Factors Impacting Variability and Downside Risk

By Michael Langemeier and Elizabeth Yeager

Michael Langemeier is a Professor in the Department of Agricultural Economics at Purdue University. Elizabeth Yeager is an Associate Professor in the Department of Agricultural Economics at Kansas State University.

Abstract

This study examined factors impacting variability and downside risk for a sample of Kansas farms using data from 2007 to 2019. Liquidity, solvency, and the percentage of labor devoted to crop production were significantly related to the standard deviation of return on equity. Downside risk was measured as the number of years during the study period in which return on equity was negative. Value of farm production, financial efficiency, liquidity, percentage of acres owned, and the percentage of labor devoted to crop production were significantly related to downside risk. The risk measures were weakly correlated with each other; thus, when developing strategies to mitigate risk it is extremely important to determine whether a farm is more concerned about variability or downside risk.

INTRODUCTION

Variability and downside risk are commonly used to measure risk in production agriculture (Hardaker et al., 2004). Variability focuses on dispersions from the mean, while downside risk focuses on low outcomes. Understanding the relative importance of the various factors impacting risk is an important component of developing and implementing a risk management strategy.

Research that examines the factors impacting risk in production agriculture, whether risk is measured using variability or downside risk, is limited and quite dated. Schurle and Tholstrup (1989) and Purdy, Langemeier, and Featherstone (1997) are representative of studies that have explored factors impacting variability. Schurle and Tholstrup (1989) investigated the relationship between business risk and farm characteristics for a sample of Kansas Farm Management Association (KFMA) farms. Business risk was measured using the variance of net farm income to capital managed squared. Farm size, the interest expense ratio, age of operator, and net farm income as a proportion of capital managed were significant and positively related to business risk, while the percentage of income derived from government payments was significant and negatively related to business risk. Purdy, Langemeier, and Featherstone (1997) examined the impact of farm characteristics on the mean and standard deviation of the return on equity using a sample of KFMA farms. Variability in return on equity, swine/crop diversification, dairy/crop diversification, and farm size were significant and positively related to mean return on equity. Age of operator, percentage of acres owned, expense ratios, and debt-to-asset ratio were significant and negatively related to the mean return on equity. The debt-to-asset ratio was significant and positively related to variability, while percentage of income derived from government payments and crop/livestock diversification were significant and negatively related to variability.

Examples of previous works that have examined factors impacting downside risk include Langemeier and Jones (2000) and Russell et al. (2019). Langemeier and Jones (2000) identified the factors impacting downside risk or the percentage of years with a negative return on equity for a sample of KFMA farms. Farm characteristics

included in the analysis were the current ratio, debt-to-asset ratio, total expense ratio, age of operator, percentage of income from livestock, and farm size. The total expense ratio, debt-to-asset ratio, percentage of income from livestock, and age of operator were significant and positively related to downside risk. Farm size was significant and negatively related to downside risk. Russell et al. (2019) investigated the effect of the ethanol mandate on downside risk for a sample of KFMA farms. The inverse current ratio, debt-to-asset ratio, and percentage of income from government payments were significant and positively related to downside risk.

The objective of this study is to examine the factors impacting variability and downside risk for a sample of KFMA farms using data from 2007 to 2019. Variability was measured using the standard deviation of return on equity for each farm, and downside risk was measured using the percentage of years for which return on equity was negative for each farm. In addition to examining the factors impacting risk, this study explored the factors impacting average financial performance, as well as the relationship between average financial performance, variability in financial performance, and downside risk.

METHODS

Regression analysis was used to investigate the relative importance of farm characteristics in explaining return on equity, standard deviation of return on equity, and downside risk, measured using the percentage of years during the study period in which return on equity was negative. Specifically, using previous research as a guide, the following relationships were examined:

