A Long-Term Analysis of Changes in Farm Size and Financial Performance

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Abstract

This paper examined the changing structure of farms in Kansas. Specifically, changes in farm size, farm type, financial performance, and economies of size were examined using five-year moving averages from 1973 to 2007. Convergence analysis was used to determine whether small farms are catching up to larger farms or whether the difference in performance between these two groups of farms was widening. Results suggested that the gaps between the small farms and large farms have widened.

Introduction

One of the main reasons for studying farm structure is to understand more fully how the production agriculture sector is changing and to understand the implications of this change to the future structure of the sector (Stanton, 1993). The existence of differences in financial performance and economies of size have broad implications for industry structure, growth, and change (Hallam, 1991). These differences may lead to consolidation of farms, but they are also of interest because they impact international competitiveness and the viability of the family farm.

Recent studies that have examined changes in farm structure include Barry et al. (2001), Short (2001), Ali (2002), Nehring et al. (2002), Morrison-Paul et al. (2004), Langemeier and Bradford (2006), Mosheim and Lovell (2006), and Hoppe et al. (2007). Barry et al. (2001) analyzed the variability of net farm income and examined the relationship between variability of net farm income and farm size. Larger farms had lower net farm income variability. Short (2001) discussed the characteristics and production costs of farms with a cow-calf enterprise. Operating costs declined with increased enterprise size. Ali (2002) discussed the characteristics and production costs of U.S. wheat farms. Per acre and per unit costs decreased as wheat acreage increased. Nehring et al. (2002) examined the impact of off-farm labor on the structure of U.S. corn and soybean farms. Off-farm income was included as an output along with corn, soybeans, livestock, and other crops. In addition to finding significant economies of size, the authors noted that substantial economies of scope existed between traditional farm products and off-farm income. Morrison-Paul et al. (2004) examined structural change on family farms. Size economies were prevalent. Langemeier and Bradford (2006) examined the relationship between overall inefficiency and farm characteristics such as

farm size, operator experience, percent of time devoted to farming, educational level, record keeping system, percent acres owned, organizational structure, and farm type for a sample of Kansas farms. Strong economies of size were found for the sample of farms. Operator experience, percent of time devoted to farming, and percent acres owned were also significantly related to overall inefficiency. Mosheim and Lovell (2006) examined economic efficiency and economies of size for U.S. dairy farms. The authors did not find evidence of significant economies of size for the sample of farms. Hoppe et al. (2007) summarized the structure and financial position of U.S. farms. Financial performance of larger farms was significantly higher than that of smaller farms. The authors also noted that the number of farms with sales over $250,000 increased over the 1982 to 2002 period.

Though contributing to the literature on farm structure, the studies cited above did not examine farm structure over a long period of time. With a long-term analysis, questions related to convergence and divergence between groups of farms can be addressed. Convergence and divergence of performance among farm groups has widely different implications on the future structure of agriculture. For example, divergence of performance between small farms and large farms would be a potential signal that farms will continue to consolidate.

The primary objective of this study was to examine the changing structure of farms in Kansas. Five-year average data for farms participating in the Kansas Farm Management Association (KFMA) program from 1973 to 2007 were used in this study. Key variables examined included value of farm production, total acres, percent of gross income derived from livestock, economic total expense ratio, operating profit margin ratio, and asset turnover ratio. The economic total expense ratio was used to examine changes in economies of size over time. Convergence analysis was used to determine whether small farms are catching up to larger

farms or whether the difference in performance between these two groups of farms was widening.

Methods

Key variables examined in this study included value of farm production, total acres, percent of gross income derived from livestock production, operating profit margin ratio, asset turnover ratio, and economic total expense ratio. The operating profit margin ratio was computed by adding interest expense and subtracting the opportunity cost on operator and family labor from net farm income and dividing the result by value of farm production. Average family living expenses and the number of operators on each farm were used to compute the opportunity cost on operator and family labor. The asset turnover ratio was computed by dividing value of farm production by average total assets. Assets were valued using the market valuation approach. The economic total expense ratio was used as the measure of economies of size. This expense ratio was computed by summing accrual expenses, depreciation, the opportunity cost on operator and family labor, and the opportunity cost on net worth, and dividing the result by value of farm production. Farms that had an expense ratio value below one were earning an economic profit.

