Factors contributing to farm management returns in Kentucky

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Abstract

Returns are generally used as a measure of how efficiently a farm is being managed. The objective of this study is to identify factors that contribute to higher farm management returns in Kentucky. Fixed-effects regression and quantile regression reveal that farm size, greater assets, percentage of cash-rented acreage have a positive influence on the management returns. Higher soil productivity ratios, government payments, and liabilities have a negative effect on the management returns. In general, hog and dairy farms yield greater returns to management compared to grain farms. Business orientation positively affects only the returns of high-returns farms.

***Key Words**: management returns, economic efficiency, panel data*

Introduction

Returns are a reasonable measure of farming success; they reflect a farm's production efficiency, organization, as well as risk management strategies (Mishra, E1-Osta, and Johnson, 1999). The source of efficiency in U.S. agriculture is constantly changing. Compared to thirty years ago, agriculture today relies on less land and labor, but more heavily on machinery, fuel, and pesticides (O'Donoghue *et al.* 2011). Innovations in farm organization, business arrangements, and production practices, have allowed farmers to produce with fewer traditional inputs; indeed, the amount of US farmland decreased 8% over the period of 1982 to 2007. To increase efficiency and cope with risk, farmers have to develop risk management strategies such as hedging, futures markets, forward-contract and relevant professional training.

A better understanding of the factors influencing farm returns will facilitate farmers willing to make changes in their farming practices in order to increase returns. It would also help policymakers to design policies that would help farmers to increase or maintain stable incomes. This study characterizes Kentucky's farms efficiency; where efficiency is defined as the returns to management.

The use of Management returns, a more refined measure of efficiency, as the outcome variable makes the particularity of the study. It also relies on a unique dataset that also permits a god measure of the efficiency.

Previous studies

The purpose of farm business analysis studies is not to prove whether farmers are prosperous or not. Their purpose is to show actual economic conditions on farms and to point out ways in which these conditions may be improved (Myers, 1926). Previous studies use varied methods and measures of farm profits – profits being indicators of farm success. Several studies assess the relationship between profits and farm characteristics. Johnson, Prescott, Banker, and Morehart, (1986), Reimund and Somwaru (1986), and Strickland (1983) find farm size, location, and grain production to be positively associated with measures of profit. Their studies also suggest that factors such as operator's primary occupation, age, and non-grain production are negatively related to farm profitability. Reinsel and Joseph (1986) conclude that farm returns vary by the commodities produced, location, size of operation, management, and natural phenomena. Additionally, managerial ability also appears in the literature as important determinant of farm success (e.g. REFS?).

Johnson et al. (1986) use a descriptive approach to determine the relationship between profits and farm characteristics. Sonka, Hornbaker, and Hudson (1989) use logit regression to determine factors affecting farm financial performance. Mishra *et al.* (1999) also use logit regression in determining factors that contribute to the profitability of cash grain farms. They use three measures of success of a farm: net farm income, operators' returns to labor and management, and operators' management income. Burton and Abderrezak (1988) use ordinary least square to determine the relationship between expected profit and farm characteristics. They conclude that expected profit may be enhanced by increasing farm size, leasing or renting intermediate and long-term assets, using production and financial inputs efficiently, and hedging.

The present study analyzes factors that contribute to farm returns, specifically, returns to management. It uses panel data collected over fourteen years, covering 659 farms in Kentucky, and employs fixed-effects estimation and quantile regression. These methods permit a better assessment of various farm characteristics but also the effect of time. Modeling farm fixed effects allows for unobserved heterogeneity between farms. Quantile regression permits the comparison of the effects of variables between different levels of management returns (low, average and high returns farms) and the assessment of distributional effects.

Methodology

The general functional form for a panel data is

$$y_{it} = \alpha + \beta X_{it} + v_i + \varepsilon_{it,} \qquad (1)$$

Here y is the return to management of farm i in time t and the vector X includes the farm size, the type of farm production, organization of the business operation, government payments, liabilities, the amount of leased or sharecropped area. v_i is the farm-specific residual which differs between farms but not within a farm. ε_{it} is the "usual" residual which is assumed to have the standard properties (zero mean, zero autocorrelation, uncorrelated with X, uncorrelated with v, and homoskedastic)

Both fixed-effects and random-effects models were estimated and the two were vetted using with the Hausman test to determine the more appropriate estimation approach.

