Relative Profitability and Risk of Kansas Farms and S&P 500

By Holly M. Bigge and Michael R. Langemeier

Abstract

This study examined the relative profitability and risk of a sample of Kansas farms and the S&P 500 index. The CAPM model was used to estimate relative profitability and risk for 318 individual farms. Results indicated that the average farm in the sample was earning 8.1 percent less than the S&P 500 over the 1982 to 2001 period. For most of the farms in the sample, the risk faced by individual farms was not related to the risk in the S&P 500 index. This suggests that there are opportunities for farm operations to diversify their farm operation risk by investing in the stock market.

Introduction

Farm managers have the opportunity to invest in the stock market, their individual operation, and/or other investments. Unsystematic and systematic risk considerations are important to the farm's decision to invest in the stock market. Unsystematic risk is operation specific. Diversifying the farm operation can eliminate this risk. However, systematic risk is not unique to individual operations and cannot be eliminated through diversification. If systematic risk for an individual farm is low compared to stocks, the farm has more incentive to invest in the stock market.

Measuring unsystematic and systematic risk typically involves an investigation of the relative profitability and risk of individual farms to an average farm in the region or as in this study to the stock market. A couple of recent studies have used the CAPM model to examine relative profitability and risk. Daniel and Featherstone (2001) examined agricultural risk among states by using the CAPM. They calculated average real returns to farm equity from each state for the period 1960 to 1997. Results of their study suggested that the profitability and risk of the agricultural sector varied among states. Tauer (2002) used the CAPM model to determine the relative profitability and risk of 62 New York farms for the 1988 to 1997 period. Tauer (2002) used the Russell 3000 index to represent the market index. For most of the farms, the risk of the individual farms was not significantly related to the Russell 3000 index. Moreover, on average, the New York farms were earning approximately 4.0 percent less than the returns that could have been generated by investing in the Russell 3000 index.

Holly M. Bigge is a former graduate research assistant, Department of Agricultural Economics, Kansas State University.

Michael R. Langemeier is a Professor of Agricultural Economics at Kansas State University. He has a Ph.D. in Agricultural Economics from Purdue University. Research interests include economic efficiency, economies of size, and profitability of farms and ranches.

Many studies (for summaries of these studies see Purdy, Langemeier, and Featherstone (1997) and Gloy, Hyde, and LaDue (2002)) have examined the determinants of relative farm financial performance. These studies can be used to identify important factors explaining the relative profitability of farms. Purdy, Langemeier, and Featherstone (1997); and Tauer (2002) have examined the relationship between risk and farm characteristics. These studies can be used to identify important factors explaining the relative risk of farms.

The objective of this study is to examine the relative profitability and risk of a sample of Kansas farms and the S&P 500. First, the CAPM model is used to compute the relative profitability and risk parameters for individual farms. Second, relative profitability and risk parameters for the individual farms are related to individual farm characteristics such as farm size and farm type.

Methods

The following regression can be used to estimate the CAPM model:

$$(1) \qquad ROE_{it} - r_{ft} = \alpha_i + \beta_i (r_{mt} - r_{ft}) + e_i$$

where ROE_{it} is the return on farm equity for farm i at time t, r_{ft} is the risk-free rate at time t, α_i is the alpha value for farm i, β_i is the beta value for farm i, r_{mt} is the average rate of return on the market index at time t, and e_i is the error term for farm i. Equation (1) is estimated separately for each farm using ordinary least squares (OLS).

The annual return on farm equity for each farm and year is computed as follows:

$$(2) \qquad ROE_{it} = (NFI_{it} - UNPAID_{it} + CGLAND_{it}) / NW_{it}$$

where i refers to individual farms, t refers to individual years, ROE is return on farm equity, UNPAID is unpaid operator and family labor, CGLAND is the capital gain or loss on owned land, and NW is average farm net worth. Because it includes unpaid operator and family labor as well as capital gains and losses on owned land, the return on farm equity represented in equation (2) can effectively be compared among farms with various levels of hired and unpaid labor, and owned land. Also, because cash interest paid is incorporated in the computation of net farm income, the return on farm equity in equation (2) can also be compared among farms with various levels of indebtedness.

The one-year Treasury bill rate is used to represent the risk-free rate. Rates are obtained from the Federal Reserve Bank of St. Louis. Tauer (2002) used the Russell 3000 as the market index, which represents 3,000 of the largest traded companies in the United States based on capitalization. The market index used in this study is the S&P 500 index. The S&P 500 index is used because most of the target audience (farmers, farm managers, farm management economists) are more familiar with this index. Rates of return for the S&P 500 index are obtained from the Federal Reserve Bank of St. Louis.

