5.23, R-square moves between 0.4 and 0.6 but has no clear trend. This indicates that the variables in the model explain about half of the ROE variation.

Figure 5.23: R-square Trend Relative to Average ROE Models



The results from the standardized beta transformation displayed in Figure 5.24 and Table 5.3 indicate that leverage is the best determinant of ROE. It ranked first for its ROE-determining power until the last few years when government payments emerged as the best determinant. The effect of government payments on ROE changed the most between the first 20 periods and the last 20; its rank changed from 4.9 to 3.2. Figure 5.24 emphasizes that government payments in the most recent five years moved into being the most important factor determining ROE relative to average. Operator age's rank also moved up from 5.7 to 4.0 on average. Like in the previous models, the largest fall in position — from 2.0 to 4.0 — was the expense ratio. Assets' rank remained relatively the same over time, and HHI started at 4.4 and moved down to 5.7. Therefore, in more recent years, HHI explains relatively less about farm financial efficiency.

Figure 5.24: Absolute Value of Standardized Betas Trend Relative-to-Average Return on Equity Models

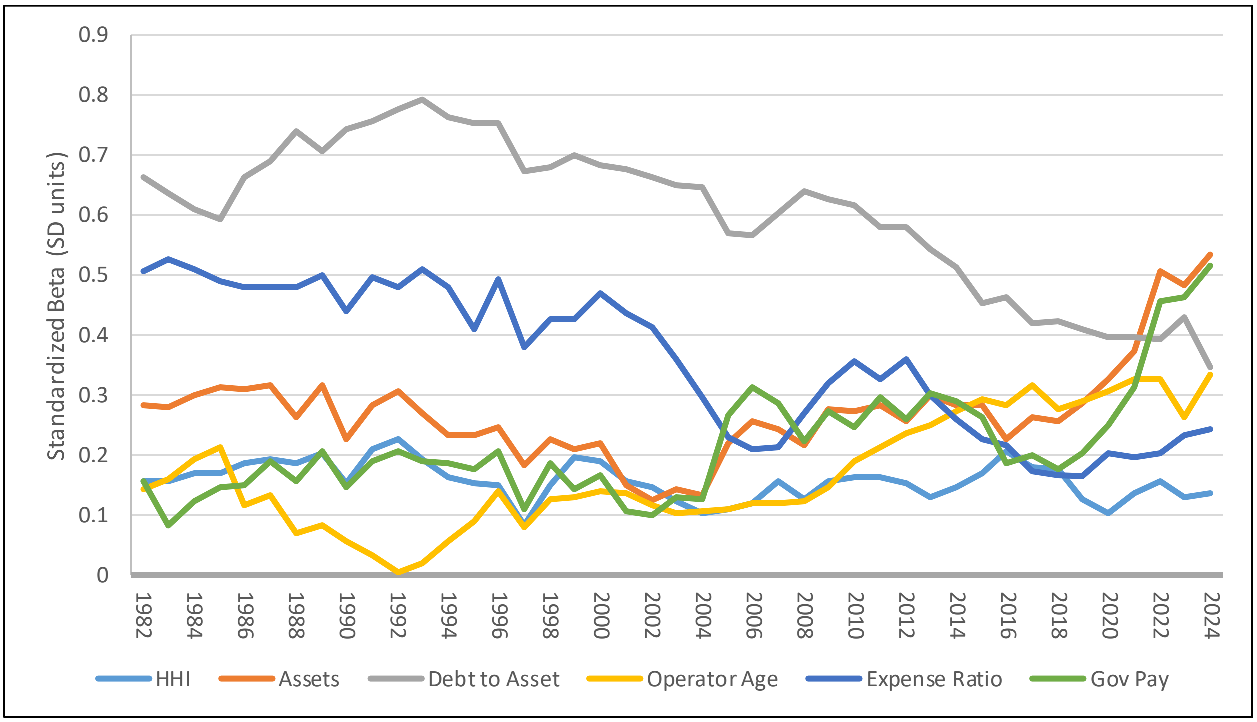


Table 5.3: Standardized Beta Rank Summary Relative-to-Average Return on Equity Models

Rank Summary by Coefficient - ROE				
Coefficient	*Avg Rank*	*First 20 Period Avg*	*Last 20 Period Avg*	*Rank Change*
HHI	5.0	4.4	5.7	-1.3
Assets	3.0	3.1	2.9	0.2
Debt to Asset	1.1	1.0	1.3	-0.3
Operator Age	4.9	5.7	4.0	1.7
Expense Ratio	2.9	2.0	4.0	-2.0
Gov Pay	4.1	4.9	3.2	1.8

The relative-to-regional-average ROE models explain the financial efficiency of farms in the dataset. They consistently do a good job of explaining variation in the dependent variables as explained by R-square. In terms of variables that explain ROE in a given period, most notably was a fall in the importance of the expense ratio — noted by the raw coefficient value and the adjusted standardized coefficients. This same trend has been noted in the other financial performance indicators models. The upward trend in the government payments' standardized coefficient indicates such payments have become more crucial in affecting farm performance. Scale has a negative, decreasing effect on ROE, and being specialized relative to average increases your return on shareholder value but with a decreasing effect.

5.4 Overall Effects

Overall, the specialization metric, HHI, had a beneficial effect on all financial metrics measured. Broadly, the results suggest more specialized farms can expect higher returns with lower volatility and above-average efficiency. Although these coefficient values were not relatively important compared with other variables in the standardized coefficient analysis, the variable's statistical significance in each of the three model specifications implies specialization's importance over time. This finding is likely due to farms more narrowly allocating time and capturing resource efficiencies when they focus on one revenue source. The results' deviation from the theory on economies of scope is a concern, but the overwhelming opposite signs suggest that the present results are consistent and reliable.