The general estimation equation is:

$$y_{it} = \alpha_i + \beta X'_{it} + v_i + u_{it,} + \varepsilon_{it,} \qquad (2)$$

where $\alpha_i = 0$ for the fixed-effects model and $u_{it,}$ is the unobserved time-invariant individual effect.

A dummy variable for year was included in the estimation to account for any time effects. The goal of the time variable is to capture any unobserved trends that could cause the coefficients to change over time.

Model validity tests were carried out in conjunction with a distributional analysis for the normality of the residuals (robustness). Validity tests include a the Breusch-Pagan test procedure for heteroskedasticity, the Wooldridge test for autocorrelation (Wooldridge, 2013), and a check for multicolinearity of the regressors using a correlation matrix.

Because profitable farms may differ systematically from less profitable farms, quantile regression analysis is also used to capture any difference in the coefficients of farm characteristics and production variables for farms that have high, average and low management returns. Whereas OLS estimates a single relationship between the dependent and independent variables, quantile regression permits the relationship to differ depending on the values of the outcome variable. Coefficients are estimated for farms at the 25th, 50th, and 75th percentile of returns.

The q^{th} quantile estimator $\widehat{\beta}_q$ minimizes over β_q the objective function:

$$Q(\beta_q) = \sum_{i:y_i \geq X_i'\beta}^{N} q|y_i - X_i'\beta q| + \sum_{i:y_i < X_i'\beta}^{N} (1-q)|y_i - X_i'\beta q|$$

Where $0 < q < 1$, and β_q is used rather than β to make clear that different choices of q estimate different values of β.

Data

The data used are an unbalanced panel of 659 farms collected by the Kentucky Farm Business Management (KBFM) program over 14 years (from 1998 to 2011) in 65 counties of Kentucky. Since 1962, The Kentucky Farm Business Management Program (KFBM) has been assisting its farmer members track financial performance, determine the profitability of individual enterprises, improve management practices, complete tax returns, set business and personal goals, and make strategic management decisions. In so doing, KFBM collects production and financial information at both farm and operator level data. Since the analysis here is done at farm level, operator level data are aggregated by farm.

Management returns are calculated as annual net farm income, less interest on equity capital, the value of family labor, and the labor and management costs of the operator(s). Specifically, management returns (MANGRT) is calculated as follows:

MANGRT = Net Farm Income – Interest on Equity Capital – Unpaid Family Labor – Operator(s) Labor and Management Income – Unpaid Operator Labor

Table 1 summarizes the management returns, as well as farm characteristics in the dataset. Management returns range from -5.557 to 5.432 million US dollars with a sample mean of 0.15 million dollars. The standard deviation of management returns between farms is nearly as large as that for individual farms across the 14-year time period.

Farm characteristics include the organization of the business operation (the business type), farm size (as measured by total cultivated area), soil productivity ratio, the type of operation (e.g. grain), assets, and the amount of leased or sharecropped area. A dummy variable indicates whether a farm is a sole proprietorship or not (e.g. partnership, trust, corporation, joint venture, Limited Liability Company or estate). The average farm size is 5,290 acres and the *between* variation (as measured by the standard deviation) is 4,340 while the *within* variation is 3,200. As is expected, farm size varies more from a farm to another than for the same farm over time. Annual government payments to the sampled farms over this time period average 560,000 US dollars. Its variation between farms is much lower (620,000) than its variation for a farm over time (900,000). This can be explained by the fact that government payments are based on the same criteria for all farms; the only difference being in their size or the policy. The type of farm production is indicated via dummy variables for hog, grain, dairy, beef or other. Surprisingly farm assets have a much higher *within* variation (4.63 million US dollar) than the *between* variation (2.90 million US dollar), indicating that farm assets change a lot over time but do not change much from one farm to another. The overall mean is 2.8 million US dollars. Finally, the total cultivated area is categorized into owned acreage, crop shared acreage and cash rented acreage, and the percentage of these categories is used to control for differences in land management.