The alpha value from equation (1) represents the return earned by a farm after adjusting for risk and specifically shows how well each farm is performing relative to the S&P 500 index. Alpha is expected to be zero in an efficient market. An alpha value greater than zero indicates the farm is earning a return more than necessary to compensate for the risk of the farm. If the alpha value is less than zero, the farm is not earning a large enough return to compensate for the risk of their operation.

The beta value from equation (1) measures the relative riskiness of each farm in comparison to the S&P 500 index. If a farm has a beta value less than one, the risk of a farm is less than the risk of the market. A beta value greater than one indicates that the farm has more systematic risk than the market.

Ordinary least squares (OLS) regressions are also used to evaluate the relative importance of farm characteristics in explaining differences in alpha and beta values among farms. The relative profitability (alpha value) regression is estimated as:

$$(3) \qquad \alpha_i = \delta_0 + \delta_i AGE_i + \delta_2 AGESQ_i + \delta_3 TER_i + \delta_4 DTAR_i + \delta_5 DTARSQ_i + \delta_6 GOVT_i + \delta_7 VFP_i + \delta_8 VFPSQ_i + \delta_9 PRCROP_i + \delta_{10} CCC_i + \delta_{11} CBF_i + \delta_{12} CD_i + \delta_{13} CSW_i + \delta_{14} GF_i + \delta_{15} CIRR_i + \varepsilon_i$$

where i represents the ith farm, AGE is the age of the primary farm operator, AGESQ is the age of operator squared, TER is the total expense ratio, DTAR is the debt to asset ratio, DTARSQ is the debt to asset ratio squared, GOVT is the percentage of income represented by government payments, VFP is the value of farm production, VFPSQ is the value of farm production squared, PRCROP is the percent of rented crop acres, CCC is a dummy variable for the crop/cow-calf farm type, CBF is a dummy variable for the crop/backgrounding farm type, CD is a dummy variable for the crop/dairy farm type, CSW is a dummy variable for the crop/swine farm type, GF is a dummy variable for the general farm type, CIRR is a dummy variable for irrigated crop farms, and e is an error term. All of the dummy variables are measured relative to the most common farm type, dryland crop farms. GOVT is measured relative to gross farm income.

Previous literature summarized by Purdy, Langemeier, and Featherstone (1997) and Gloy, Hyde, and LaDue (2002) is used to derive expected regression coefficient signs in equation (3). A non-linear relationship between the alpha values and operator age is anticipated. The AGE variable is expected to be positive and the AGESQ variable is expected to be negative.

The TER variable is expected to be negatively related to the alpha values. Controlling expenses is critical to farm profitability (Nivens, Kastens, and Dhuyvetter (2002)). As the total expense ratio increases, we expect relative profitability to decline.

The DTAR variable is included in equation (3) as a measure of leverage. A non-linear relationship between the DTAR variable and the alpha values is anticipated. If the return on equity is higher than the interest rate, then we expect a positive relationship between alpha and the debt to asset ratio. If the return on equity is relatively low compared to the interest rate, then a negative relationship between alpha and the debt to asset ratio would be anticipated.

The GOVT variable is added to account for the impact of government payments on relative profitability. This variable captures differences in crop rotations and the relative importance of crops to individual farms.

The VFP variable is included in equation (3) to account for the impact of farm size on relative profitability. A non-linear relationship between the alpha values and value of farm production values is anticipated. Specifically, VFP is expected to be positive and VFPSQ is expected to be negative.

The PRCROP variable is used to examine the relationship between the percent of crop acres rented and relative farm profitability. If the PRCROP variable is negatively related to relative profitability, then as you increase the percent of crop acres rented, profitability decreases. Conversely, if the PRCROP variable is positively related to relative profitability, then an increase in the percent of crop acres rented results in an increase in profitability.

The relative risk (beta value) regression is estimated as:

$$\beta_i = \eta_0 + \eta_1\ AGE_i + \eta_2\ AGESQ_i + \eta_3\ TER_i + \eta_4\ DTAR_i + \eta_5\ DTARSQ_i + \eta_6\ GOVT_i + \eta_7\ VFP_i + \eta_8\ VFPSQ_i + \eta_9\ PRCROP_i + \eta_{10}\ CCC_i + \eta_{11}\ CBF_i + \eta_{12}\ CD_i + \eta_{13}\ CSW_i + \eta_{14}\ GF_i + \eta_{15}\ CIRR_i + v_i \quad (4)$$

where β_i is the beta value for the i^{th} farm; AGE, AGESQ, TER, DTAR, DTARSQ, GOVT, VFP, VFPSQ, PRCROP, CCC, CBF, CD, CSW, GF, and CIRR are defined for equation (3) above, and v_i is an error term for the ith farm.