1. ROE = f(VFP, PGOVT, ExpR, CR, DTAR, POWN, CROPL)
2. SROE = f(VFP, PGOVT, ExpR, CR, DTAR, POWN, CROPL)
3. DOWN = f(VFP, PGOVT, ExpR, CR, DTAR, POWN, CROPL)

where ROE represents the average return on equity for each farm; SROE represents the standard deviation of return on equity for each farm; DOWN represents the percentage of years for which return on equity was negative for each farm; VFP represents value of farm production, a measure of farm size; PGOVT represents the percentage of value of farm production derived from government payments; ExpR represents the economic total expense ratio; CR represents the inverted current ratio; DTAR represents the debt-to-asset ratio; POWN represents the percentage of acres owned; and CROPL represents the percentage of labor devoted to crop production. Return on equity was computed by subtracting unpaid family and operator labor from net farm income and dividing the result by average net worth. Unrealized capital gains on land were excluded from the computation of ROE. The definitions of all of the other dependent and independent variables are self-explanatory, with the possible exception of the economic total expense ratio, which is computed by adding together accrual expense, unpaid operator and family labor, and an opportunity charge on owned equity and then dividing the result by value of farm production. More information pertaining to this ratio can be obtained from Langemeier (2013).

Rather than providing regression coefficients for each dependent variable, we present the standardized beta coefficients for each regression. Because they are unitless, standardized beta coefficients can be used to rank the relative importance of each independent variable. Coefficients that are larger in absolute value are relatively more important in explaining the dependent variable. Each standardized beta coefficient is computed by multiplying the independent variable's regression coefficient by the ratio of the standard deviation for the independent variable of interest to the standard deviation of the dependent variable. Interpretation is in terms of standard deviations. For example, a standardized beta coefficient of 1 would indicate that a 1 standard deviation change in the explanatory variable would result in a 1 standard deviation change in the dependent variable.

To further explore differences in return on equity, variability, and downside risk, farms were sorted into top and bottom groups. Approximately 30% of the farms had 0, 1, or 2 years in which return on equity was negative. These 80 farms were designated as the top group in terms of downside risk. The bottom group was represented by the remaining 190 farms. Because 80 farms were designated as being in the top group in terms of downside risk, the same number of farms were used to designate the top groups in terms of ROE and the standard deviation of ROE. It is important to note that the same 80 farms did not represent the top group for return on equity, the standard deviation of return on equity, or downside risk. The top group in terms of return on equity had an average return on equity for the period of 0.0517 or greater. The top group for the standard deviation of return on equity measure was represented by farms with a standard deviation below 0.0495. T-tests were used to determine whether there were significant differences in the independent variables between the top and bottom groups for each dependent variable.

DATA

The data used in this study came from the KFMA data bank. Specifically, KFMA farms with continuous data from 2007 to 2019 were used in the analysis. A total of 270 farms had continuous data over the study period.

Table 1 presents the summary statistics for dependent and independent variables. The average return on equity (ROE) was 0.0171. Because this study focuses on a farm's ability to cover unpaid family and operator labor, ROE excludes capital gains on land that in general are not available to cover unpaid labor. The ROE values in Table 1 represent the average ROE for the 270 farms. Using average net farm income, average unpaid operator and family labor, and average net worth for the 270 farms, return on equity was 0.0277. Average downside risk was 0.352, which indicates that on average 35.2% of the years during the 2007 to 2019 period had a ROE below zero (i.e., downside risk was prevalent). The number of farms with zero or one year in which ROE was negative was 17 and 32, respectively.

The average value of farm production was approximately $576,000, and the average percentage of value of farm production derived from government payments from all sources was 5.8%. The average economic total expense ratio was 1.292, which indicates that on average the farms were not able to fully cover accrual expense, opportunity cost on unpaid family and operator labor, and opportunity cost on owned equity (Langemeier, 2013). The average current ratio (inverted current ratio) was 3.26 (0.307), and the average debt-to-asset ratio was 0.210. On average, approximately one-third of the total acres operated per farm was owned. The average percentage of labor devoted to crop production was approximately 80%.

RESULTS

The standardized beta coefficients for each dependent variable are illustrated in Table 2. Value of farm production was significant and positively related to ROE, and the economic total expense ratio and debt-to-asset ratio were significant and negatively related to ROE. These results are consistent with Purdy, Langemeier, and Featherstone (1997). The economic total expense ratio had the largest absolute value for any of the standardized beta coefficients in the ROE regression. Using the standardized beta coefficient for the economic total expense ratio, a 1 standard deviation increase in the economic total expense ratio would result in a 0.409 standard deviation decrease in ROE. Table 3 presents differences in characteristics between farms in the bottom and top ROE categories. To be in the top ROE category, a farm had to have an average ROE during the study period of at least 0.0517. There were 80 farms in the top category and 190 farms in the bottom category. The average ROE was 0.0924, and average standard deviation of ROE was 0.138 for the top group. On average, the downside risk measure for the farms in the top group was 0.161. Focusing on the variables that were significantly related to ROE in Table 3, the farms in the top group were larger, had a substantially lower economic total expense ratio, and had a higher debt-to-asset ratio.