Table 1: Summary statistics for continuous variables (T = 14 years and K = 659 farms)

Variables	Definition	Variation	Mean	Std. Dev.	Min	Max
MANGRT	Management returns in 100,000 US dollar	Overall	1.54	4.56	-55.57	54.32
		Between		3.08	-9.14	33.83
		Within		3.65	-49.02	49.63
BUSITYP	Organization of the business operation (=1 Individual, 0 Otherwise)	Overall	0.61	0.49	0.00	1.00
		Between		0.38	0.00	1.00
		Within		0.36	-0.32	1.53
FSIZE	Farm size (tillable acreage) in 1,000 acres	Overall	3.87	5.29	0	77.81
		Between		4.34	0	65.38
		Within		3.20	-16.42	49.19
SPRATING	Soil Productivity Rating	Overall	63.49	10.56	0	91
		Between		7.62	0	77.12
		Within		8.41	-0.51	107.08
HOG	Type of operation (=1 Hog, 0 Otherwise)	Overall	0.02	0.15	0.00	1.00
		Between		0.13	0.00	1.00
		Within		0.12	-0.64	0.95
GRAIN	Type of operation (=1 Grain, 0 Otherwise)	Overall	0.69	0.46	0.00	1.00
		Between		0.37	0.00	1.00
		Within		0.33	-0.24	1.62
DAIRY	Type of operation (=1 Dairy, 0 Otherwise)	Overall	0.14	0.35	0.00	1.00
		Between		0.30	0.00	1.00
		Within		0.24	-0.76	1.07
BEEF	Type of operation (=1 Beef, 0 Otherwise)	Overall	0.12	0.33	0.00	1.00
		Between		0.23	0.00	1.00
		Within		0.25	-0.78	1.05
OTHLIVSTOCK	Type of operation (=1 Other livestock, 0 Otherwise)	Overall	0.03	0.16	0.00	1.00
		Between		0.11	0.00	1.00
		Within		0.14	-0.47	0.95
GOVPAY	Government payment in 100,000 US dollars	Overall	0.56	1.09	0	15.30
		Between		0.62	0	5.10
		Within		0.90	-3.21	12.37
NTFARM	Net farm income in 100,000 US dollars	Overall	2.96	5.22	-52.23	74.28
		Between		3.72	-3.50	41.70
		Within		4.09	-45.77	68.19
NOFARM	Nonfarm income in 100,000 US dollars	Overall	0.49	3.04	-.69	184.18
		Between		0.96	-0.38	17.00
		Within		2.81	-16.51	167.67
ASSET	Farm assets in 100,000 US dollars	Overall	28.06	56.68	-28.78	1345.32
		Between		28.99	0	438.93
		Within		46.38	-410.87	934.45
LIAB	Liabilities in 100,000 US dollars	Overall	8.74	21.56	-29.73	400.80
		Between		10.95	0	101.78
		Within		17.96	-106.01	359.78
OWNEDAC	Percentage of owned acreage	Overall	40.52	29.86	0	100
		Between		23.69	0	100
		Within		22.14	-41.67	124.53
CROPSHAC	Percentage of crop shared acreage	Overall	27.23	27.28	0	100
		Between		21.17	0	100
		Within		19.86	-37.73	106.48
CASHAC	Percentage of the cash rented acreage	Overall	38.15	29.30	0	100
		Between		22.68	0	100
		Within		21.60	-48.52	117.24

Results

Fixed-effects model: model validity and robustness checks

The Hausman test indicates a systematic difference between the two regressions and that the fixed-effects model outperforms the random-effects model. The Wooldridge test for autocorrelation reveals that autocorrelation is not an issue. And a normality check shows that residuals follow a normal distribution (Figure 3 in the appendix).

To test for heteroskedasticity, the residuals, the squared residuals, and the predicted values are inspected. Based on visual inspection (Figure 2 in the appendix), heteroskedasticity is suspected. Squared residuals are then regressed on the independent variables. The F-statistic reveals the presence of heteroskedasticity: (F-statistic = 2.95 and p-value = 0.0000.) To address the heteroskedasticity issue, the robust standard errors were used. Estimation results with robust standard errors are presented in Table 2.

Fixed – effects model: results

Estimated coefficients for a fixed-effects model with robust standard errors are presented in Table 2.

The effect of farm size is significantly positive with a one-acre increase in the size of the farm increasing the management returns by 53 US dollars. Bagi (1981) finds different results in his study of the relationship between farm size and economic efficiency in India's farms. The study shows that, in general, smaller farms produce higher output.

Surprisingly, the effect of the soil productivity rating on the management return is significantly negative with one point increase in the soil productivity rating (SPRATING) decreasing the management returns by 0.03 US dollar.

