The impact of specialization on farm financial performance

by

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B.S., Virginia Polytechnic Institute and State University, 2017

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

2019

Approved by:

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Abstract

The impact of specialization on farm financial performance depends on the magnitude of economies of size and scope, as well as manager productivity, commodity pricing performance, and producer risk preference. The objective of this study was to investigate the impact of risk and specialization on farm financial performance, specifically on the mean and variance of return on equity. A balanced panel of 459 Kansas farms was created from Kansas Farm Management Association member farms from 2009 through 2018. Four measures of specialization were used in the model: Herfindahl index; crop-livestock and crop-custom work interaction terms; percentage of income from grains and percentage of income from cash crops; and percentage of income from livestock. The impact of specialization and risk on mean financial performance and the impact of specialization on risk were estimated using three-stage least squares regression and two-stage least squares regressions. Variable means and regression coefficients from the three-stage least squares regression were used to calculate financial performance elasticities.

Results show specialization is associated with increased mean financial performance and variance in financial performance. Diversifying into both crop and livestock production is associated with decreased mean farm financial performance. Liquidity and financial efficiency were associated with relatively large impacts on mean financial performance, suggesting that effective cost management is associated with higher mean financial performance. Operator age, solvency, and specializing into production of cash crops such as soybeans and cotton were associated with increased variance in financial performance. These findings have implications for farms to better allocate resources to improve returns and manage risk, and for the use of Extension resources in working with farms of different enterprises.

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Acknowledgements

I am so grateful for everyone I've been blessed to cross paths with over the years. Thank you for your encouragement and support, and for shaping me into the person I am today. There are too many of you to name here, but your kindness has not gone unnoticed. I consider it a deep honor and look forward to paying forward all that you have invested in and shared with me.

To my advisor, Dr. Pendell, thank you for your patience and guidance throughout my time at Kansas State. I appreciate how generous you were in sharing your time and for being a sounding board for my overflow of ideas. I appreciate your help as I launch into the "real world" and am grateful for the opportunity to learn from you.

To my committee member, Dr. Coffey, thank you for your support and encouragement these past two years and for all of your help on my committee. I wouldn't have made it beyond the first semester without you. I appreciate your feedback on my research and grounded advice.

To my committee member, Dr. Tonsor, thank you for your help with my research and for your wisdom and guidance on my committee. I greatly appreciate the way you stretched my thinking and always encouraged me to dig deeper.

To my classmates turned best friends, Amanda and Allison, thanks for some of the best adventures. Y'all are destined for great things, and I can't wait to see where life takes you next.

To my church family, I so greatly appreciate your warm welcome and kindness in taking me in. I am honored and blessed to do life together and learn alongside you. Because of you, Kansas became home.

To my parents, thank you for loving me unconditionally and for all of your support and encouragement over the years. You instilled in me a sense of wonder and first cultivated my love for the agriculture industry and all it stands for. It's been one of life's great blessings to call you my parents.

To my sister, thank you for being my best friend, partner in crime, and better half. Your love of life and everyone you meet is the example I aspire after. I'm so grateful for all of our adventures over the years and can't wait to see where life takes us next.

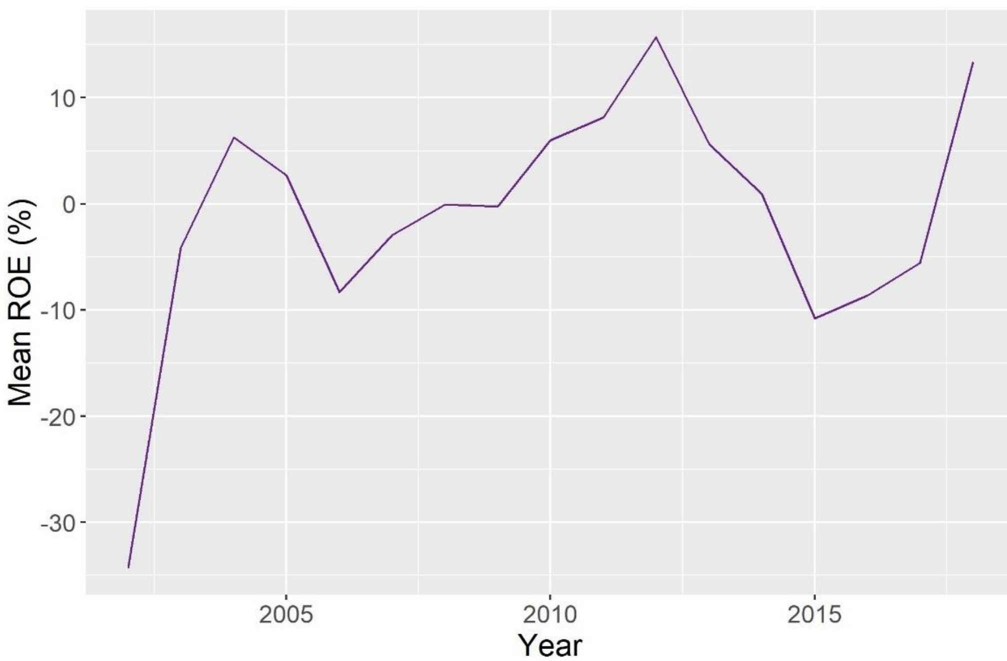
Chapter 1 - Introduction

Farmers face daily management decisions to both manage risk and maximize net return. At the farm and enterprise level, this includes choices between specialization to capture economies of scale and diversification to manage risk and capture economies of scope (Purdy, Langemeier and Featherstone 1997). According to the America’s Diverse Family Farms: 2018 Edition, the income of 59% of farm households was at or above the median for all U.S. households in 2017 (Burns and MacDonald 2018). However, farm income has fluctuated greatly for several decades and that volatility has not diminished over time (Mishra and Sandretto 2002). Farmers may use enterprise diversification to manage risk at the farm level and use off-farm income to help minimize farm household volatility (Mishra and Sandretto 2002). On the other hand, physical, site, and human capital specificity may create economies of size and encourage enterprise specialization. This paper examines the impact of risk and specialization on mean financial performance. Specialization is found to increase both mean and variance in farm financial performance.

The impact of specialization on farm financial performance and risk depends on economies of scale and scope, as well as other factors such as commodity prices and management ability. A farm may be able to capture economies of scale as it becomes more specialized by better utilizing physical and human assets and capital. However, by becoming more specialized, a farm may also expose itself to greater risk through weather and price fluctuations. A farm may capture economies of scope by diversifying when practices exhibit complementarities. Diversification may also allow a farm to manage risk if enterprise returns are not perfectly correlated.

Purdy et al. (1997) found that specialization positively impacted both mean and variance in return on equity (ROE) using data from Kansas farms from 1984 through 1995. However, much has changed in agriculture in recent years. Farms tend to be larger and more specialized, and often depend on a diversified household income portfolio (MacDonald, Hoppe and Newton 2018). The two most common specializations among U.S. farms and ranches are specialization into grain/oilseeds and specialization into beef cattle farming/ranching (MacDonald et al. 2018). Over half of crop production in the U.S. now comes from farms producing two or fewer crops (MacDonald et al. 2018). The number of farms producing livestock, with no crop production, has risen steadily over the past two decades (MacDonald et al. 2018). Figure 1-1 shows the mean ROE of Kansas Farm Management Association farms from 2002 through 2018.

Figure 1-1 Mean Return on Equity (ROE) of Kansas Farm Management Association Farms



Results show that specialization, as measured by the Herfindahl index, has a positive, significant impact on mean and variance in return on equity. The interaction term between crop and livestock income was found to be statistically significant; farms that diversify into crop and livestock production are associated with a decrease in mean ROE. Other measures of specialization, including percentage of income from specific commodities and interaction terms crops and custom work, were not found to be statistically significant. As calculated in this study, the Herfindahl index captures diversification at the whole-farm level across livestock, crop, and custom work—while the other measures of specialization are specific to enterprises. It may be possible that the true benefits of specialization/diversification are captured most fully at the whole-farm level.

The objective of this research is to investigate the impact of risk and specialization on farm financial performance. Specifically, we will evaluate the impact of specialization and variance of return on equity on the mean of return on equity, and the impact of specialization on the variance of return on equity using Kansas farm-level panel data from 2009 through 2018. An expected return-variance (E-V) conceptual framework is used. Models are estimated using both three-stage least squares regression and two-stage least squared regression to evaluate the impact of specialization and diversification on farm financial performance.

The remainder of this thesis is organized as follows: Chapter 2 will provide an overview of the literature. Chapter 3 will begin by describing data and methods used in the analysis. Chapter 4 will provide results and Chapter 5 will provide the conclusions, limitations and suggestions for future research. A robustness check estimated by 3SLS regression using enterprise count in place of the Herfindahl index is presented in Appendix A.

Chapter 2 - Review of Literature

Chapter 2 provides background into the impact of specialization on economies of scale and scope, identifies ways that farmers may choose to specialize/diversify at the enterprise, farm, and household levels, and highlights recent trends in American farm specialization. This chapter provides a review of past literature related to factors impacting farm financial performance and risk.

Specialization in Agriculture

Economies of Scale and Scope

The impact of specialization on farm financial performance depends on the magnitude of economies of size and scope, as well as manager productivity, commodity pricing performance, and producer risk preference (Langemeier and Jones 2000; Katchova 2005; Purdy et al. 1997; Barry, Escalante and Bard 2001; Mugera, Langemeier and Ojede 2016; Mishra et al. 2012). A production process exhibits economies of scale when average cost declines as output increases (i.e., marginal cost is less than average cost) (Besanko et al. 2010). However, if economies of scope are present, specialization would be expected to have a negative impact on mean farm financial performance.