The measure of economies of scale, assets, was an interesting variable in these models. It did not produce conclusive results in the risk models but showed a strong positive relationship with CF and a strong negative relationship with farm financial efficiency. This indicates that larger farms should expect higher returns with potentially lower variance in returns but with less efficient use of shareholder dollars. In the CF models, assets had a large relative impact in the standardized coefficient ranking methodology. However, compared to other variables, it showed that it was not as relevant when determining risk or efficiency. This is consistent with what was observed in the raw coefficients. The theory of economies of scale can neither be accepted nor rejected in this case as it is shown that larger firms return more, which is consistent with the theory, but not as efficiently as smaller farms, which is inconsistent. The lack of sufficient large-scale farms in the dataset could give reason to this. Most KFMA farms being smaller scale could skew the results.

Some results for the leverage ratio were noteworthy. From a risk perspective, the increase in the coefficients value indicates that farms are penalized more today for being highly leveraged relative to average. In the earlier observation years, the CF models point to farms returning more if they are highly leveraged. That said, these coefficient values switched to negative in the early 2000s. Therefore, in more recent years, being more leveraged than average not only indicates a farm takes on more financial risk, but also it will have lower expected returns. The ROE model results are most likely more of a correlation effect between ROE and leverage than a causal relationship, despite leverage having a positive effect with ROE. Compared with other variables in the standardized coefficient rank summaries, the leverage metric is becoming increasingly significant in determining financial risk; however, it is not a large driver of CF. It was also the most relevant variable in the ROE models.

Operator age had overall negative effects on financial metrics. Older operators had more volatile, lower, and less efficient returns. Most of these coefficients were also statistically significant. Negative trends in the CF models' coefficients indicate that older operators more recently have generated lower operating cash flow than in the past. When looking at the standardized coefficients, operator age ranked in the middle to back of the group when it came to effect. However, in every model, operator age ranked as a more relevant predictor in the last 20 years than the first 20 years of the observation timeline.

The expense-to-revenue ratio has been perhaps one of the most important management-controlled variables (Nivens, Kastens, and Dhuyvetter, 2002). This study found that farms with a higher expense ratio than average can expect more volatile, lesser, and less efficient returns than the average regional farm. Each of these coefficients was statistically significant. Trends indicate that the expense ratio is becoming less important, however, as coefficient values in each of the models declined in absolute value over time. Additionally, the expense ratio was and still is the most important variable in determining risk, despite the coefficient value trending toward zero. However, in the CF and ROE models, the expense ratio dropped from being one of the highest-ranked variables to one of the lowest, indicating that some variables are becoming more important as we move across the timeline.

The approach to government payments changed markedly over the timeline, and multiple defining government actions took place during the observation period. These swings in government strategy seem to be captured in coefficient changes in each of the models overtime. In the risk models, a statistically significant and negative effect is observed early in the timeline. Toward the end of the period, the coefficient declines in magnitude and becomes less negative and statistically insignificant. Overall, the coefficient's value suggests lower relative risk when you receive more government payments than average. When analyzing the CF models, a clear positive value can be observed, and an upward trend started in the early 2000s. The ROE models indicate a positive value as well with more cyclical trends, indicating potential heightened importance during times of overall financial stress in the agricultural economy. This all indicates that receiving more government payments than average will result in less volatile, greater, and more efficient returns. Compared with other variables in the models, government payments are becoming a less important factor when looking at farm risk, but with respect to CF and ROE, such payments are playing a more crucial role than in the past.

Chapter 6 - Conclusion and Discussion

Production agriculture has advanced and evolved throughout the past century. This research has aimed to outline the effect of changes, notably farm consolidation and specialization, during the past half-century on farm financial performance. The research builds on Purdy et al. (1997) and their estimation of agricultural industrialization's impacts.

This study uses three financial performance measures to track farm risk, returns, and financial efficiency: operating cash flow coefficient of variation, operating cash flow, and return on equity. By employing a one-year rolling regression model over 10-year periods with regional benchmarking to account for regional biases, the effects of multiple variables (i.e., scope, scale, leverage, operator age, expense efficiency, and government payments) on financial performance over time were analyzed.

Overall, the findings support farms have trended toward specialization, and the economies of scope coefficient proxy variable suggests more specialized farms garner better returns more efficiently and in a less volatile manner. Specialization yielding better and more efficient returns has been supported in the literature (Purdy et al., 1997; El Benni et al., 2012). The result that specialization can reduce the variability of returns is a less supported concept but mentioned by Helmers, Langemeier, and Shaik (2005). Compared with other variables in the risk models, specialization was an important metric, but its importance has declined. Farm enterprise specialization mattered less with respect to measuring returns and efficiency.

Evidence suggests that larger farms post larger and less volatile returns. Additionally, consistent with Nivens et al. (2002), the research suggests that a farm's best financial risk management tool is controlling expenses relative to revenues. This factor was the most important variable throughout the observation period, though its effectiveness may be declining. Finally, government programs increasingly have a role in generating operating cash flow and bolstering ROE. However, payments from such programs have become less influential in decreasing relative risk — most likely because of the payments shifting from "opt-in" programs to more ad hoc-style support.

This study has limitations tied to the KFMA dataset. Most notably, the number of farms in the dataset have declined. This could explain the widening confidence intervals for model coefficients over time. Another concern is the dataset's definition of depreciation. The dataset switched depreciation's definition, and no clear method would allow for converting between the two. Removing it from the dependent variables was the best alternative. The final concern stems from characteristics of farms in the dataset. Because the dataset primarily includes smaller Kansas farms, this analysis fails to reflect circumstances on larger and possibly more progressive farms. Despite this, the dataset offers a robust picture of "farms of the middle."

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