To be included in this study, a farm had to have five years of continuous data during any continuous five-year period from 1973 to 2007. Moving five-year averages were calculated for each farm that met this qualification. This created snapshots in time dating from 1973 to the present. Farms were sorted into quartiles and deciles by value of farm production. Due to the ease at which it can be used to combine diverse products, value of farm production was used as the measure of farm size. Averages of the top and bottom value of farm production quartiles were used in the trend regressions discussed below. Deciles, sorted by

value of farm production, were used to test for convergence. A description of the convergence tests can be found below.

Exponential trend regressions are a common method used to examine structural change (Allen et al., 2005). The following equation was used to examine trends in the key variables discussed above and to examine differences in the key variables between the top and bottom quartiles:

(1) $Y_t = \alpha B^t$

where Y_t is the trend value of the time series at time period t and B is the key variable of interest. It is convenient to estimate equation (1) in log-linear form:

(2) $\ln Y_t = a + b_t$

where $a = \ln \alpha$ and $b = \ln B$. The antilog of a and b can be used to find α and B. The growth rate of Y_t equals B-1.

Equation (2) was estimated to find the growth rate of the six key variables: value of farm production, total acres, percent of gross income derived from livestock production, operating profit margin ratio, asset turnover ratio, and economic total expense ratio. Equation (2) was also used to examine the growth rate of the differences in total acres, percent of gross income derived from livestock production, economic total expense ratio, operating profit margin ratio, and asset turnover ratio between the top and bottom value of farm production quartiles. The number of observations for each trend regression was thirty-one; there was one observation for each five-year snapshot.

Convergence analysis is used extensively to examine alternative growth theories (Islam, 2003). Convergence tests were used in this study to determine whether differences in farm size and financial performance are converging or diverging. Farms were sorted into deciles using

value of farm production to study convergence. Two types of convergence are examined in this study: β-convergence and σ-convergence.

β-convergence tests whether there is negative correlation between initial income level and the growth rate of a specific variable. β-convergence can be tested using the following relationship:

(3) $g_i = f(vfp_{1i})$

where g_i represents the growth rate of a key variable for decile i and vfp_{1i} represents the initial level of value of farm production for decile i. Growth rates for each decile were obtained by running trend regressions. Equation (3) was examined for each key variable. There were ten observations for each specification of equation (3), one observation for each value of farm production decile. If the relationship between the growth rate and the initial income level is significant and negative, convergence is evident. Conversely, if the relationship is significant and positive, divergence is evident.

The σ in σ-convergence represents the standard deviation of the distribution of income for a specific time period. σ-convergence examines whether the standard deviation in income levels among groups of farms is increasing or decreasing over time. σ-convergence can be tested using the following relationship:

(4) $\sigma_j = f(time)$

where σ_j represents the standard deviation of variable j for a specific five-year period and time represents a linear time trend. Equation (4) was examined for each key variable. The standard deviation of each key variable was computed using the value of farm production decile data for each five-year snapshot. There were thirty-one observations for each regression, one

observation for each five-year snapshot. If σ-convergence is present, there will be a significant relationship between σ and the time trend.

Data

The data for this study were obtained from the Kansas Farm Management Association databank (Langemeier, 2003). Farms represented in this databank are members of the Kansas Farm Management Association and generally provide the association with annual data. To be included in this study, a farm had to have five years of continuous, usable data for a five-year period between 1973 and 2007. In addition to not having five years of continuous data, farms were deleted from the study if they had negative expenses, if they were primarily sheep or turkey farms, if they recorded zero workers, and/or had a negative value of farm production. The number of farms included in each five-year snapshot ranged from 973 for the 1981-1985 period to 1,451 for the 1996-2000 period.