Specialization can enable producers to take advantage of economies of scale. Economies of scale can be achieved when tradeoffs exist among alternative technologies, when production is capital intensive, and in situations of large inventory volume (Besanko et al. 2010). If economies of size are prevalent for a particular enterprise, specialization into that enterprise would be expected to have a positive impact on mean financial performance (Langemeier and Jones 2000). Pope and Prescott (1980) suggest that a farmer may have an incentive to specialize if there are large, positive covariances and large differences in mean return between enterprises. However, specialization also exposes farms to greater market risks and production risks from pests and disease (Hoppe 2014). Specialization has been associated with larger farm size—both in terms of acreage and value of equipment (Mishra et al. 2012). As a farm grows in size to capture economies of scale, it may also undertake greater risk, and specialization would preclude the use of diversification to manage such risk. Using Kansas farm data from 1993 to 2010, Mugera et al. (2016) found that farms experienced a decline in scale efficiencies during the 2000s compared to the 1990s.

Asset specificity may encourage specialization. Farms may face physical asset specificity if specialized equipment and labor are used during only a limited time of the year (Mishra et al. 2012). Economies of scale can be achieved by spreading of product-specific fixed costs over greater output—lowering average costs. Site specificity can support specialization based on geographic region and occurs when a specific natural resource occurs near another asset such as transportation (Mishra et al. 2012). Human capital specificity can occur as farmers gain experience and hone their skills within a specific enterprise over time; as they gain experience, they would be expected to make increasingly specialized production decisions and investments. Such economies of learning are distinct from economies of scale, and could be large when economies of scale are small, and vice versa (Besanko et al. 2010).

Potential benefits from diversification for the farm business are two-fold: 1) economies of scope and 2) risk reduction by combining enterprises with imperfectly correlated revenues (Katchova 2005). A firm has economies of scope if it achieves savings as it produces more diverse goods and services (Besanko et al. 2010). Practices exhibit complementarities, or synergies, when the presence of one practice enhances another (Besanko et al. 2010). In the case of specialized assets, diversification can help to economize on transaction costs—rather than dividing the company into joint ventures, alliances, or contracts. Economies of scope can also come from the complementary use of farm activities and equipment (Katchova 2005).

Diversification would be expected to be optimal for a producer who is risk averse (Pope and Prescott 1980; Besanko et al. 2010). Given an individual's risk tolerance, an investor will choose the portfolio that maximize their expected return (Markowitz and Fabozzi 2011). In their quadratic programming model of an Oklahoma crop/livestock farm, Mapp et al. (1979) found that the optimal enterprise mix to maximize farmers' utility changed greatly when constraints were included to account for the farmers' risk preference. Farmers must consider the tradeoffs between economies of scope and the costs associated with diversification, such as the need for diverse equipment and managerial experience and giving up economies of scale (Katchova 2005).

Ways Producers Specialize

According to Enjolras et al. (2014), a farm/farm household may choose to diversify/specialize at multiple levels: through enterprise selection, production decisions within a specific enterprise, and by balancing time between farm work and other activities. Pope and Prescott (1980) note that—within a risk-preference framework—net worth, experience, and organizational form may impact producer behavior and the choice to diversify/specialize.

When choosing enterprises to diversify/specialize into, producers may consider: profitability, resources, information, marketing, enthusiasm, and risk (Katchova 2005). Farmers will allocate their labor to an enterprise with less-risky returns if they are risk averse and perceive one enterprise as more risky (Mishra and Goodwin 1997). Mishra, El-Osta and Johnson

(1999) suggested that diversification can help to smooth farm income if returns to the different enterprises are imperfectly correlated. Mishra et al. (1999) used a logit analysis of the 1994 Agricultural Resource Management (ARMS) to evaluate the success of cash grain farms; they found that farmers with diverse enterprises were more likely to be successful than those who did do not diversify.

Farmers may also adjust their management practices within an enterprise to manage risk. Barry et al. (2001) and Enjolras et al. (2014) note several production methods producers may choose to diversify, including number of crop varieties and irrigation. Gillespie, Basarir and Schupp (2004) note that cow-calf producers may choose to diversify into backgrounding calves after weaning, and found that producers that diversified their operations have greater interest in alternative marketing arrangements. Further, Mishra et al. (1999) found that risk management strategies—such as diversification, using forward contracting for inputs, government program participation, and spreading sales of over the year—all contributed toward success of cash grain farms. Nehring et al. (2014) found that both size (harvested acres on farm) and diversification increased asset efficiency and thus ROE.

Most American farms and ranches are owned and operated by families seeking to increase household wealth through allocation of the family's resources, even beyond the farm. At the farm household level, farm income volatility can influence decisions surrounding off-farm employment (Mishra and Sandretto 2002) and household wealth portfolios (Blank et al. 2009). The recent trend among farm households to depend on diverse sources of income is driven by many factors, including increases in competition in agricultural markets, off-farm employment opportunities, and demand for farmland for nonagricultural purposes (Blank et al. 2009). Further, USDA data suggests a trend in recent years where the nonfarm assets of farm households have grown in size relative to the household's farm assets (Blank et al. 2009). In their analysis of Canadian farm operators' use of off-farm income as a risk management tool, Jetté-Nantel et al. (2011) found that farm income volatility was positively related to both the likelihood of off-far work and the level of off-farm employment income; they concluded that farmers' production decisions were influenced by a household income portfolio that included off-farm employment.

Trends in Specialization in Agriculture

The 2011 Agricultural Resource Management Survey (ARMS) found that the average family farm in the United States produced 1.6 commodities (Hoppe 2014). The Structure and Finances of U.S. Farms: Family Farm Report notes that family farms tend to become more diversified as they grow in size: smaller family farms averaged one to two commodities per farm, while large-scale farms averaged three to four commodities per farm (Hoppe 2014). The Survey considered a farm to be specialized if the commodity accounted for over half of its total value of farm production.

The 2012 Census of Agriculture revealed that specialization into beef cattle increased while specialization into grain and oilseeds decreased among large farms as the farm's total acreage increased (MacDonald et al. 2018). Twenty-six percent of farms with 2,000 to 4,000 acres of farmland specialized in beef cattle farming/ranching, while 60% of farms with 10,000 to 24,999 acres of farmland and 69% of farms with more than 25,000 acres of farmland specialized into beef cattle farming/ranching. In contrast, 52% of farms with 2,000 to 4,000 acres of farmland and only 5% of farms with more than 25,000 acres of farmland specialized in grain and oilseed production. Grain and oilseeds and beef cattle farming/ranching were the most common specializations among large farms.

In addition to shifting to larger enterprises, U.S. crop production has become more specialized (MacDonald et al. 2018). In 1996, farms with one or two crops produced 46% of total crop production; in 2015, crop production from farms with one or two crops grew to represent 60% of total crop production. Corn production saw a dramatic shift to farms producing two crops: 53% of total corn production in 2015 came from farms producing two crops, compared to only 33% of corn production in 1996. Soybeans followed a similar pattern as corn with two-enterprise farms responsible for 50% of total soybean production in 2015. Hay, wheat, rice, peanut, and cotton production also showed trends toward specialization. The share of total production from farms with livestock fell over the past two decades (1996—2015) for all major and minor field crops except potatoes.

United States livestock production has also become more specialized over the past two decades (MacDonald et al. 2018). The share of all livestock production that came from farms without crop production grew from 22% in 1996 to 33% in 2015. Each major livestock commodity saw growth into specialization. The poultry sector was the most specialized in 2015 (52% of production occurred on farms without crop production), followed by cattle, hogs, then dairy. Hog production saw a large increase in specialization, with 31% of production occurring on farms without crop production in 2015—compared to 14% in 1996.

The Impact of Specialization on Farm Financial Performance

The current study follows previous research by Purdy et al. (1997), that evaluated the impact of specialization and diversification on mean farm financial performance and risk, using a panel of 320 Kansas farms from 1985 through 1994. Purdy et al. (1997) used an Expected return-

Variance conceptual framework to evaluate the relationship between mean rate of MROE and the variance in rate of ROE (VROE). Mean ROE was hypothesized to be influenced by VROE, age, percentage of acreage owned, operating expense ratio, depreciation expense ratio, debt to asset ratio, specialization, and total acres operated. Variance in ROE was hypothesized to be influenced by operator age, debt-to-asset ratio, specialization, percentage of gross cash farm income received from government payments, total acres operated, and region. Four specifications of each the mean ROE and VROE equation were used for each of the specialization/diversification measures used: Herfindahl index using income from crops, livestock, and custom work; interaction terms between crop and livestock income; percentage of income from crops; and percentage of income from livestock. The Herfindahl index and percentages of income from crops and livestock were used to evaluate the impact of specialization, while the interaction terms between crops and livestock were used to evaluate the impact of diversification. The authors used the three stage least squares method to estimate both mean ROE and variance ROE equations.

Purdy et al. (1997) found that age of operator, percentage of acres owned, financial efficiency, and leverage were negatively related to financial performance, while farm size was positively related to financial performance. Unlike crop production, specializing in livestock production (beef, swine, or dairy) reduced the variability of financial performance. Specializing in swine, dairy or crop production increased mean financial performance, and specializing in beef production decreased mean financial performance. The increase in mean financial performance associated with swine and dairy production was more likely the result of product-specific economies of scale, while the increase in mean financial performance associated with crop production was more likely the result of an increase in risk.

Mishra et al. (2012) used a DuPont analysis of 1996 – 2009 farm-level USDA ARMS data and found that specialization was a key driver of all three components of ROE: profit margins, asset turnover ratio, and asset-to-equity ratio. Other key drivers of at least one component of ROE included: operator education, operator age, farm size and typology, level of government payments, and whether the farm was involved with vertical coordination and contracting.

