16. Productivity Convergence Across Kansas Farms

Beth Yeager **<eyeager@agecon.ksu.edu>**

Beth is a Graduate Research Assistant at Kansas State University where she is pursuing a Ph.D. in Agricultural Economics. Beth holds a B.S. degree in Agricultural Economics from Kansas State University. Her research has primarily focused on farm efficiency, productivity, and benchmarking of financial performance.

Michael Langemeier **<mlange@agecon.ksu.edu>**

Michael Langemeier is a professor of Agricultural Economics at KSU. He has been on the faculty since 1990. Extension and research interests include benchmarking of technical and financial performance, strategic positioning, and economies of size. In addition to his extension and research program, Michael teaches courses in Farm Management, Production Economics, and Managerial Economics.

Abstract/Summary

This presentation will document changes in productivity across Kansas farms over the last 30 years. The Malmquist productivity index is used to estimate the productivity changes for each farm every year and to determine if farms are "catching-up" to the same levels of productivity as the top farms in the study. Differences among these farms in terms of size, sources of income, productivity indices, and financial ratios will be discussed.

Productivity Divergence Across Kansas Farms
Elizabeth Yeager and Michael Langemeier
2009 Risk and Profit Conference
August 2009

Introduction

Productivity growth is one way to measure how well farms are doing over a period of time. Productivity measures the quantity of outputs relative to the level of inputs. The more output resulting from the same or decreasing level of inputs results in an increase in productivity.

Previous research that addresses productivity growth and divergence for a sample of farms is limited. Clark and Langemeier (2007) examined the relationship between productivity and farm size for a sample of Kansas farms. However, the authors did not examine convergence or divergence. A study by Ball et al. (2004) found that there were significant signs of productivity convergence across the 48 continental states from 1960 to 1999. States with lower productivity in 1960 were catching up to those with higher initial productivity.

The objective of this study is to examine productivity differences across individual Kansas farms for a 30-year period and to determine whether productivity is converging or diverging. The Malmquist productivity index is computed for each farm in each year. If the farms are converging, the greatest growth will be in the farms that are trying to catch-up to the levels of the most productive farms. If productivity is diverging, differences in productivity across farms are widening. This study also identifies the sources of some of the differences in productivity in terms of farm size, sources of income, productivity indices, and financial ratios.

Methods

Input based Malmquist productivity indices (MPI) were calculated for each farm and year (Färe and Grosskopf, 1996). This required defining input distance functions with multiple input and output quantities. Readers are directed to the aforementioned study as well as Ariyaratne et al. (2006) if they are interested in the specific linear program models used to calculate the indices.

Improvement in productivity is shown by an MPI greater than one. A value of less than one is an indication of deterioration. Unity indicates there has been no change in MPI. The MPI can be further broken down into an efficiency change (EFFC) and a technical change (TECH) component. Efficiency change represents a movement towards or away from the production frontier. A movement towards the production frontier would improve productivity. Efficiency change can be further decomposed into pure technical efficiency change (PTEC) and scale change (SCC). Technical change represents a shift in the production frontier. Technical change can be further decomposed into input biased technical change (IBTECH), output biased technical change (OBTECH), and a magnitude component (MATECH). Input biased technical change suggests that the technologies that have been adopted use more of a particular input and less of another input or inputs. For example, many technologies are purchased input and capital using, and labor saving. In this case, technology would be biased towards purchased inputs and capital. Output biased technical change reflects differences in outputs produced based on the adoption of technology. An example would be the adoption of a no-till production system in central and western Kansas. Often, this production system will increase the production of feed grains and decrease the production of wheat.

Following the work of Ball et al. (2004), a regression was used to test for convergence. The rate of growth of MPI over the entire time period is a function of the natural log of the initial growth rate and the following ratios: capital to labor, purchased inputs to labor, and livestock to crop. If the farms are converging to the same level of productivity, the expected sign on the initial growth rate variable will be negative. The opposite is true, if there is divergence. In this case, the sign on the initial growth rate variable will be positive. The capital to labor and purchased inputs to labor ratios are used to explore input bias while the livestock to crop ratio is used to explore output bias.

Additional regressions were used to identify the impacts of the input ratios and income shares on changes in EFFC and TECH. This allows for further explanations of the changes in productivity.

Data

Summary statistics for the sample of farms are presented in Table 1. For a farm to be included in the analysis, continuous whole-farm data had to be available from 1979-2008. There were 135 KFMA farms with the required data. For more information on the variables available in the KFMA databank and variable definitions, see Langemeier (2003).

Input and output indices were computed for each farm and year by dividing income and expense items by price indices. The inputs used in the analysis were labor, purchased inputs, and capital. The outputs used in the analysis were crop and livestock. Additional analysis broke crop income down into feed grain, small grain, hay and forage, and oilseed income; and livestock income into beef, dairy, and swine income.