Table 1 contains the averages for the farm size, farm type, and performance variables by five-year period. Total acres increased from 1,369 to 1,873 over the study period. The percent of gross income derived from livestock production decreased over the study period. Unlike the economic total expense ratio and asset turnover ratio, the operating profit margin ratio was lower in the 2000s compared to the 1970s. The primary difference between the economic total expense ratio and the operating profit margin ratio was the inclusion of the opportunity cost on net worth in the computation of the economic total expense ratio. On average, the sample farms owned between two-thirds and three-fourths of their assets. The relatively lower interest rates in the 2000s made the opportunity cost on net worth relatively lower for those time periods. This artifact at least partially explains the difference between the trends for the economic total expense ratio and the operating profit margin ratio.

Table 2 contains the five-year averages for farms in the top and bottom value of farm production quartiles. Total acres increased substantially for the top quartile over the study period. For the bottom quartile, total acres remained relatively constant. The economic total expense ratio for the top quartile was below one for the 2003-2007 period indicating that on average these farms were earning an economic profit. The economic total expense ratio for the bottom quartile during the same time period was 1.684. The bottom quartile exhibited a positive operating profit margin ratio until the 1979-1983 period where it turned negative for the rest of the time periods. The asset turnover ratio for the top quartile increased from 0.244 in 1973-1977 to 0.355 in 2003-2007. In contrast, the asset turnover ratio for the bottom quartile decreased over the study period.

Results

Table 3 presents the estimated growth rates for the trend regressions for each variable and for the difference in each variable between the top and bottom value of farm production quartiles. If a positive sign is recorded for a growth rate, the variable is increasing over time. All six variables had growth rates that were statistically significant. Value of farm production had a growth rate of 0.0346 or 3.46 percent per year. To examine the effects of inflation, a trend regression was run using the Personal Consumption Expenditures Price Index (Federal Reserve Bank of St. Louis) to obtain an inflation rate. The growth rate for inflation was 0.0371. This growth closely mimics the growth rate in value of farm production. Total acres grew at a rate of 1.12 percent per year. The growth rates for the economic total expense ratio and the operating profit margin ratio were a negative 1.18 percent and 2.50 percent, respectively. A negative growth rate for the economic total expense ratio represents an improvement in performance over time. Conversely, a negative growth rate for the operating

profit margin ratio represents deterioration in performance over time. The asset turnover ratio exhibited a growth rate of 1.61 percent, representing an improvement in performance over time.

Trend regressions were also used to estimate growth rates for the difference between the average values of the top and bottom value of farm production quartiles. Exponential trend regressions were used to estimate growth rates for differences in value of farm production, total acres, economic total expense ratio, operating profit margin ratio, and asset turnover ratio between the top and bottom value of farm production quartiles. Because the difference between the two quartiles was negative for some of the time periods, a linear trend regression was used for the percent of gross income derived from livestock production variable. The trend regressions examining differences between the value of farm production quartiles are reported in the second column of Table 3. The positive growth rates for the difference in value of farm production and total acres between the top and bottom quartiles indicates that farm size differences were widening over time. The difference between the percent of gross income derived from livestock production between the two groups of farms was not significant. The financial performance regressions indicate that the difference in financial performance between the two groups of farms widened over time. The results of quartile regressions provide evidence of divergence in farm size and financial performance for the sample of farms. The convergence analysis below will be used to verify the results for the value of farm production quartiles.

Table 4 presents the β-convergence results. If the initial level of value of farm production variable is negatively related to the growth rate for each variable, with the exception of the economic total expense ratio, smaller farms are catching up, either in terms of farm size or financial performance, with larger farms. In other words, a negative sign would suggest that

the variable is converging for the sample of farms. If the initial level of the value of farm production variable is positive, divergence is occurring. The opposite signs as those noted above would apply to the economic total expense ratio. For this variable, a decline represents an improvement. The significant signs on initial value of farm production for the value of farm production, total acre, economic total expense ratio, and asset turnover ratio regressions provide evidence of divergence in farm size and financial performance between small and large farms.