Nehring et al. (2014) completed a similar DuPont analysis of U.S. cow-calf enterprises to determine the factors driving economic and financial success. Main drivers of ROE included: region, number of harvested acres on the farm, diversification, operator off-farm work, spousal off-farm work, and technology adoption. Both farm and household income diversification may impact ROE, as indicated by significance of harvested acres, proportion beef, and both operator and spousal off-farm income. Number of cows included in the operation and whether the stocker or finisher operations were included were actually found to have less of an impact on driving ROE of cow-calf operations.

Mishra et al. (1999) measured the likelihood of a farm's success using a logit analysis of 1994 ARMS survey data. Three profitability measures were used to define success if greater than zero: modified net farm income per dollar of assets, operators' labor and management, operators' management income. They found that farmers who diversified were more likely to be successful than those who did not. Other factors that improved success included risk management strategies such as forward contracting inputs and participation in government programs, use of new technology, participation in Extension programs, and good management practices such as using rented or leased land and keeping good financial records.

Mugera and Langemeier (2011) used bootstrap data envelopment analysis to examine technical and scale efficiency scores of Kansas farms and determine whether farm size and specialization matter for productive efficiency. Technical efficiency was found to differ by farm size, but not specialization, with smaller farms less efficient than larger farms. A general deterioration in technical efficiency over the sample period suggested that farms may not have been able to implement new technology or have become more inefficient in farm management.

Chapter 3 - Data and Methods

The purpose of this research is to determine the impact of specialization on farm financial performance and risk. Three-stage least squares regression is used to evaluate the impact of enterprise and operator characteristics on farm financial performance. As a robustness check, two-stage least squares is also used to estimate the model. Data for the balanced panel of 459 Kansas farms comes from the Kansas Farm Management Association (KFMA) database of producer members from 2009 through 2018.

Expected Return-Variance (E-V) Model

The Expected Return-Variance (E-V) analysis is used to evaluate the relationship between risk and return and is the conceptual basis for this study. As noted by Purdy et al. (1997), an advantage of the E-V model is that mean and variance, the first two moments, represent all choices. A mean-variance efficient portfolio, "gives the highest expected return of all feasible portfolios with the same risk" (Markowitz and Fabozzi 2011). The optimal portfolio would be the point that the indifference curve is tangent to the Markowitz efficient frontier created from the mean-variance efficient investments (Markowitz and Fabozzi 2011).

Levy and Markowitz (1979) demonstrated how the E-V model can be used to approximate risk-averse utility functions. An investor would seek to maximize the utility function $U(R)$, where R is the rate of return this period on his/her portfolio. Levy and Markowitz (1979) show that choosing the E, V efficient set can yield returns that are nearly as good as the maximum attainable $EU(R)$ when speculative extremes have low probabilities. If a choice includes both a safe and risky asset, the EV-efficient set includes the utility-maximizing decision (Tobin 1958; Purdy et al. 1997).

The following linear relationship between risk and return can be specified if producer choices are based on a combination of safe and risky assets:

$$E(y) = \alpha + \lambda/2 \quad Var(y) \tag{3.8}$$

where $E(y)$ is the expected or mean outcome, $Var(y)$ is the variance of outcomes, α is the intercept, and λ is the Pratt-Arrow absolute risk aversion coefficient (Purdy et al. 1997). The Pratt-Arrow absolute risk aversion coefficient, a measure of local risk aversion, can be defined as

$$r(x) = -u''(x)/u'(x), \tag{3.9}$$

where $u(x)$ is a utility function for money (Pratt 1964). Utility function $u(x)$ takes on greater curvature as risk aversion increases (Ross 1981). However, expected utility functions are not uniquely defined; this transformation is needed as a measure to remain constant (Pratt 1964).

Conceptual Model

As described in previous literature, the mean ROE is a measure of profitability indicating the return in profit each dollar in equity generates. The following relationship is specified:

$$MROE = f(VROE, AGE, POWN, ICR, DER, OER, NFIR, SPEC, ACRES) \tag{3.1}$$

where *MROE* is the mean return on equity for each farm, *VROE* is the variance of return on equity for each farm, *AGE* is the age of the operator, *POWN* is the percentage of total acres owned, *ICR* is the inverted current ratio, *DER* is the depreciation expense ratio, *OER* is the operating expense ratio, *NFIR* is the net farm income ratio, *SPEC* is a measure or set of measures relating to specialization or diversification, and *ACRES* is the total number of acres operated.

To model risk, a separate equation is estimated:

$$VROE = f(AGE, DTAR, SPEC, GOVT, ACRES, REGION), \tag{3.2}$$

where *DTAR* is the debt-to-asset ratio, *GOVT* is the percentage of gross farm income from government payments, *REGION* is a set of dummy variables indicating the KFMA region in which the farm was located, and all other terms are as defined previously. Following Purdy et al. (1997), the risk equation is estimated four times (once for each of the four specialization specifications).

Variables

The variables listed in the conceptual model above are described below in detail.

Operator Age

Operator age would be expected to have a negative impact on farm financial performance. Mishra et al. (2012) found that asset turnover ratio decreased as operator age increased. They suggested that farmers acquire more assets as they grow older. This finding was supported by Katchova (2005), who found that older farms tended to have farms of higher value. In their analysis of the factors contributing to earnings success of cash grain farms, Mishra et al. (1999) found that operator age, the operator having a primary occupation other than farming, and livestock production were negatively related to a measure of profit.

Inverted Current Ratio

The expected sign for the inverted current ratio is negative. The current ratio is a measure of liquidity and indicates how much of a farm's current liabilities can be covered if current assets were liquidated. The inverted current ratio is calculated as:

$$Inverted\ Current\ Ratio = \frac{Current\ Liabilities}{Current\ Assets}. \qquad (3.3)$$

As the inverted current ratio increases, its ability to immediately repay its current liabilities through its current assets decreases.

Depreciation Expense Ratio

The expected sign for the depreciation expense ratio, a measure of financial efficiency, is negative. The depreciation expense ratio indicates the amount of income the farm needs to maintain the capital used. The depreciation expense ratio is calculated as:

$$Depreciation\ Expense\ Ratio\ =\frac{Total\ Depreciation}{Gross\ Farm\ Income}. \tag{3.4}$$

As the depreciation expense ratio increases, a farm could be wearing out its capital too quickly.

Operating Expense Ratio

The expected sign for operating expense ratio, a measure of financial efficiency, is negative. Operating Expense Ratio is calculated as:

$$Operating\ Expense\ Ratio\ =\frac{Operating\ Expenses}{Gross\ Farm\ Income}. \tag{3.5}$$

Operating expenses exclude principal and interest of loans. As the operating expense ratio increases, a farm becomes more easily vulnerable to changes in markets.

Net Farm Income Ratio

The expected sign on the net farm income ratio is positive. The net farm income ratio is a measure of financial efficiency and indicates the percentage of net farm income remaining following the payment of all expenses except labor and management. The net farm income ratio is calculated as:

$$Net\ Farm\ Income\ Ratio = \frac{Net\ Farm\ Income}{Gross\ Income}. \tag{3.6}$$

As the net farm income ratio increases, a farm is more efficient in managing its costs relative to gross income.

Debt-to-Asset Ratio

The debt-to-asset ratio indicates the amount of the debt the farm has relative to its assets. The debt-to-asset ratio is calculated as:

$$Debt-to-Asset\ Ratio\ = \frac{Total\ Liabilities}{Total\ Assets}. \tag{3.7}$$

The expected sign for debt-to-asset ratio, a measure of solvency, is unknown. As noted by Katchova (2005), the risk-reduction hypothesis would mean that debtholders would have a higher value by diversifying and the farmer-equity holder of a leveraged farm would have a lower value by diversifying. An all-equity farm would not have the same opportunity to shift risk to debtholders as a leveraged farm. However, unlike corporate firms, diversified farms tend to have higher assets for additional enterprises.

Government Payments

Government payments would be expected to have a positive impact on mean financial performance. Mishra, Moss and Erickson (2009) found that government payments impact the farm profit margin and thus impact the value of farm assets such as land, but had no impact on asset turnover. Mishra et al. (2012) found that government payments were a key driver of both asset turnover ratio and net profit margins and note the programs' intended purpose of reducing agricultural risk. Mishra et al. (1999) also found that government payments had a positive impact on farm financial success. Blank et al. (2009) found that government payments had a larger impact on mean farm income as farm size increased, suggesting that payments may go to farms for factors other than financial need.

Specialization

The impact of specialization into crop and livestock production is mixed in the literature. Yeager and Langemeier (2011), in their analysis of Kansas farms, found that the top 45 farms for annual productivity growth tended to receive a larger percentage of income from oilseeds, feed grains, and swine—and received relatively less of their income from small grains. Nehring et al. (2014) found that, among U.S. cow-calf producers, as the proportion of farm from beef cattle increased, the farm's return on equity also increased. However, Purdy et al. (1997) found that specializing in beef production actually decreased mean financial performance—while specializing in swine, dairy, or crop production increased performance. They found that farms with both a crop and livestock enterprise tended to have less variability in financial performance, suggesting decreased risk through diversification.

Acreage, Percentage of Acres Owned

Acres operated would be expected to positively impact mean financial performance (Purdy et al. 1997). Acres operated may be positively related with specialization (Mishra et al. 2012). On U.S. cow-calf operations, Nehring et al. (2014) found that the number of harvested acres on the farm was a major driver of higher return on equity, leading to greater asset efficiency. Further, larger farms may perceive different goals for their operations. Young and Shumway (1991) found that cow-calf producers were more likely to perceive profit maximization as an objective of their operation as their pasture acreage increased in size.

Interestingly, Barry et al. (2001) found that farm acreage was not significant on farm income volatility in a cross-sectional model, but was significant in a time-series model. They suggest that this may be due to periodic variations in farm size, differences in crop prices and yield, degree of enterprise diversification, and geographic location may have an impact over time (Barry et al. 2001). Purdy et al. (1997) found that percentage of acres owned was negatively related to financial performance.