There is less previous literature available to ascertain the expected relationship between farm characteristics and relative risk. Purdy, Langemeier, and Featherstone (1997) found a significant and negative relationship between risk and the percent of income derived from government payments, and a significant and positive relationship between risk and specialization, and risk and the debt to asset ratio. Purdy, Langemeier, and Featherstone (1997) did not find a significant relationship between risk and farm size, and risk and age of operator. Tauer (2002) did not find a significant relationship between risk and age of operator, and risk and the debt to asset ratio. Tauer's (2002) results with respect to the debt to asset ratio are somewhat surprising. The debt to asset ratio is widely believed to increase risk. However, it is important to remember here that risk is being measured relative to the stock market. In other words, only systematic risk is being measured. Farm managers typically view risk as the variability of outcomes. This measure of risk may or may not be correlated with systematic risk.

Rather than presenting the regression coefficients, the regression results generated through the estimation of (3) and (4) will be summarized by examining the impact of changes in the independent variables on relative profitability and relative risk. For operator age, the total expense ratio, the debt to asset ratio, the percent of income from government payments, value of farm production, and the percent of total acres rented variables; the impact of a one standard deviation increase in each variable on the alpha and beta values will be examined. Regression coefficients are used to measure the changes in alpha and beta values. Changes for each variable are examined holding all of the other independent variables at their means.

For the dummy variables, the impact of a one unit change in the dummy variable on the alpha and beta values will be examined. A one unit change in a dummy variable makes the dummy variable effective so it illustrates the increase or decrease in the alpha and beta values resulting from a switch from a dryland crop farm to another farm type.

Data

The data used in this study came from the Kansas Farm Management Association (KFMA) databank. Specifically, KFMA farms with 20 years of continuous data from 1982 to 2001 are used in the analysis. A total of 318 farms had continuous data over this time period.

The average and standard deviation of the rate of return on farm equity, the risk-free rate, the rate of return for the S&P 500 index, and each farm characteristic are summarized in Table 1. The rate of return on farm equity for each farm was computed using information on net farm income, unpaid operator and family labor, capital gains and losses on owned land, and average farm net worth. Net farm income was computed by subtracting all cash expenses, including cash interest expense, from value of farm production. All percentage variables are expressed in decimal form.

The average rate of return on the S&P 500 index was 16.13 percent. The average rate of return on one-year Treasury Bills was 6.69 percent. In contrast, the average rate of return on farm equity for the 318 farms was -0.72 percent. It is important to note, however, that the return on farm equity varied widely among farms. This will become evident when the relative profitability results are discussed in the next section. As mentioned above, return on farm equity is computed using information on net farm income, unpaid operator and family labor, capital gain or loss on owned land, and average net worth. Average net farm income, unpaid operator and family labor, and capital gain on land were $37,691, $29,712, and $1,141, respectively. Average farm net worth was $540,379.

The average operator age was approximately 53 years. The average debt to asset ratio was approximately 25 percent. On average, the farms had a value of farm production of $173,851. On average, the farms derived approximately 12 percent of

Table 1. Summary Statistics for Rates of Return and Farm Characteristics

Variable	Average	Standard Deviation
Rate of Return on S&P 500	0.1613	0.1399
Rate of Return on Treasury Bills	0.0669	0.0236
Rate of Return on Farm Equity	-0.0072	0.1191
Age of Operator	52.8	11.22
Total Expense Ratio	0.8314	0.3258
Debt to Asset Ratio	0.2467	0.1997
Percent of Income from Government Payments	0.1202	0.1059
Value of Farm Production	173,851	152,668
Percent of Total Acres Rented	0.3995	0.2817
Crop/Cow-Calf	0.1476	0.3548
Crop/Backgrounding	0.0855	0.2797
Crop/Dairy	0.07	0.2551
Crop/Swine	0.044	0.2052
General Farm	0.0857	0.2799
Irrigated Crop	0.0453	0.2079

Table 2. Alpha Estimates for 318 Kansas Farms

Estimate	Number of Farms
Less than -0.275	2
-0.275 to -0.250	2
-0.250 to -0.225	6
-0.225 to -0.200	4
-0.200 to -0.175	11
-0.175 to -0.150	14
-0.150 to -0.125	21
-0.125 to -0.100	34
-0.100 to -0.075	54
-0.075 to -0.050	65
-0.050 to -0.025	58
-0.025 to 0.000	35
0.000 to 0.025	8
0.025 to 0.050	2
Greater than 0.050	2

gross farm income from government payments. The dryland crop farm type was the most common farm type followed by the crop/cow-calf farm type (approximately 15 percent of the farms), and the crop/backgrounding and general farm types (approximately 8.5% of the farms).