Table 5 presents the σ-convergence results. A negative and significant sign would provide evidence of convergence while a positive and significant sign would provide evidence of divergence. The time trend variable was significant and positive for all of the variables except the percent of gross income derived from livestock production variable. Thus, the σ-convergence results also provide evidence that farm size and financial performance diverged over time.

Summary and Implications

The primary objective of this study was to document the changing structure of Kansas farms over the 1973 to 2007 period. The analysis focused on six variables: value of farm production, total acres, percent of gross income derived from livestock production, economic total expense ratio, operating profit margin ratio, and asset turnover ratio. Results provided evidence of divergence in terms of farm size and financial performance between small and large farms. The larger farms appear to be growing more rapidly and their relative financial performance is improving over time.

This study has important implications regarding the future structure of Kansas farms. Throughout the study period, large farms were in a better competitive position than small

farms. This difference has been documented by previous research. What is unique with regard to this study are the results suggesting that the differences in farm size and financial performance between small and large farms are widening over time. Based on the results of this study, the consolidation of farms is likely to continue and may even accelerate.

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Table 1. Summary Statistics for a Sample of Kansas Farms.

	Value of Farm Production	Total Acres	% Livestock Income	Economic Total Expense Ratio	Profit Margin Ratio	Asset Turnover Ratio
1973-1977	85,116	1,369	0.458	1.307	0.234	0.210
1974-1978	86,990	1,382	0.509	1.396	0.188	0.196
1975-1979	99,487	1,433	0.527	1.331	0.229	0.202
1976-1980	103,266	1,405	0.526	1.415	0.212	0.197
1977-1981	110,037	1,424	0.513	1.504	0.196	0.196
1978-1982	119,286	1,410	0.530	1.553	0.186	0.204
1979-1983	121,187	1,361	0.504	1.628	0.157	0.205
1980-1984	121,124	1,362	0.498	1.718	0.113	0.207
1981-1985	127,504	1,408	0.471	1.737	0.102	0.214
1982-1986	132,791	1,433	0.493	1.710	0.111	0.228
1983-1987	136,397	1,483	0.489	1.672	0.133	0.243
1984-1988	146,710	1,512	0.479	1.614	0.162	0.265
1985-1989	152,485	1,566	0.498	1.582	0.171	0.276
1986-1990	155,994	1,584	0.511	1.519	0.189	0.285
1987-1991	157,271	1,572	0.506	1.449	0.182	0.287
1988-1992	159,434	1,578	0.505	1.359	0.187	0.284
1989-1993	157,356	1,609	0.499	1.307	0.164	0.277
1990-1994	159,264	1,607	0.483	1.256	0.150	0.273
1991-1995	160,749	1,654	0.456	1.227	0.125	0.273
1992-1996	172,809	1,667	0.415	1.166	0.154	0.289
1993-1997	186,558	1,683	0.392	1.152	0.153	0.302
1994-1998	187,049	1,681	0.356	1.189	0.121	0.297
1995-1999	198,023	1,708	0.359	1.172	0.131	0.302
1996-2000	206,184	1,707	0.350	1.153	0.141	0.309
1997-2001	210,405	1,736	0.339	1.189	0.104	0.300
1998-2002	207,101	1,776	0.331	1.235	0.061	0.285
1999-2003	213,557	1,808	0.325	1.194	0.080	0.290
2000-2004	220,693	1,806	0.321	1.170	0.086	0.293
2001-2005	234,858	1,827	0.343	1.159	0.087	0.288
2002-2006	259,637	1,862	0.354	1.152	0.093	0.286
2003-2007	304,663	1,873	0.323	1.101	0.139	0.299

Source: Kansas Farm Management Association databank, 1973-2007.

Table 2. Summary Statistics for the Top and Bottom Quartiles.