Region

Financial performance and risk would be expected to vary by region due to differences in weather and cropping practices (Poon and Weersink 2011; Purdy et al. 1997), and thus regional dummy variables were controlled for in the model. Mishra et al. (2009), in their national analysis of U.S. farm profitability, found significant differences in profitability by region. Mishra et al. (2012) found that variations in agricultural returns across regions over time were most likely due to different crop portfolios. Nehring et al. (2014) found similar results in their analysis of United States cow-calf producers, with region being one of the biggest drivers of higher return on equity. Blank, Erickson and Moss (2005) also found profit patterns unique to state and regional agriculture. Further, regional socioeconomic differences can affect off-farm work availability and thus cropping portfolio choices (Poon and Weersink 2011; Alasia et al. 2009; Enjolras et al. 2014; Howard and Swidinsky 2000; Jetté-Nantel et al. 2011).

Ordinary Least Squares, Instrumental Variable Approach, Two-Stage Least Squares, & Three-Stage Least Squares

The following represents a regression with an endogenous variable:

$$Y = \gamma_0 + X_1\gamma_1 + \rho S + \varepsilon, \tag{3.10}$$

where Y is the dependent variable, γ_0 is a constant, X_1 is a row vector of covariates, γ_1 is a vector of coefficients (Angrist and Imbens 1995). Given that S is the endogenous variable, the following equation demonstrates the relationship of S to the covariates X_1 and additional covariates X_2 that are not included in the original regression:

$$S = \delta_0 + X_1\delta_1 + X_2\delta_2 + \eta. \tag{3.11}$$

Instrumental variables must only impact the outcome of interest through the treatment of interest (Angrist and Imbens 1995). Instrumental variables can be evaluated in several ways: fitting straight lines using Wald's method, comparing Wald and OLS, and using two-stage least squares (Angrist and Imbens 1995).

Two-stage least squares can be used to address simultaneous equation bias and, more broadly, omitted-variable bias in single equation regression applications (Angrist and Imbens 1995). A key assumption of the ordinary least squares method is that the error term is not correlated with the predictor variables. In contrast, two-stage least squares assumes that a secondary predictor is not correlated to the error term but is correlated to the problematic predictor variable.

Both Wald and two-stage least squares estimates may be reported for models with constant treatment effects, as the two-stage least squares estimates compared to any single Wald estimate have asymptotically lower sampling variance. As noted by Angrist and Imbens (1995), care must be given when interpreting causality of treatment using two-stage least squares and could only be considered causal if treatment status was manipulated in some way. Two-stage least squares is less efficient than ordinary least squares when all explanatory variables are exogenous (Hausman 1978). As noted by Hausman (1978), if the differences between the ordinary least squares and two-stage least squares estimates are not statistically significant, all variables are exogenous.

Estimating a structural equation using two-stage least squares involves two steps: regressing the endogenous regressor on all covariates in the equation and all potential instruments, and then using those model-estimated values from the first stage to estimate the coefficients in one single structural equation (Zellner and Theil 1962; Angrist and Imbens 1995). The second stage estimates the following:

$$Y = \gamma_0 + X_1\gamma_1 + \rho\hat{s} + v, \tag{3.12}$$

where $\hat{s}$ is the fitted value from the first-stage regression and

$$v = \{\varepsilon + \rho[S - \hat{s}]\}. \tag{3.13}$$

Thus, in this case X_1 and $\hat{s}$ can be considered instruments and the two-stage least squares considered as an IV estimator (Angrist and Imbens 1995). Two-stage least squares is more efficient than instrumental variable estimation. The order condition for two-stage least squares requires that the number of exogenous instruments be at least as large as the number of endogenous variables.

The three-stage least squares method adds an additional step to the two-stage least squares to estimate all coefficients simultaneously using the estimated moment matrix of the structural disturbances (Zellner and Theil 1962). In three-stage least squares estimation, all coefficients are estimated simultaneously. In the first stage of three-stage least squares estimation, two-stage least squares estimation is used to estimate the residuals of the structural equations, for all identified equations. The estimated residuals are then used to compute the optimal instrument. Finally, the optimal instrument is then used to jointly estimate the system of equations. Three-stage least squares uses a set of instrumental variables that is common to all equations and is a special case of multi-equation generalized methods of moments.

Three-stage least squares allows correlations of the unobserved disturbances across multiple equations (Zellner and Theil 1962). Because of these full-information characteristics, estimates using three-stage least squares are more efficient than estimates from the two-stage least squares when other equations are over-identified. Estimates from the three-stage least squares are asymptotically normal and consistent. However, if any equation in the system is mis-specified, the two-stage least squares method is more robust. Key assumptions made when using three-stage least squares includes: linear stochastic structural equations, that the reduced form exists so that the system can be solved for the jointly dependent variables, and that the disturbances of the structural equations have zero mean, are serially independent, and are homoscedastic in the sense that their variances and contemporaneous covariances are finite and constant through time.

Zellner and Theil (1962) note three conditions where estimates using two-stage least squares and three-stage least squares estimation would be equivalent. If there are no mutual correlations between the structural disturbances across equations, estimates would be equivalent. Estimates would also be equivalent if all equations in the system are just-identified. If a subset equations is over-identified while other equations in the system are just-identified, estimates using two-stage least squares would be equivalent to estimates using three-stage least squares for the subset of over-identified equations.

Measuring Specialization

Past studies have evaluated several measures of specialization. Pope and Prescott (1980) used four measures of specialization in their analysis of a large cross-section of California crop farms: index of maximum proportion, number of enterprises, Herfindahl specialization index, and an entropy index. The index of maximum proportion was calculated as:

$$Maximum\ Proportion = \max p_i, \tag{3.14}$$

where p_i represents the maximum proportion of gross cash income from *i* enterprise. As specialization increases, the index of maximum proportion would be expected to increase. Number of enterprises was the only metric of the four specialization measures used that was not bounded by zero and one. As specialization increases, the number of enterprises would decrease. Number of enterprises (N) was calculated as:

$$Number\ of\ Enterprises = \sum_{i=1}^{N} I(p_i)\ . \tag{3.15}$$

The Herfindahl index was calculated as:

$$Herfindahl = \sum_{i=1}^{N} p_i^2. \tag{3.16}$$

If a farm were completely specialized, the Herfindahl index would equal one; as *N* becomes large, the Herfindahl index approaches zero.

Purdy et al. (1997) also used four measures of specialization: the Herfindahl index, crop-livestock interaction terms, percentage of income from crops, and the percentage of income from livestock. The Herfindahl index, the percentage of income from crops, and the percentage of income from livestock were included to evaluate the impact of specialization. The percentage of income from crops included the percentage of income from grains and the percentage of income from soybeans/sunflowers; both were included to evaluate the impact of specializing into different sectors of crop production. The percentage of income from livestock included the percentage of income from beef, the percentage of income from swine, and the percentage of income from dairy. Interaction terms between crop and livestock income were used to evaluate the impact of diversification on financial performance, and included a crop-beef interaction term, crop-swine interaction term, and crop-dairy interaction term.

Data

The empirical application of the model outlined previously will use balanced panel data of 459 Kansas farms from 2009 through 2018 to investigate the impact of risk and specialization on mean financial performance. All farms were members of the Kansas Farm Management Association (KFMA), an organization affiliated with the Kansas State Department of Agricultural Economics that provides financial analysis and assistance for Kansas farm members. Enterprise-level production, financial, and cost data of Kansas farm members are maintained by KFMA. The 459 farms used in the balanced sample represent 19.5% of the total number of farms that were registered through the KFMA for at least one year from 2009 through 2018.

Select profitability, financial factors, and production measures for the balanced panel of 459 Kansas farms are displayed in Table 1. The implicit price deflator for personal consumption expenditures is used to convert all financial variables to January 1, 2018 dollars (U.S. Bureau of Economic Analysis 2019).

Table 3-1 Financial and Production Measures for a Sample of 459 Kansas Farms, 2009-2018

Table 1, Balanced Panel (2009-2018)