Results

Table 2 presents the range of alpha values resulting from the empirical estimation of equation (1). The alpha values range from -0.323 to 0.068. The alpha value results support other studies that have found wide differences in relative profitability among farms (Purdy, Langemeier, and Featherstone (1997); Gloy, Hyde, and LaDue (2002); Tauer (2002)).

Of the 318 farms, 306 had negative alpha values. An alpha value less than zero indicates that the farm was not earning a large enough return to compensate for the risk of their operation. The average alpha value was -0.081. This suggests that on average the risk adjusted farm return was 8.1 percent less than the return of the S&P 500 index. Approximately 29 percent of the farms had an alpha value less than -0.10. Another 67 percent of the farms had an alpha value between -0.10 and 0.00. The remaining 4 percent of the farms had an alpha value that was positive. The farms with a positive alpha earned a higher risk adjusted return than the S&P 500 index.

A two-tailed t-test was used to determine whether the individual alpha estimates are significantly different from zero. If the alpha estimates are significantly different from zero, the farm's profitability is significantly different from the market. The results showed that 198 farms had alpha values that were statistically different from zero at the 5 percent level. One of these 198 farms had an alpha value that was significantly greater than zero; the rest of the farms had alpha values that were statistically less than zero.

The beta values resulting from the estimation of equation (1) indicate how risky a farm was relative to the market. Table 3 presents the range of beta values. The average beta value was 0.068. All of the farms had a beta value that was less than one. A beta value less than one indicates that the risk of the farm was less than the risk of the market. The low beta values suggest that systematic risk was low for the individual farms.

Table 3. Beta Estimates for 318 Kansas Farms

Estimate	Number of Farms
Less than 0.00	86
0.00 to 0.10	131
0.10 to 0.20	62
0.20 to 0.30	20
0.30 to 0.40	9
0.40 to 0.50	4
0.50 to 0.60	4
Greater than 0.60	2

Table 4. Sensitivity of Relative Profitability (Alpha Value) to Changes in the Independent Variables

Variable	Unit of Measure	Change in Alpha
Age of Operator	1 std dev	-0.0074
Total Expense Ratio	1 std dev	-0.0067
Debt to Asset Ratio	1 std dev	-0.0173
Percent of Income from Government Payments	1 std dev	0.0028
Value of Farm Production	1 std dev	0.0337
Percent of Total Acres Rented	1 std dev	-0.0041
Crop/Cow-Calf	1 unit	-0.0033
Crop/Backgrounding	1 unit	0.009
Crop/Dairy	1 unit	0.0054
Crop/Swine	1 unit	0.0229
General Farm	1 unit	0.0033
Irrigated Crop	1 unit	0.0099

A two-tailed t-test was used to determine whether the individual farm beta values were statistically less than one. The t-test results showed that 300 of the 318 farms had beta values that were significantly less than one.

Table 4 presents the sensitivity of relative profitability (alpha values) to changes in the independent variables. The regression coefficients resulting from the empirical estimation of equation (3) were used to generate Table 4. All of the variables except DTARSQ, CCC, and GF were significant at the 5 percent level. Of the continuous variables (which exclude the dummy variables), the debt to asset ratio and the value of farm production had the largest impact on the alpha values. The debt to asset ratio was negatively related to relative profitability. This result makes sense given that the return on farm equity for most farms was substantially below borrowing rates. The positive relationship between the value of farm production and relative profitability is indicative of economies of scale. A one standard deviation increase in the value of farm production (holding all other variables at their means) would result in a 3.37 percent increase in the return on farm equity. A one standard deviation increase in value of farm production would result in a value of farm production of $326,519. To put this number into perspective, approximately 5 percent of the farms had a value of farm production over $500,000. These farms would have an estimated return on equity that is approximately 7 percent higher than the average return on farm equity.