	Value of Farm Production		Total Acres		Percent Livestock Income	
	Bottom	**Top**	**Bottom**	**Top**	**Bottom**	**Top**
1973-1977	37,664	158,841	888	1,992	0.499	0.389
1974-1978	38,187	162,921	869	1,980	0.483	0.455
1975-1979	42,750	188,053	861	2,088	0.437	0.511
1976-1980	44,833	194,698	849	2,049	0.462	0.509
1977-1981	47,858	206,718	855	2,101	0.476	0.509
1978-1982	49,337	225,446	807	2,087	0.494	0.536
1979-1983	49,854	226,784	808	2,056	0.540	0.490
1980-1984	47,099	232,768	778	2,066	0.525	0.497
1981-1985	46,840	250,243	754	2,154	0.474	0.472
1982-1986	48,174	260,215	755	2,182	0.457	0.508
1983-1987	49,883	264,712	750	2,267	0.421	0.524
1984-1988	52,880	287,076	775	2,337	0.383	0.520
1985-1989	53,657	303,103	800	2,367	0.443	0.531
1986-1990	55,285	310,061	817	2,391	0.448	0.555
1987-1991	56,877	313,555	837	2,424	0.487	0.544
1988-1992	56,652	320,668	842	2,468	0.473	0.540
1989-1993	55,222	317,424	843	2,526	0.466	0.526
1990-1994	54,060	323,396	816	2,536	0.494	0.498
1991-1995	52,713	330,794	863	2,617	0.501	0.465
1992-1996	54,630	357,392	935	2,588	0.470	0.414
1993-1997	56,896	386,238	911	2,623	0.462	0.384
1994-1998	56,056	388,127	902	2,592	0.457	0.341
1995-1999	58,675	411,309	895	2,602	0.418	0.359
1996-2000	60,535	428,788	877	2,691	0.396	0.348
1997-2001	59,531	441,425	833	2,777	0.385	0.328
1998-2002	58,358	434,679	884	2,849	0.386	0.326
1999-2003	61,342	445,640	879	2,961	0.374	0.327
2000-2004	63,290	460,727	887	2,923	0.363	0.330
2001-2005	68,417	493,084	876	2,910	0.366	0.355
2002-2006	71,007	560,987	864	2,983	0.372	0.388
2003-2007	82,564	657,355	867	2,996	0.362	0.351

Table 2. Continued.

	Economic Total Expense Ratio		Profit Margin Ratio		Asset Turnover Ratio	
	Bottom	**Top**	**Bottom**	**Top**	**Bottom**	**Top**
1973-1977	1.541	1.198	0.097	0.276	0.173	0.244
1974-1978	1.672	1.273	0.032	0.234	0.158	0.230
1975-1979	1.624	1.228	0.072	0.271	0.158	0.231
1976-1980	1.717	1.298	0.051	0.255	0.157	0.227
1977-1981	1.829	1.380	0.049	0.235	0.152	0.227
1978-1982	1.935	1.417	0.019	0.226	0.153	0.238
1979-1983	2.046	1.484	-0.033	0.202	0.155	0.238
1980-1984	2.187	1.552	-0.099	0.164	0.153	0.246
1981-1985	2.248	1.574	-0.123	0.152	0.152	0.254
1982-1986	2.168	1.565	-0.115	0.164	0.166	0.264
1983-1987	2.117	1.545	-0.094	0.184	0.179	0.275
1984-1988	2.018	1.515	-0.070	0.211	0.201	0.289
1985-1989	1.957	1.480	-0.063	0.219	0.211	0.300
1986-1990	1.892	1.423	-0.037	0.233	0.212	0.314
1987-1991	1.809	1.354	-0.042	0.227	0.212	0.320
1988-1992	1.753	1.256	-0.058	0.238	0.204	0.320
1989-1993	1.710	1.203	-0.086	0.218	0.195	0.316
1990-1994	1.694	1.152	-0.116	0.208	0.184	0.310
1991-1995	1.722	1.113	-0.176	0.190	0.173	0.319
1992-1996	1.724	1.051	-0.164	0.221	0.163	0.343
1993-1997	1.687	1.044	-0.152	0.215	0.171	0.358
1994-1998	1.763	1.074	-0.204	0.185	0.164	0.357
1995-1999	1.723	1.066	-0.186	0.190	0.171	0.358
1996-2000	1.663	1.053	-0.162	0.196	0.181	0.363
1997-2001	1.725	1.091	-0.204	0.153	0.170	0.359
1998-2002	1.844	1.125	-0.284	0.119	0.152	0.342
1999-2003	1.763	1.088	-0.241	0.140	0.154	0.346
2000-2004	1.730	1.051	-0.238	0.155	0.155	0.359
2001-2005	1.705	1.036	-0.235	0.162	0.154	0.351
2002-2006	1.741	1.038	-0.252	0.163	0.148	0.342
2003-2007	1.684	0.991	-0.212	0.208	0.156	0.355