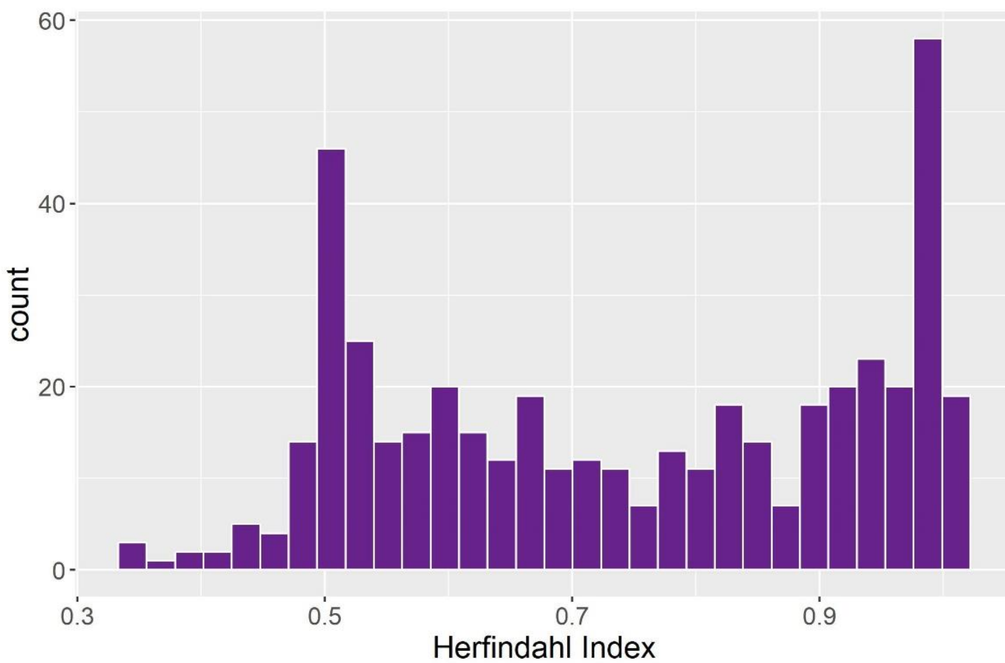
Variable	Unit	Mean	Stan. Dev.	Minimum	Maximum
		<u>Profitability Measures:</u>			
Gross Farm Income	$	586,093.87	777,383.39	0	16,290,357.18
Net Farm Income	$	153,101.38	208,376.66	-1,707,483.52	3,122,179.60
ROA	%	1.47	29.90	-1036.70	61.00
ROE	%	1.34	52.82	-1816.80	1,640.00
Profit Margin Ratio	%	1.57	32.26	-796.20	76.30
		<u>Solvency Measures:</u>			
Debt-to-Asset Ratio	%	22.80	24.37	-0.50	500.00
Total Assets	$	2,264,082.49	2,205,318.66	903.20	22,294,994.23
Net Worth	$	1,830,159.74	1,936,924.18	-101,369.23	20,797,011.06
		<u>Financial Efficiency Measures</u>			
Asset Turnover Ratio	%	36.35	80.97	1.20	3,968.70
Operating Expense Ratio	%	71.58	21.38	13.10	526.80
Depreciation Expense Ratio	%	9.59	5.78	0	105.00
Interest Expense Ratio	%	3.54	4.23	-6.0	43.00
Net Farm Income Ratio	%	15.28	24.76	-531.80	83.20
		<u>Liquidity Measures</u>			
Inverted Current Ratio	%	37.47	44.84	0	395.73
		<u>Farm Characteristics</u>			
Age of Operator	Years	58.33	10.82	23.00	96.00
% Acres Owned	%	34.17	27.68	0	100.00
Herfindahl Index	Index	0.744	19.12	0.33	1.00
Enterprise Count	Count	5.94	1.95	1.00	11.00
% Income from Livestock	%	24.54	28.90	-209.21	100.00

% Income from Crops	%	72.65	29.57	0	290.11
% Income from Custom Work	%	2.79	6.37	0	60.20
% Income from Govt. Pmt.	%	5.59	3.90	0	41.8
		Production Characteristics			
Total Acres Operated	No.	2,299.29	1,956	0	1,6358
Irrigated Crop Acres	No.	83	304	0	3,963
Dryland Crop Acres	No.	1,456	1,205	0	11,188
Pasture Acres	No.	716	1,363	0	16,008
Beef Cows	No.	65	99	0	834
Sows	No.	30	388	0	8,483
Dairy Cows	No.	4	30	0	475
Beef Feeders	No	167	542	0	10,882
Number of Farms	No.	459	459	459	459

The average gross cash farm income (GCFI) for the 459 Kansas farms included in the dataset for the 2009 to 2018 period was $586,094, with a low of $14,164 and a high of $12,490.135. On average, income from livestock accounted for 24.4% of GCFI, total crop production income accounted for 72.8% of GCFI, and income from custom work accounted for 2.8% of GCFI. Of total income from crop production, 64.4% came from grain sorghum, wheat, corn, and other small grains; 33.0% came from cash crops such as soybeans and cotton; and 2.6% came from hay and forage production. Livestock production was primarily beef, with 12.6% of total average GCFI on average from cow-calf sales, 1.0% of GCFI from raised swine, 0.1% of GCFI from milk sales, and 0.04% of GCFI from eggs/poultry sales.

The Herfindahl index was calculated to evaluate the extent to which the farm was diversified or specialized (Purdy et al. 1997; Pope and Prescott 1980). Following Purdy et al. (1997), three enterprises were used in the calculation of the Herfindahl index: crops, livestock, and custom work. The farm's average percentage of GCFI for each enterprise over the 10-year time period was used to calculate one Herfindahl index for each farm. A fully specialized farm would have a Herfindahl index of one, while a diversified farm would have a Herfindahl index of 0.33. For the 459 farms included in the dataset, the average Herfindahl index was 0.75, with a low of 0.33 and a high of 1.00. Figure 3-1 displays the distribution of the Herfindahl index for the 459 farms in the dataset from 2009 through 2018.

Figure 3-1 Herfindahl index of 459 Kansas farms, 2009-2018



As a robustness check, an enterprise count was also calculated for each farm and used in the model in place of the Herfindahl index. Enterprise count was calculated following Pope and Prescott (1980). Using data available in the Kansas Farm Management Association database, enterprises include: barley, corn, cotton, dairy, eggs, feeder cattle, feeder sheep, feeder pigs, fruit, grain sorghum, grass and legume seed, hay, lumber, miscellaneous cash crops, nursery crops, oats, other grains, peanuts and rice, pinto and dry beans, popcorn, raised beef, raised sheep, raised swine, raised poultry, rye, sugar beets, silage (corn and sorghum), soybeans, sunflowers, tobacco, tree nuts, truck crops, vegetables, and wheat. An enterprise was counted once if sales for that enterprise were greater than zero in at least one year from 2009 to 2018. The average enterprise count for farms in the dataset is 6.0, with a minimum of 1.0 and a maximum of 11.0. Figure 3-2 displays the distribution of enterprise counts and Figure 3-3 displays the total number of farms that produced a given enterprise in at least one year between 2009 and 2018. Soybeans, wheat, and corn were the most common crop enterprises of farms in the data set, and cow-calf enterprises and feeder calf enterprises were the most common livestock enterprises of farms in the data set.

Results for the robustness check using enterprise count in place of the Herfindahl index are reported in Appendix A. The Herfindahl index is a measure of specialization; it approaches one as a farm becomes more specialized. In contrast, the enterprise count is a measure of diversification; a farm would be considered more diverse (less specialized) as its enterprise count increases. As a result, the expected sign of the enterprise count would be opposite the expected sign of the Herfindahl index in both the MROE and VROE equations. Enterprise count was not statistically significant in the either the MROE nor VROE equations when estimated using 3SLS. Results suggest that a higher enterprise count was found to be associated with a decrease in both mean and variance of ROE.

Figure 3-2 Enterprise count of 459 Kansas farms, 2009-2018

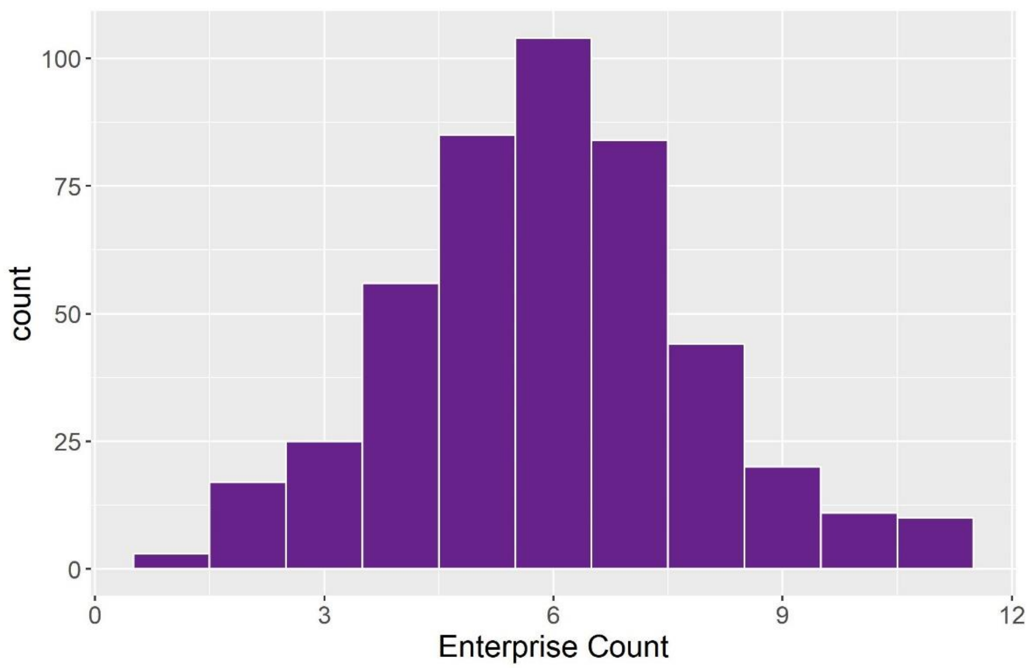
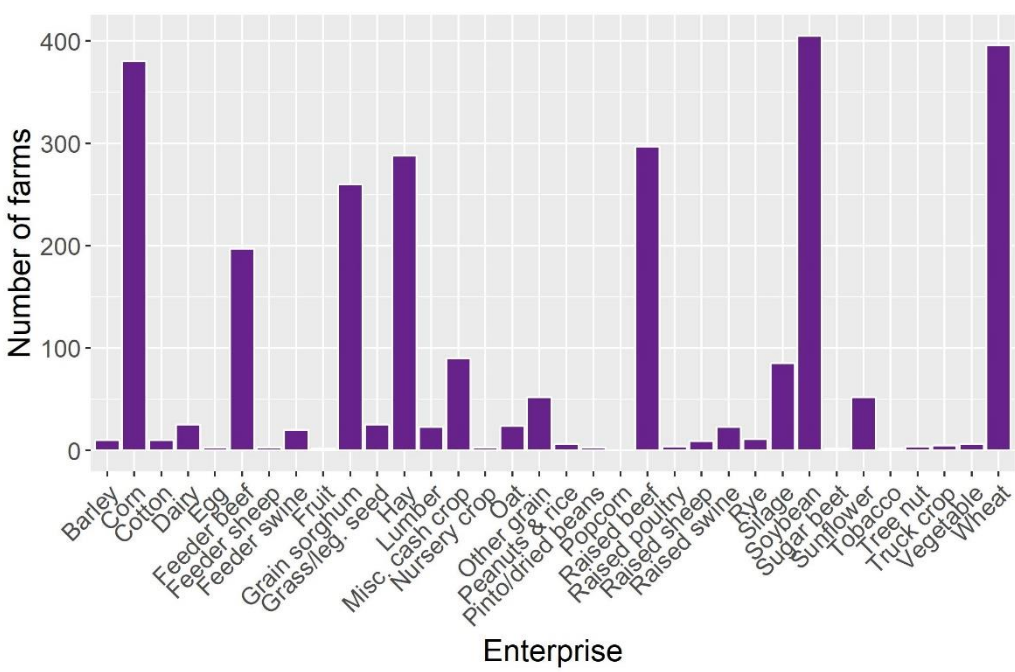