The debt-to-asset ratio and the percentage of labor devoted to crops were significant and positively related to the standard deviation in ROE (SROE), while the inverted current ratio was significant and negatively related to SROE (Table 2). The results with respect to the debt-to-asset ratio and the percentage of labor devoted to crop production were consistent with Purdy, Langemeier, and Featherstone (1997). The inverted current ratio was not included as an independent variable for SROE in Purdy, Langemeier, and Featherstone (1997). In terms of absolute values, the debt-to-asset ratio had the largest standardized beta coefficient. Using the standardized beta coefficient for the debt-to-asset ratio, a 1 standard deviation increase in the debt-to-asset ratio would result in a 0.609 standard deviation increase in SROE. Table 4 presents the characteristics for the farms in the bottom and top SROE categories. There were 80 farms in the top category and 190 farms in the bottom category. To be in the top SROE category, a farm had to have an SROE value of 0.0495 or less. Average ROE and SROE for the farms in the top group, in terms of SROE, were 0.008 and 0.035, respectively. On average, downside risk was 0.372 for the top group. Focusing on the variables that were significant in the SROE regression, the farms in the top group had a higher current ratio and a lower debt-to-asset ratio, and they devoted less of their time to crop production.

Langemeier and Yeager (2021) examined differences in farms for Sharpe ratio categories. The Sharpe ratio is computed by dividing ROE by SROE (see Sharpe [1966] and Sharpe [1994] for more information pertaining to the computation and use of Sharpe ratios). There were only four farms that were in both the top ROE category and the top SROE category. Clearly, it was very difficult to have both a high ROE and a low SROE.

The economic total expense ratio, inverted current ratio, and percentage of labor devoted to crop production were significant and positively related to downside risk, while value of farm production and percentage of

acres owned were significant and negatively related to downside risk (Table 2). The results with respect to the economic total expense ratio, inverted current ratio, and value of farm production were consistent with Langemeier and Jones (2000). In contrast to the results in this study, Langemeier and Jones (2000) found a negative relationship between downside risk and percentage of labor devoted to crop production. The percentage of acres owned was not included as an independent variable in the Langemeier and Jones (2000) study. Using absolute values, the economic total expense ratio had the largest standardized beta coefficient. Using the standardized beta coefficient for the economic total expense ratio, a 1 standard deviation increase in the economic total expense ratio would result in a 0.759 standard deviation increase in downside risk. Table 5 presents the characteristics of farms in the bottom and top downside risk categories. There were 80 farms in the top category and 190 farms in the bottom category. To be in the top downside risk category, a farm had to have two or fewer years in the study period for which ROE was negative. MROE and SROE for the top group with respect to downside risk were 0.073 and 0.084, respectively. Focusing on the variables that were significant in the downside risk regression, farms in the top downside risk group were larger, had a substantially lower economic total expense ratio, had a higher current ratio, and devoted more of their labor to crop production. The percentage of total acres operated that was owned was similar between the top and bottom categories. As noted above, there were 49 farms with only 0 or 1 year for which ROE was negative. MROE for this group of farms was 0.0779 compared to the average for the entire sample of only 0.0171.

Langemeier and Yeager (2021) examined differences in farms for Sortino ratio categories. The Sortino ratio is computed by dividing ROE by a downside risk measure (see Sortino and Price [1994] for more information pertaining to the computation and use of the Sortino ratio). There were 51 farms in both the top ROE category and the top downside risk category. The average ROE and downside risk measure for this group was 0.095 and 0.080. These results suggest that it was possible for farms to have a relatively high ROE and a relatively low level of downside risk during the study period.