Table 3. Growth Rates Calculated Using Trend Regressions.

Characteristic	Full Sample		Quartiles	
Value of Farm Production	0.034579	***	0.0445234	***
Total Acres	0.011167	***	0.021298	***
Percent Livestock Income	-0.017524686	***	-0.002316	
Economic Total Expense Ratio	-0.011841564	***	0.017539	***
Operating Profit Margin Ratio	-0.024984	***	0.042360	***
Asset Turnover Ratio	0.016081	***	0.0280892	***
PCE Price Index	0.037137	***		

Note: One asterisk denotes significance at the 10% level, two asterisks denote significance at the 5% level, and three asterisks denote significance at the 1% level.

Table 4. Estimated Regressions to Determine β-Convergence.

Variable	Model 1[a]		Model 2[b]		Model 3[c]		Model 4[d]		Model 5[e]		Model 6[f]	
$Intercept_t$	0.01677	***	0.00286		-0.01664	**	-0.00452		0.08897		0.00303	
	(0.00287)		(0.26176)		(0.01383)		(0.12607)		(0.22695)		(0.58058)	
VFP_t	1.47248E-07	***	7.76528E-08	**	-7.06732E-09		-5.55941E-08	*	-6.69553E-07		1.03833E-07	*
	(0.00611)		(0.01149)		(0.89785)		(0.07022)		(0.35620)		(0.08535)	

Note: The p-values are in parentheses. One asterisk denotes significance at the 10% level , two asterisks denote significance at the 5% level, and three asterisks denote significance at the 1% level.

[a]Model 1: Growth Rate of Value of Farm Production regressed on initial Value of Farm Production

[b]Model 2: Growth Rate of Total Acres regressed on initial Value of Farm Production

[c]Model 3: Growth Rate of Percent Livestock Income regressed on initial Value of Farm Production

[d]Model 4: Growth Rate of Economic Total Expense Ratio regressed on initial Value of Farm Production

[e]Model 5: Growth Rate of Profit Margin Ratio regressed on initial Value of Farm Production

[f]Model 6: Growth Rate of Asset Turnover Ratio regressed on initial Value of Farm Production

Table 5. Estimated Regressions to Determine σ-Convergence.

Variable	Model 1[a]	Model 2[b]	Model 3[c]	Model 4[d]	Model 5[e]	Model 6[f]
$Intercept_t$	39,348.52***	441.93***	0.05005***	0.18607***	0.08903***	0.02065***
	(<.00010)	(<.00010)	(<.00010)	(<.00010)	(<.00010)	(<.00010)
$time_t$	5,268.68***	13.62***	0.00011	0.00603***	0.00427***	0.00215***
	(<.00010)	(<.00010)	(0.59123)	(<.00010)	(<.00010)	(<.00010)

Note: The p-values are in parentheses. One asterisk denotes significance at the 10% level, two asterisks denote significance at the 5% level, and three asterisks denote significance at the 1% level.

[a]Model 1: Standard Deviation of Value of Farm Production regressed on time trend

[b]Model 2: Standard Deviation of Total Acres regressed on time trend

[c]Model 3: Standard Deviation of Percent Livestock Income regressed on time trend

[d]Model 4: Standard Deviation of Economic Total Expense Ratio regressed on time trend

[e]Model 5: Standard Deviation of Profit Margin Ratio regressed on time trend

[f]Model 6: Standard Deviation of Asset Turnover Ratio regressed on time trend