Figure 3-3 Enterprises of 459 Kansas farms, 2009-2018



Chapter 4 - Results

Regression Results

Estimated marginal effects of farm characteristics, financial efficiency, and operator characteristics on mean farm financial performance were calculated and are reported in Tables 4-1 and 4-2. The model was completed for each of four specialization measures: Herfindahl index; crop-livestock and crop-custom work interaction terms; percentage of income from small grains and cash crops; and percentage of income from livestock. Interaction terms were calculated by multiplying together the percentage of gross cash farm income from each enterprise category. Each model was estimated using three-stage least squares (3SLS). Models were also estimated using two-stage least squares (2SLS) as a robustness check.

Table 4-1 Empirical Models Examining the Impact of Diversification on the Mean and Variance of Return on Equity, Estimated Using Three-Stage Least Squares

	Dependent Variable			
	MROE (1)	MROE (2)	MROE (3)	MROE (4)
Variance in ROE	-0.00226 (0.546)	-0.00283 (0.407)	-0.00143 (0.678)	-0.00172 (0.616)
Operator Age	-0.00115 (0.112)	-0.00104 (0.153)	-0.00108 (0.138)	-0.00115 (0.113)
Acres Owned, Percent	-0.016 (0.557)	-0.013 (0.634)	-0.020 (0.484)	-0.017 (0.544)
Inverted Current Ratio	-0.068*** (0.000)	-0.069*** (0.000)	-0.069*** (0.000)	-0.068*** (0.000)
Depreciation Expense Ratio	-0.199 (0.457)	-0.255 (0.341)	-0.150 (0.591)	-0.121 (0.662)
Operating Expense Ratio	-0.467* (0.042)	-0.453* (0.048)	-0.432 (0.062)	-0.405 (0.077)
Net Farm Income Ratio	-0.121 (0.577)	-0.114 (0.598)	-0.062 (0.777)	-0.047 (0.829)
Acres Operated, Total	0.00000508 (0.163)	0.00000522 (0.152)	0.00000313 (0.401)	0.00000397 (0.273)
Herfindahl Index	0.100*** (0.009)			
Crop-Livestock		-0.226*** (0.006)		
Crop-Custom Work		0.141 (0.543)		
Percentage Small Grains			0.042 (0.186)	
Percentage Cash Crop			0.000498 (0.991)	
Percentage Livestock				-0.035 (0.216)

Intercept	0.398 (0.062)	0.481* (0.027)	0.416 (0.054)	0.420 (0.053)

	VROE	VROE	VROE	VROE
Operator Age	0.051*** (0.000)	0.048*** (0.000)	0.048*** (0.000)	0.050*** (0.000)
Debt-to-Asset Ratio	8.630*** (0.000)	8.656*** (0.000)	8.597*** (0.000)	8.570*** (0.000)
Percentage Govt. Pmt.	-1.076 (0.765)	-0.926 (0.797)	-0.620 (0.865)	-1.291 (0.722)
Acres Operated, Total	-0.0000586 (0.416)	-0.0000752 (0.294)	-0.0000672 (0.348)	-0.0000754 (0.291)
Herfindahl	1.493* (0.027)			
Crop-Livestock		-2.854* (0.047)		
Crop-Custom		-7.671 (0.070)		
Percentage Small Grains			-0.323 (0.650)	
Percentage Cash Crops			2.134* (0.027)	
Percentage Livestock				-0.664 (0.158)
Northeast Region	-0.440 (0.217)	-0.408 (0.252)	-0.502 (0.160)	-0.512 (0.153)
North Central Region	0.019 (0.956)	-0.022 (0.948)	0.220 (0.545)	-0.059 (0.860)
South Central Region	-0.059 (0.889)	-0.048 (0.910)	0.522 (0.321)	-0.052 (0.904)
Southwest Region	-0.232 (0.769)	-0.166 (0.833)	0.527 (0.557)	-0.292 (0.713)

Northwest Region	0.408 (0.0450)	0.428 (0.425)	1.147 (0.093)	0.376 (0.490)
Intercept	-5.474*** (0.000)	-3.761*** (0.000)	-4.782*** (0.000)	-4.062*** (0.000)
N	459	459	459	459
R-sq	0.137	0.134	0.137	0.134
Df_m	9	10	10	9

p-values in parentheses
*p<0.05, ** p<0.01, ***p<0.001

Table 4-1 presents the econometric results from the 3SLS regressions for the mean ROE and variance in ROE equations. The system R^2 measures for the four equations using different measures of specialization ranged from 0.134 to 0.137.

Results for the mean ROE equations are presented in table 4-1. The inverted current ratio, a measure of liquidity, was significant at the 1% significance level in all equations. The operating expense ratio, a measure of financial efficiency, was significant at the 5% significance level in equations (1) and (2). The coefficients on variance in ROE, operator age, percentage of acres owned, depreciation expense ratio, net farm income ratio, and total acres operated were not significant in the MROE equations. Table 4-1 also presents the results for the VROE equations. Operator age and debt-to-asset ratio were significant at the 1% significance level for all equations.

Several coefficients on variables used to measure specialization were significant. The coefficient on the Herfindahl index, a measure of specialization, was significant in both MROE and VROE equations. The sign of the coefficient on the Herfindahl index was positive, indicating that both MROE and VROE increased as the Herfindahl index increased (as a farm became more specialized). The coefficient of the crop-livestock interaction term was statistically significant at the 1% significance level in the MROE equation and had a positive sign. The coefficient on percentage of income from cash crops was statistically significant in the VROE equation at the 1% significance level and had a positive sign, indicating that the VROE increased as a farm received a greater percentage of its income from cash crops such as soybeans and cotton. No coefficients on other measures of specialization were significant in either the MROE nor VROE equations.

Table 4-2 presents the econometric results from the 2SLS regressions for the mean ROE and variance in ROE equations. The system R^2 measures for the four equations using different measures of specialization ranged from 0.178 to 0.183.

Table 4-2 Empirical Models Examining the Impact of Diversification on the Mean and Variance of Return on Equity, Estimated Using Two-Stage Least Squares

	Dependent Variable			
	MROE (1)	MROE (2)	MROE (3)	MROE (4)
Variance in ROE	0.00250 (0.476)	0.00216 (0.537)	0.00324 (0.358)	0.00296 (0.398)
Operator Age	-0.00146* (0.048)	-0.00134 (0.071)	-0.00137 (0.065)	-0.00144 (0.051)
Acres Owned, Percent	0.00615 (0.983)	0.00412 (0.887)	-0.00325 (0.910)	-0.000679 (0.981)
Inverted Current Ratio	-0.070*** (0.000)	-0.071*** (0.000)	-0.071*** (0.000)	-0.070*** (0.000)
Depreciation Expense Ratio	0.146 (0.597)	0.110 (0.690)	0.198 (0.491)	0.214 (0.454)
Operating Expense Ratio	-0.109 (0.645)	-0.082 (0.730)	-0.081 (0.734)	-0.058 (0.807)

Net Farm Income Ratio	0.229 (0.306)	0.250 (0.263)	0.281 (0.211)	0.292 (0.190)
Acres Operated, Total	0.00000510 (0.167)	0.00000536 (0.146)	0.00000323 (0.392)	0.00000413 (0.259)
Herfindahl Index	0.0838* (0.032)			
Crop-Livestock		-0.191* (0.021)		
Crop-Custom Work		0.203 (0.389)		
Percentage Small Grains			0.034 (0.286)	
Percentage Cash Crop			-0.107 (0.810)	
Percentage Livestock				-0.027 (0.342)
Intercept	0.079 (0.720)	0.130 (0.563)	0.096 (0.668)	0.097 (0.666)

	VROE	VROE	VROE	VROE
Operator Age	0.051*** (0.000)	0.048*** (0.000)	0.048*** (0.000)	0.050*** (0.000)
Debt-to-Asset Ratio	8.638*** (0.000)	8.662*** (0.000)	0.048*** (0.000)	8.579*** (0.000)
Percentage Govt. Pmt.	-1.748 (0.640)	-1.531 (0.682)	-1.387 (0.715)	-1.906 (0.612)
Acres Operated, Total	-0.0000551 (0.451)	-0.0000722 (0.323)	-0.0000640 (0.380)	-0.0000733 (0.313)
Herfindahl	1.519* (0.027)			
Crop-Livestock		-2.893* (0.047)		

Crop-Custom		-7.711 (0.073)		
Percentage Small Grains			-0.190 (0.794)	
Percentage Cash Crops			1.980* (0.045)	
Percentage Livestock				-0.667 (0.162)
Northeast Region	-0.370 (0.317)	-0.352 (0.342)	-0.452 (0.223)	-0.464 (0.212)
North Central Region	0.070 (0.839)	0.0460 (0.895)	0.197 (0.602)	-0.037 (0.915)
South Central Region	-0.020 (0.965)	-0.00271 (0.995)	0.477 (0.383)	-0.00521 (0.991)
Southwest Region	-0.105 (0.898)	-0.060 (0.942)	0.496 (0.595)	-0.197 (0.811)
Northwest Region	0.420 (0.452)	0.447 (0.425)	1.021 (0.150)	0.384 (0.497)
Intercept	-5.520*** (0.000)	-3.789*** (0.000)	-4.781*** (0.000)	-4.071*** (0.000)
N	459	459	459	459
R-sq	0.182	0.183	0.181	0.178
Df_m	9	10	10	9

p-values in parentheses
*p<0.10, ** p<0.05, ***p<0.001

Econometric results were similar for regressions estimated using 3SLS estimation and 2SLS estimation. Three-stage least squares regression estimation can be more efficient as it allows for correlations between disturbances across multiple equations. However, 2SLS is more robust if any equation is mis-specified. Similar to the regression estimates using 3SLS, the coefficient on the inverted current ratio was statistically significant in all equations and had a negative sign. Operator age was statistically significant in equation (1) using 2SLS estimation but was not statistically significant using 3SLS regression. The coefficient for operating expense ratio was not statistically significant at the 0.05 significance level for any equations estimated using 3SLS.