The type of business organization that is, whether the farm is an individual owned business or not does not have a significant effect on returns to management with the fixed-effect model.

In terms of farm type, results suggest that dairy farms have higher management returns in Kentucky. Dairy farms, other livestock farms, hog and beef farms have respectively $81,000, $78,000, $65,000 and 27,000 US dollar returns higher than grain operations, the omitted category. This result is unexpected. Over the last 5 years, grain farms have been significantly more profitable than any livestock farms on the KFBM program.

Land management strategies such as renting are an important determinant of farm management efficiency. The cash-rented percentage has a positive effect on the management returns. When the percentage of cash rented acre in the tillable acreage increase by one, management returns increase by 1000 dollars. The percentage of cash-rented acreage in the overall cultivated acreage has a greater influence on the returns indicated by the highly significant coefficient. It appears that it is more profitable and advantageous for a farm to rent more land than to buy it. This may be because farmers are able to eliminate land on which productivity or fertility is decreasing. Mishra et al. (1999) explain this positive linkage between renting and farm success as due to the fact that renting or leasing land frees some capital resources from being otherwise tied up in land mortgage and interest payments.

Surprisingly, estimation results suggest that government payments (GOVPAY) have a negative effect on the management returns. GOVPAY coefficient is statistically significant at 5% level with one-dollar increase in government payments decreasing the returns on management by 0.41 dollar.

Assets and liabilities also are important determinant of farm management efficiency. Assets have a positive effect on the management returns while liabilities, expectedly have a negative influence on the management returns. One dollar increase in assets increases management returns by 30 cents whereas one dollar increase in liabilities decreases the management returns by 40 cents.

None of the year dummy coefficient is significant. However, year dummy coefficients have a negative sign from 1999 to 2007 and coefficients of years 2008 to 2011 are positive. This can be explained by the recent food price spikes.

Table 2: Fixed-effects (within) regression with robust standard errors results

Variables	Coefficients	Robust Std. Err.
BUSITYP	-0.05	0.14
FSIZE	0.53***	0.06
SPRATING	-0.03***	0.01
HOG	0.65	0.61
DAIRY	0.81**	0.40
BEEF	0.27	0.20
OTHLIVSTOCK	0.78*	0.51
GOVPAY	-0.41**	0.19
NOFARMINC	-0.02	0.02
ASSETS	0.03***	0.00
LIABILITIES	-0.04***	0.01
CROPSHARE	0.00	0.00
CASHAC	0.01***	0.00
Year		
1999	-0.16	0.22
2000	-0.01	0.25
2001	-0.48	0.24
2002	-0.01	0.25
2003	-0.19	0.24
2004	-0.20	0.24
2005	-0.28	0.24
2006	-0.19	0.26
2007	-0.17	0.25
2008	0.15	0.31
2009	0.11	0.26
2010	0.38	0.35
2011	0.04	0.35
Constant	0.48	
Observations	4550	
Number of farms	658	
R-squared	0.39	

Note: *** Significant at 1%; ******significant at 5%, * significant at 10%.
Robust standard errors are preferred to account for the heteroskedasticity

Quantile regression analysis: results

The purpose of using quantile regression in this paper is to permit the coefficients on farm characteristics to differ between the low-return (25^{th} percentile), median-return (50^{th} percentile), and high-return (75^{th} percentile) farms in the sample. Quantile regression coefficients can be interpreted similarly to those from the OLS fixed effect model. Quantile regression results are summarized in Table 3.

Unsurprisingly, the general results from the quantile regression analysis are qualitatively similar to those from the fixed effect model. Farm size (FSIZE) preserves its sign and remains highly significant across quantiles. The increase in the management returns increases across quantiles from the low returns farms to the high ones. Likewise, GOVPAY keeps its negative sign and is highly significant for all quantiles. This decrease in the management returns diminishes across quantiles from the low returns farms to the high returns farms. Coefficients on assets (ASSETS) and the percentage of cash rented acre (CASHAC) also preserve their sign and statistical significance, with a positive effect on the response variable in both estimations. However, exception is made for the dummy variable BEEF. Its coefficient which was positive and not significant becomes negative and highly significant. With the quantile regression, beef farms appear to have less management returns than grain farms irrespective of the quantile. In addition, year dummy also keeps the same trend.