The crop/swine, irrigated crop, and the crop/backgrounding farm types were considerably more profitable than the base farm type (dryland crop). The crop/swine farm had an alpha value that was 0.0229 higher than the average alpha value for dryland crop farms. The irrigated crop and crop/backgrounding farm types had alpha values that were 0.0099 and 0.0090 higher than the average alpha value for dryland crop farms.

Table 5. Sensitivity of Relative Risk (Beta Value) to Changes in the Independent Variables

Variable	Unit of Measure	Change in Beta
Age of Operator	1 std dev	0.0027
Total Expense Ratio	1 std dev	-0.0005
Debt to Asset Ratio	1 std dev	0.0116
Percent of Income from Government	1 std dev	-0.0018
Value of Farm Production	1 std dev	0.0072
Percent of Total Acres Rented	1 std dev	0.0028
Crop/Cow-Calf	1 unit	-0.0219
Crop/Backgrounding	1 unit	-0.0128
Crop/Dairy	1 unit	-0.0624
Crop/Swine	1 unit	-0.0698
General Farm	1 unit	-0.0658
Irrigated Crop	1 unit	0.1452

Table 5 presents the sensitivity of relative risk (beta values) to changes in the independent variables. The regression coefficients resulting from the empirical estimation of equation (4) were used to generate Table 5. All of the variables except TER, GOVT, and CBF were significant at the 5 percent level. The debt to asset ratio and value of farm production had the largest impact on the beta values. A one standard deviation increase in the debt to asset ratio results in a 0.0116 increase in the average beta value. A one standard deviation increase in the value of farm production results in a 0.0072 increase in the average beta value. In either case, the beta value would be substantially below one.

The changes in beta for crop/dairy, crop/swine, and general farm types illustrated in Table 5 imply an average beta value for these farm types that was close to zero. The irrigated crop farm had a beta value that was three times as large as the beta value for the average farm. It is important to note, however, that even the beta value for the irrigated crop farms was substantially below one. The results with respect to farm type suggest that relative risk was not particularly sensitive to changes in farm type, or diversification between crop and livestock enterprises.

Summary and Implications

This study examined the relative profitability and risk of a sample of Kansas farms and the S&P 500 index. The CAPM model was used to relate the relative profitability and risk of 318 individual farms to the S&P 500 index. Results indicated that the average farm in the sample was earning 8.1 percent less than the S&P 500 over the 1982 to 2001 period. Approximately 96 percent of the farms had risk adjusted returns that were lower than the returns generated from investment in the S&P 500 index. Risk adjusted returns were relatively lower in this study than those found in Tauer (2002) for the 1988-1997 period. The relatively low risk adjusted returns were at least in part the result of the financial crisis faced by many farms in the early to mid 1980's. For most of the farms in the sample, individual farm risk was not related to the risk associated with investing in the S&P 500 index.

The alpha and beta values presented in this study have strong implications with regard to an individual farm's investment in the stock market. A low alpha value implies that the market index for stocks is relatively more profitable than investment in individual farms. Moreover, the low beta value implies that the risk of the market is not highly correlated with the risk of an individual farm's returns. These two things taken together imply that potentially strong benefits could be derived from an individual farm's investment in the stock market.

The results of this study also have implications regarding farm expansion. In addition to using net farm income above unpaid labor to invest in the stock market, efficient farms can also use net farm income above unpaid labor to expand their farm operation. When evaluating farm expansion, individual farms should compare the benefits of investing in the stock market with the benefits associated with farm expansion. Which of these two avenues an individual farm pursues will depend on their current level of cost efficiency, economies of scale, and their willingness to bear risk.

References

Daniels, M.S. and A.M. Featherstone. "Assessing Agricultural Risk Among States." *Journal of the American Society of Farm Managers and Rural Appraisers*. 65(2001):107-114.

Federal Reserve Bank of St. Louis. http://research.stlouisfed.org/fred2/.

Gloy, B.A., J. Hyde, and E.L. LaDue. "Dairy Farm Management and Long-Term Farm Financial Performance." *Agricultural and Resource Economics Review*. 31(October 2002):233-247.

Kansas Farm Management Association. http://www.agecon.ksu.edu/kfma/.

Nivens, H.D., T.L. Kastens, and K.C. Dhuyvetter. "Payoffs to Farm Management." *Journal of Agricultural and Applied Economics*. 34(April 2002):193-204.

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

Tauer, L.W. "Estimating Risk-Adjusted Interest Rates for Dairy Farms." *Agricultural Finance Review*. 62(Spring 2002):59-68.