Econometric results using 2SLS regressions and 3SLS regressions were similar for all four specialization variables. Using the two-stage least squares, the Herfindahl index as a measure of specialization was statistically significant at the 0.05 percent significance level. Similar to the results estimated and presented in Table 4-1 using 3SLS, the coefficient of the crop-livestock interaction term was statistically significant in both the MROE and VROE equations. The coefficient on the percentage of income from cash crops (such as cotton and soybeans) was statistically significant in the VROE equation; farms that diversify into both crop and livestock production are associated with lower variance in ROE. Similar to the results estimated using 3SLS, the coefficient on the percentage of income from livestock was not statistically significant as estimated using 2SLS.

Financial performance elasticities are presented in Table 4-3 and were calculated using the regression coefficients presented in Table 4-1 and the variable means presented in Table 3-1. All percentage variables were estimated in decimal form and all elasticities for variables appearing in both equations were estimated using the chain rule. In terms of magnitude, operating expense ratio was found to have the largest impact on MROE in the first equation in Table 4-3, followed by the Herfindahl index, operator age, the inverted current ratio, the depreciation expense ratio, the net farm income ratio, total acres operated, percentage acres owned, and VROE (Table 4-1 and Table 4-2).

Table 4-3 Financial Performance Elasticities for Mean Return on Equity Equations

	Equation Number			
Variable	(1)	(2)	(3)	(4)
VROE	-0.0048	-0.0060	-0.0031	-0.0037
Operator Age	-0.5586	-0.5195	-0.5076	-0.5461
Acres Owned, Percent	-0.0422	-0.0342	-0.0505	-0.0440
Inverted Current Ratio	-0.1933	-0.1964	-0.1967	-0.1922
Depreciation Expense Ratio	-0.1446	-0.1852	-0.1090	-0.0879
Operating Expense Ratio	-2.5325	-2.4565	-2.3427	-2.1963
Net Farm Income Ratio	-0.1400	-0.1319	-0.0715	-0.0543
Acres Operated, Total	0.0908	-0.0946	0.0562	0.0714
Herfindahl Index	0.7250			
Crop-Livestock		0.0055		
Crop-Custom Work		0.0211		
Percentage Small Grains			0.1472	
Percentage Cash Crop			-0.0047	
Percentage Livestock				-0.0626

There was a relatively large and negative relationship between the operating expense ratio and mean financial performance. Using the elasticity from the first equation presented in Table 4-2, a 10% increase in the operating expense ratio (0.7158 to 0.7874) would result in a 25.3% decrease in MROE from 0.0134 to 0.0100. Operating expense ratio, a measure of financial efficiency, is an indicator of how well a farm manages operating expenses (expenses excluding principal and interest) relative to gross farm income. As expected, as operating expense increased relative to gross farm income, MROE decreased.

The relationship between operator age and mean financial performance was negative. Using the elasticity from the first equation presented in Table 4-2, a 10% increase in the operator age (from 58.33 to 64.163) would result in a 5.6% decrease in MROE from 0.0134 to 0.0126. In the econometric regression using 3SLS, operator age was significant for the first equation presented in table 4-1 for both MROE and VROE.

The elasticity of the inverted current ratio had the expected negative sign and was significant in each MROE equation. The inverted current ratio indicates a farm's current liabilities relative to its current assets and is thus an indicator of a farm's liquidity. As the inverted current ratio increases, a farm's ability to repay its current liabilities by liquidating its current assets decreases. Using the elasticity in equation (1) presented in Table 4-2, a 10% increase in the inverted current ratio (0.3747 to 0.4122) would result in a decline in MROE by 1.93% from 0.0134 to 0.0131.

Using the elasticities presented in Table 4-3, the relationship between the depreciation expense ratio and MROE was negative for all four equations. The depreciation expense ratio indicates the amount of income the farm needs to maintain the capital used. As the depreciation ratio increases, a farm may be at risk of using capital too quickly. Using the elasticity in equation

(1) presented in Table 4-2, a 10% increase in the deprecation expense ratio (0.0959 to 0.10549) would result in a decline in MROE by 1.4% from 0.0134 to 0.0132. The depreciation expense ratio was not statistically significant in the 3SLS regressions at the 0.05 significance level in any of the four equations presented in Table 4-2.

There was a negative relationship between MROE and VROE in all equations, and MROE was relatively unresponsive to changes in the VROE compared to other variables. VROE was not significant in any of the four 3SLS regressions on MROE. Using the elasticity from the first equation presented in Table 4-2, a 10% increase in the VROE (0.2815 to 0.3097) would result in a decline in MROE by -0.048%, or a decline in MROE from 0.0134 to 0.01339.

Several measures of specialization were used, but only the coefficients of the Herfindahl index and the crop-livestock interaction term were statistically significant in the MROE equation. The coefficient of the Herfindahl index variable in equation 1 of Table 4-1 was positive and statistically significant in both the MROE and the VROE equations. This suggests that specialization increases both mean and variance in financial performance. The elasticity of the Herfindahl index on mean financial performance was positive and relatively large compared to other variables, due to its positive sign in both the MROE and VROE equations. Using the elasticity for the Herfindahl index presented in Table 4-2, a 10% increase in the Herfindahl index (0.744 to 0.818) would result in an increase in MROE by 7.3%, or an increase in MROE from 0.0134 to 0.0144. As discussed previously, the Herfindahl index would be 0.33 for a farm that is diversified and 1.00 for a farm that is fully specialized into a single enterprise. A farm could achieve this increase in the Herfindahl index (an increase in specialization) with infinite combinations and changes in enterprises. As an example, a 10% increase in the Herfindahl index (0.744 to 0.818) would be the equivalent of a farm that receives 70% of GCFI from enterprise 1, 50.3% of GCFI from enterprise 2, and 0% of GCFI from enterprise 3 becoming more specialized to where 80% of GCFI is from enterprise 1, 42.2% of GCFI is from enterprise 2, and 0% of GCFI is from enterprise 3.

The crop-livestock interaction term had a small, but positive impact on mean financial performance, as indicated by the elasticity presented in Table 4-2, due to the differences in sign of the crop-livestock interaction term between the MROE and the VROE equations as well as the negative sign of the coefficient of VROE in the MROE equation. Although the percentage of income from cash crops variable had a positive and statistically significant coefficient in the MROE equation, its negative coefficient in the VROE equation caused it to have a relatively small and negative impact on mean financial performance as indicated by the elasticities presented in Table 4-2.

Discussion

In 2015, the majority of agricultural production in the United States came from farms with over $1 million in sales (MacDonald et al. 2018). Consolidation into crop production in the United States consistently increased from 1982 through 2012; consolidation into livestock production in the United States increased in a more episodic pattern (MacDonald et al. 2018). In addition to consolidating, American agriculture has become more specialized in recent decades (MacDonald et al. 2018). The majority of US crop production now comes from farms producing two or fewer crops, and nearly a third of the nation’s livestock in 2015 was raised on farms that do not raise crops. Farms in the Kansas Farm Management Association (KFMA) dataset have followed similar trends.

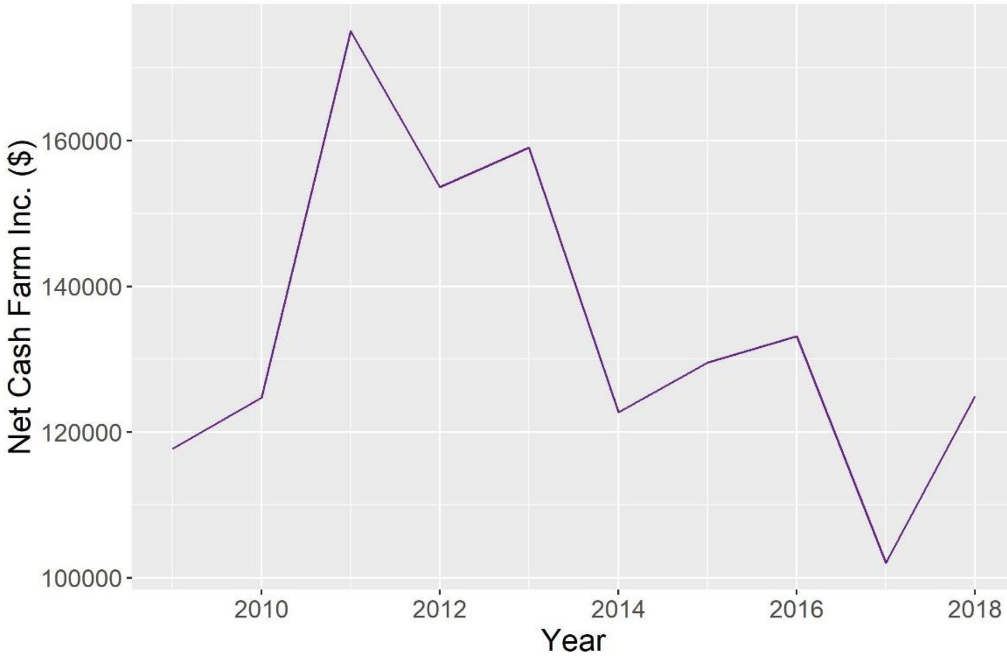
The average Herfindahl index of farms in the Purdy et al. (1997) dataset was 0.6691, with the average farm in the data set receiving 34% of gross cash farm income (GCFI) from livestock production and 62% from crop production. In contrast, the average Herfindahl index of farms in this study was 0.744, with the average farm in the data set receiving 25% of GCFI from livestock production and 73% of GCFI from crop production. Further, the average GCFI from 2009 through 2018 of the 459 KFMA member farms used in this study was $586,094, with an average ROE of 1.34%. In contrast, the average GCFI from 1985 through 1994 of the 320 KFMA member farms used by Purdy et al. (1997) was $236,166 with an average ROE of 3.95%.