Here we find that the effect of some factors differ systematically between the 75^{th} percentile farms and the 25^{th} and 50^{th} percentile farms. The coefficients on business type organization (BUSTYP) which is not statistically significant in the fixed-effects regression becomes significant for medium/average (at 10% level) and higher returns farms (at 1% level) with a change of sign (the coefficient is now positive). This indicates that business type organization matters to higher returns category than the others. Specifically, being a sole proprietorship is correlated with higher management returns at higher quantiles. The effect of SPRATING is not significant for the 75^{th} percentile unlike the other percentiles and the coefficient of the variable is positive for this quantile positive. For higher return farms, the more profitable type of operation is hog farms (HOG has the higher coefficient and significant at 1%). Thus, the earlier result that suggests that dairy farms have greater returns compared to grain farms holds only in case of low returns farms.

With the exception of the dummy variable DAIRY, all coefficients significant in the fixed-effects regression have the same signs in the quantile regression analysis across all quantiles. In the first quantile, the dairy farm coefficient is significant at the 5% level but not significant for medium/average and higher returns dairy farms. However, the non-significance of the coefficients in other quantiles could be explained by the few numbers of farms represented in those categories.

Table3: Quantile regression results

Variable	q25		q50		q75	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
BUSITYP	-0.04	0.04	0.08*	0.04	0.18***	0.06
FSIZE	0.18***	0.02	0.36***	0.02	0.61***	0.03
SPRATING	-0.01***	0.00	0.00***	0.00	0.00	0.00
HOG	0.00	0.17	0.32***	0.11	0.69***	0.22
DAIRY	0.24***	0.06	0.18***	0.05	0.08	0.08
BEEF	-0.15***	0.05	-0.21***	0.06	-0.20***	0.08
OTHLIVESTOCK	0.15*	0.09	0.28**	0.13	0.47***	0.12
GOVPAY	-0.22***	0.05	-0.38***	0.07	-0.60***	0.09
NOFARMINC	-0.04	0.04	-0.06	0.07	-0.01	0.08
ASSETS	0.01***	0.00	0.02***	0.00	0.02***	0.00
LIAB	-0.01**	0.00	-0.01	0.01	0.00	0.01
CROPSHAC	0.01***	0.00	0.00***	0.00	0.00	0.00
CASHAC	0.01***	0.00	0.01***	0.00	0.01***	0.00
1999	-0.06	0.12	-0.03	0.11	0.15	0.21
2000	0.04	0.10	0.03	0.12	0.11	0.21
2001	0.00	0.09	-0.06	0.11	-0.27	0.16
2002	0.10	0.11	-0.01	0.11	0.10	0.19
2003	-0.04	0.10	0.00	0.11	-0.20	0.18
2004	0.02	0.09	-0.04	0.06	-0.18	0.14
2005	-0.13	0.09	-0.11	0.09	-0.26	0.15
2006	0.09	0.09	-0.10	0.12	-0.09	0.15
2007	-0.03	0.09	0.00	0.10	-0.17	0.16
2008	0.00	0.10	0.00	0.11	0.00	0.17
2009	0.02	0.08	0.01	0.08	-0.01	0.15
2010	0.09	0.09	-0.05	0.10	-0.07	0.19
2011	-0.11	0.09	-0.23	0.14	-0.24	0.20
Constant	-0.59***	0.16	-0.47***	0.14	-0.33*	0.18
Observations	4550					

Note: * ** Significant at 1%; ****significant at 5%, * significant at 10%.

Conclusions

The purpose of this study was to identify the factors contributing to farm management returns and which type of farm has the greater returns. A fixed-effects regression along with a quantile regression was used on data collected by the Kentucky Business Farm Management (KBFM) program from 1998 to 2011.

Farm characteristics variables such as farm size, soil productivity rating, the type of business organization, as well as production variables such as assets, and the amount of leased or sharecropped area are factors that have greater contribution to the farm management returns. The study also reveals that hog and dairy farms have respectively higher management returns than grain farms. Besides, the percentage of cash-rented acreage in the overall cultivated acreage has a greater influence on the management returns. A policy prescription can be to encourage farmers to rent more land but there is a caveat. Our study cannot establish the causality.

Other risk management variables such as crop insurance, participation in futures market or contracting sales could have been used for this analysis but were not available. Also, variables that capture the use of technology would have also been relevant to the study. These are some limitations of the study. However, the results provide a good understanding of key factors in farming success to both farmers and policymakers.

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