In light of differences in the factors related to ROE, SROE, and downside risk, correlation coefficients were computed to examine the pairwise relationship between the three measures. The correlation coefficient between ROE and SROE as well as between ROE and downside risk were significant. Results indicated that it was very difficult for a farm to have both a high ROE and a low SROE. In other words, there is a tradeoff between risk, as measured using the standard deviation, and return. Farms wanting to mitigate the standard deviation will likely end up with a lower ROE. Conversely, approximately 19% of the farms were in both the top categories with respect to ROE and downside risk. Also, as noted above, farms with less downside risk tended to have a higher ROE. Finally, the correlation between the two risk measures was relatively low (0.059) and not significant. This result stresses the importance of identifying which measure of risk as being the most relevant to a particular farm before developing risk mitigation strategies.

CONCLUSIONS AND IMPLICATIONS

This article examined factors impacting variability and downside risk for a sample of Kansas farms using data from 2007 to 2019. The results of this study have important implications to farms and those working with farms, including professional farm managers, marketing and agronomic advisors, crop insurance agents, and lenders.

Variability was measured using the standard deviation of return on equity. Downside risk was measured using the number of years during the study period in which return on equity was negative. Both measures of risk were significantly correlated with average return on equity. However, the two measures of risk were not significantly correlated with each other, suggesting that it is imperative that a decision maker determine which of these risk measures is more pertinent to their farm when they are developing risk mitigation strategies.

Average return on equity and downside risk were significantly related to farm size. Larger farms had higher rates of return and less downside risk. However, farm size was not important in explaining risk as measured with the standard deviation of financial performance.

Financial efficiency, measured using the economic total expense ratio, was a significant variable in the average return on equity and downside risk regressions, but not in the standard deviation of return on equity regression. Farms with a lower economic total expense ratio had higher financial performance and faced less downside risk. In fact, financial efficiency was the most important factor explaining downside risk. Farms in the top return on equity category had an average return on equity of 0.0924 compared to the average for the group of only 0.0171.

Farms that were in the top category in terms of the standard deviation of return on equity and downside risk had higher current ratios. However, the current ratio was not an important factor explaining average financial performance.

As expected, the debt-to-asset ratio was a very important factor explaining the standard deviation of financial performance. Somewhat surprisingly, the debt-to-asset ratio was significant and negatively related to return on equity. Though not tested in this paper, farms with low debt-to-asset ratios likely grew at lower rates, thus impacting their ability to garner economies of scale. Interestingly, the debt-to-asset ratio was not a significant factor impacting downside risk.

Numerous farms in the sample produced both crops and livestock. The primary crops produced were corn, grain sorghum, soybeans, and wheat. Beef cow production was the most common livestock enterprise utilized by the farms included in this study. Farms that specialized in crop production tended to have higher financial performance. Specializing in crop production had a different impact on the two risk measures. Specialized farms had a higher standard deviation of financial performance but faced less downside risk.

What are the implications of this study for benchmarking? In addition to average financial performance, individual farms should also think about the factors that impact variability and downside risk. Particularly in the case when using variability as the risk measure, pursuing a strategy to mitigate risk may reduce average financial performance.

REFERENCES

Hardaker, J.B., R.B.M. Huirne, J.R. Anderson, and G. Lien. 2004. *Coping with Risk in Agriculture*, 2nd ed. Cambridge: CABI Publishing.

Langemeier, M. 2013. "Measuring Economies of Size with Expense Ratios." *Journal of the American Society of Farm Managers and Rural Appraisers* 76: 222–235.

Langemeier, M.R., and R.D. Jones. 2000. "Measuring the Impact of Farm Size and Specialization on Financial Performance." *Journal of the American Society of Farm Managers and Rural Appraisers* 63: 90–96.

Langemeier, M., and E. Yeager. 2021. "Examining Differences in Risk Adjusted Returns Among Farms." *Journal of the American Society of Farm Managers and Rural Appraisers* 84: 66–70.

Purdy, B.M., M.R. Langemeier, and A.M. Featherstone. 1997. "Financial Performance, Risk, and Specialization." *Journal of Agricultural and Applied Economics* 29: 149–161.

Russell, L.A., D.W. Wood, G.A. Ibendahl, and M.R. Langemeier. 2019. "The Effect of the 2007 Ethanol Mandate on Downside Risk in Agriculture." *Applied Economics Letters* 26 (8): 698–702.