Purdy et al. (1997) found that risk, operator age, financial efficiency, and farm size had the greatest impact on mean financial performance. In contrast, the financial performance elasticities for mean ROE found in this study suggest that the operating expense ratio (a measure of financial efficiency), specialization, operator age, and the inverted current ratio (a measure of liquidity) had the greatest impact on mean financial performance. As the agriculture industry continues its pattern of consolidation, results from this study suggest that farm managers' ability to effectively manage and keep operating costs low relative to farm income is associated with higher mean farm financial performance. Results from this study also suggest that farms that are less liquid (less able to cover current liabilities with current assets), are associated with lower mean farm financial performance. Purdy et al. (1997) did not include the inverted current ratio or another measure of liquidity in their analysis.

Similar to Purdy et al. (1997), results from this study also suggest that specialization is associated with greater mean and variance of farm financial performance. Farms in the KFMA dataset used in this study from 2009 through 2018 were, on average, more specialized than the KFMA farms in the dataset used by Purdy et al. (1997) from 1985 through 1994. Over 140 farms in the dataset used in this study had a Herfindahl index greater than 0.9, indicating that they were nearly fully specialized; 45 farms in the dataset had a Herfindahl index less than 0.5. Figure 3-2 presents the distribution of the Herfindahl index for farms in the dataset from 2009 through 2018. Results from this study, similar to Purdy et al. (1997), also suggest that receiving a higher percentage of income from cash crops is associated with greater variance in ROE.

In contrast to Purdy et al. (1997), this study found that VROE was associated with lower mean financial performance. Using the financial performance elasticities for mean financial performance found in this study, VROE had the smallest relative impact on mean financial performance of all independent variables. This could be caused by several factors. As indicated by Figure 4-1, the decade from 2009 through 2018 was characterized by large fluctuations in farm income. Results in this study suggest that farm that were unable to manage the risk/variance in farm financial performance were associated with lower mean financial performance. However, the coefficient of VROE was not statistically significant in any of the four MORE regression equations. As the farms that are part of KFMA dataset have shifted over time to be larger and more specialized on average, and as the distribution of farm size and specialization has shifted as well, it is possible that they could be more vulnerable to fluctuations in farm income. Results from all VROE equations estimated using 3SLS regression suggest that farms with older operators and farms that are more leveraged (a higher debt-to-asset ratio) are associated with greater risk/variance in ROE.

Figure 4-1 Net Cash Farm Income of all KFMA farms, 2009-2018



Chapter 5 – Summary and Concluding Remarks

American agriculture continues to become more specialized. The impact on specialization for farm financial performance depends on the magnitude of returns of scope and scale, as well as the impact of specialization on risk. The objective of this research was to evaluate the impact of farm specialization on mean financial performance. Farm-level, longitudinal data from 459 Kansas Farm Management Association member farms from 2009 through 2018 was used in the analysis. The impact of farm and operator characteristics on mean financial performance was estimated using 3SLS regression.

Specialization was found to increase both mean and variance of farm financial performance. Whole-farm specialization as measured by the Herfindahl index was found to increase both mean and variance of ROE. Producing both livestock and crops was associated with lower mean financial performance. As a farm became more specialized into small grains, variance in their financial performance increased.

Several farm and operator traits were controlled for in the analysis. Operating expense ratio, a measure of financial efficiency, was found to have a large and negative impact on mean financial performance. Operating expense ratio is calculated as a farm's operating expenses relative to its gross farm income and indicates how efficiently a farm manages its operating costs. If farm management controls their expenses more efficiently, their financial performance would be expected to improve. The inverted current ratio, a measure of liquidity, was found to have a large negative impact on mean financial performance. The inverted current ratio reflects a farm's ability to repay its current liabilities by liquidating its current assets. As inverted current ratio increases, a farm becomes less liquid and its mean financial performance would be expected to decrease. An increase in operator age and an increase in debt-to-asset ratio (farms became more leveraged) were both associated with an increase in the variance of ROE.

Limitations

This research focused on crop, livestock, and custom work as a measure of specialization due to limitations in the dataset. Specialization measures were limited to measurements using percentage of enterprise income as a percentage of gross farm income. However, as an enterprise such as a cow-calf enterprise expands (becomes more specialized), its sales that year would be expected to decline as they retained heifers to expand the herd in the future. To account for this, data was aggregated at the crop, livestock, and custom-work levels and averaged over the 10-year timeframe to calculate specialization measures. However, specialization measures were limited to this proxy using percentage of income and did not include behavioral aspects or farmers' stated future plans.

The impact of local economic conditions and the decision to work off-farm were not considered. Off-farm income was estimated using a separate equation in the 3SLS regression alongside VROE but was not found to be significant and removed from the final model specification. It may be possible that the decision to specialize/diversify is endogenous with the decision to work off-farm as well as farm financial performance. However, total off-farm income in the dataset was reported only at the household level—rather than distinguishing between operator and spousal off-farm income.

Future Research

The Herfindahl index, used in this study as a measure of specialization, was calculated using the farm's average percentage of GCFI from the crop, livestock, and custom work enterprises over the 10-year timeframe. However, it is possible that farms may become more/less specialized within those three enterprises from year to year. Aggregating enterprises at the crop, livestock, and custom work level did not allow the Herfindahl index to capture the impact of a farm's specialization/diversification of crop choice/patterns within an enterprise. Future research should evaluate the best timeframe to base the Herfindahl index.

The crops enterprise used to calculate the Herfindahl index was the sum of all income from all crops produced, and the livestock enterprise was the sum of all livestock produced. However, as discussed previously, the average farm in the dataset produced 6 different crops and livestock in at least one year over the 10-year time period. Future research should further investigate the Herfindahl index as a measure of specialization. It is possible that farms may adjust their crop portfolio from year to year, and that decision to specialize/diversify by altering crop mix was not captured in this study.

This research focused on the impact of specialization on the mean and variance of farm financial performance. However, farm families increasingly rely on a diverse income portfolio at the household level (Mishra and Sandretto 2002; Burns and MacDonald 2018). The decision to specialize/diversify at the farm level may impact both the operator's decision to work off-farm and the amount of off-farm income earned. Additionally, specializing/diversifying into certain enterprises may allow for farm household wealth accumulation through assets such as farmland (Blank et al. 2009).

Little is understood of the impact of farm specialization/diversification on farm household income and wealth accumulation. A farm may make the decision to specialize/diversify based on household and local economic characteristics—in addition to the impact on farm financial performance. If so, the impacts of farm specialization/diversification may impact farm financial performance and variance, household income, and household wealth accumulation. Future research should evaluate the farm and household characteristics associated with the decision to specialize at the farm level and the impact of specialization at the farm level on household income and wealth accumulation.

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Appendix A - Enterprise Count

	Dependent Variable	
	MROE, 2SLS (1)	MROE, 3SLS (2)
Variance in ROE	0.00348 (0.317)	-0.000993 (0.770)
Operator Age	-0.00149* (0.045)	-0.00121 (0.097)
Acres Owned, Percent	-0.00409 (0.887)	-0.0197 (0.478)
Inverted Current Ratio	-0.0679*** (0.000)	-0.0657*** (0.000)
Depreciation Expense Ratio	0.310 (0.244)	-0.00617 (0.981)
Operating Expense Ratio	-0.0337 (0.886)	-0.362 (0.112)
Net Farm Income Ratio	0.326 (0.137)	0.00559 (0.979)
Acres Operated, Total	0.00000430 (0.243)	0.00000411 (0.259)
Enterprise Count	-0.00313 (0.385)	-0.00356 (0.317)
Intercept	0.0794 (0.719)	0.386 (0.072)
	VROE	VROE
Operator Age	0.0485*** (0.000)	0.0483*** (0.000)
Debt-to-Asset Ratio	8.599*** (0.000)	8.589*** (0.000)
Percentage Govt. Pmt.	-1.967 (0.601)	-1.398 (0.701)

Acres Operated, Total	-0.0000630 (0.393)	-0.0000657 (0.364)
Enterprise Count	-0.100 (0.144)	-0.0977 (0.148)
Northeast Region	-0.392 (0.291)	-0.453 (0.206)
North Central Region	0.104 (0.770)	0.0598 (0.861)
South Central Region	0.150 (0.735)	0.0833 (0.846)
Southwest Region	-0.139 (0.866)	-0.237 (0.766)
Northwest Region	0.452 (0.421)	0.428 (0.430)
Intercept	-3.652*** (0.000)	-3.638*** (0.000)
N	459	459
R-sq	0.181	0.141
Df_m	9	9

p-values in parentheses
*p<0.05, ** p<0.01, ***p<0.001