Schurle, B., and M. Tholstrup. 1989. "Farm Characteristics and Business Risk in Production Agriculture." *North Central Journal of Agricultural Economics* 11: 183–188.

Sharpe, W.F. 1966. "Mutual Fund Performance." *Journal of Business* 39: 119–138.

Sharpe, W.F. 1994. "The Sharpe Ratio." *Journal of Portfolio Management* 21: 49–58.

Sortino, F.A., and L.N. Price. 1994. "Performance Measurement in a Downside Risk Framework." *Journal of Investing* 3: 59–64.

Table 1. Summary Statistics for Dependent and Independent Variables		
Variable	**Average**	**Standard Deviation**
Return on Equity	0.0171	0.0844
Standard Deviation of Return on Equity	0.1175	0.2041
Downside Risk	0.352	0.241
Value of Farm Production ($1,000)	576.1	504.3
Percentage of VFP from Government Payments	0.0581	0.0278
Economic Total Expense Ratio	1.292	0.323
Inverted Current Ratio	0.307	0.462
Debt-to-Asset Ratio	0.210	0.168
Percentage of Acres Owned	0.331	0.248
Percentage of Labor Devoted to Crops	0.800	0.185

Table 2. Standardized Beta Coefficients for Each Dependent Variable						
Variable	**ROE**		**Std Dev ROE**		**Downside Risk**	
	Beta	**Sig**	**Beta**	**Sig**	**Beta**	**Sig**
Value of Farm Production	0.272	***	−0.087		−0.204	***
Percentage of VFP from Government Payments	0.030		−0.027		0.021	
Economic Total Expense Ratio	−0.409	***	−0.010		0.759	***
Inverted Current Ratio	−0.070		−0.190	**	0.145	**
Debt to Asset Ratio	−0.220	***	0.609	***	−0.055	
Percentage of Acres Owned	0.055		−0.069		−0.309	***
Percentage of Labor Devoted to Crops	−0.038		0.114	*	0.232	***

Note: The underlying regression coefficients for standardized beta coefficients with one asterisk, two asterisk, and three asterisks were significant at 10%, 5%, and 1%, respectively.

Table 3. Farm Characteristics Between Return on Equity Categories			
Variable	**Bottom Group**	**Top Group**	**Sig**
Value of Farm Production ($1,000)	423.0	939.6	***
Percentage of VFP from Government Payments	0.0597	0.0543	*
Economic Total Expense Ratio	1.398	1.040	***
Inverted Current Ratio	0.423	0.367	
Debt-to-Asset Ratio	0.196	0.242	*
Percentage of Acres Owned	0.371	0.236	***
Percentage of Labor Devoted to Crops	0.770	0.873	***

Note: Significant differences between columns were represented with one asterisk (10% level), two asterisks (5% level), and three asterisks (1%).

Table 4. Farm Characteristics Between Standard Deviation of Return on Equity Categories			
Variable	**Bottom Group**	**Top Group**	**Sig**
Value of Farm Production ($1,000)	643.1	416.8	***
Percentage of VFP from Government Payments	0.0558	0.0637	*
Economic Total Expense Ratio	1.223	1.457	***
Inverted Current Ratio	0.463	0.272	***
Debt-to-Asset Ratio	0.255	0.103	***
Percentage of Acres Owned	0.248	0.529	***
Percentage of Labor Devoted to Crops	0.816	0.764	**

Note: Significant differences between columns were represented with one asterisk (10% level), two asterisks (5% level), and three asterisks (1%).

Table 5. Farm Characteristics Between Downside Risk Categories			
Variable	**Bottom Group**	**Top Group**	**Sig**
Value of Farm Production ($1,000)	441.4	895.9	***
Percentage of VFP from Government Payments	0.0597	0.0544	*
Economic Total Expense Ratio	1.373	1.099	***
Inverted Current Ratio	0.442	0.321	***
Debt-to-Asset Ratio	0.214	0.199	
Percentage of Acres Owned	0.329	0.336	
Percentage of Labor Devoted to Crops	0.788	0.830	*

Note: Significant differences between columns were represented with one asterisk (10% level), two asterisks (5% level), and three asterisks (1%).