The average total farm income over the 30-year period was $201,525. Total farm income was comprised of crop income of $106,379 and livestock income of $95,166. Average total acres and crop acres were 1,566 and 974, respectively. On average, approximately 63 percent of farmers' time was spent on crop production. The largest source of crop income was small grains, which was comprised almost exclusively of wheat. Beef income was by far the largest source of livestock income. The average profit margin and asset turnover ratios were 0.155 and 0.247, respectively.

Results

The average MPI over the 30 year period was 1.0049 resulting in an average annual change in productivity of 0.49 percent. The highest average change was 6.46 percent and the lowest average change was -7.99 percent. Technical change averaged 0.30 percent per year and efficiency change averaged 0.18 percent per year.

Table 2 provides a summary of the differences in farm characteristics, productivity indices, and financial ratios by categories defined using the MPI. Farms in the top third had an average MPI of at least 1.0159 and farms in the bottom third had an average MPI of less than 0.9963. The average annual productivity increase for the top 45 farms was 2.39 percent while the average annual productivity decrease for the bottom 45 farms was 1.46 percent. If the farms in the top group continued to have an annual productivity increase of 2.39 percent compared to the average of 0.49 percent with inputs remaining the same, outputs would increase by 27 percent for the top group and only 5 percent for the average over a ten year period.

The first ten years of the sample period (1979-1988) saw the largest differences between the top and bottom farms in terms of MPI. The average annual productivity increase for the top farms was 2.18 percent and the average annual productivity decrease for the bottom farms was 2.49 percent during this time period. The second ten years (1989-1998) resulted in the highest productivity increases for both the top and bottom farms with average annual productivity increases of 6.49 percent for the top group and 3.68 percent for the bottom group. The last ten year period (1999-2008) resulted in negative growth for both groups. The average annual productivity decreased 1.75 percent for the top group and decreased 5.80 percent for the bottom group during this time period.

In terms of farm characteristics, the farms in the top productivity group were larger in terms of total farm income, crop farm income, and livestock farm income. The average total farm income for the 45 farms in the top group was $265,120 and for the 45 farms in the bottom group was $154,799. The farms in the top third had more farm income coming from oilseeds and feed grains and less coming from small grains and hay and forage as compared to the farms in the bottom third. In terms of income from livestock sources, the farms in the top third had more income coming from swine compared to the farms in the bottom third.

The farms in the top third had significantly higher profit margin, asset turnover, and return on investment ratios. It is important to note that the return on investment ratio did not include capital gains on land. The top third also had significantly higher values for PTEC, SCC, EFFC, MATECH, TECH, and MPI. The bottom third had negative average growth in all components of MPI except for IBTECH and OBTECH.

The regression results for the convergence test indicated a significant positive relationship between the average productivity levels and the log of the initial productivity levels; thus, the sample of farms experienced divergence (Table 3). In other words, there has not been a tendency for the farms with a lower productivity index to catch up to the productivity levels of the top farms in the sample. The purchased inputs to labor ratio was positive and significant at the five percent significance level indicating that as purchased inputs grow relative to labor the average MPI increases. The livestock to crop ratio was negative and significant at the ten percent significance level indicating that as livestock outputs increase relative to crop outputs there is a decrease in the average MPI.

The purchased inputs to labor ratio had a positive and significant impact on EFFC and TECH. An increase in purchased inputs compared to labor resulted in a movement towards the production frontier and a shift in the production frontier. The capital to labor ratio did not have a significant impact. These results can be found in Table 4.

Regression analysis was used in Table 5 to explore the relationship between EFFC and TECH and income shares. Small grain income was removed from the regressions to prevent the independent variables from summing to unity. This variable was chosen because it represented the largest average source of income for the farms. An increase in swine income had a positive and significant effect on EFFC. An increase in feed grain income had a positive and significant effect on TECH.

Summary and Conclusions

This study used 30 years of continuous data for 135 farms in Kansas to explore changes in productivity. Malmquist productivity indices were calculated for each farm every year and these indices were used to determine whether there was productivity convergence or divergence in Kansas farms. The results showed that there was significant divergence among the farms. Thus, there was not a tendency for farms to catch-up to the same levels of productivity as the top farms in the sample.

The average annual productivity growth over the sample period, 1979-2008, was 0.49 percent. The average growth for the top 45 farms based on MPI was 2.39 percent and the average productivity decrease was 1.46 percent for the bottom 45 farms. On average, both groups of farms had productivity increases from 1989-1998 and productivity decreases from 1999-2008.

The top farms based on MPI were larger in terms of total farm income, crop farm income and livestock farm income. They also had significantly higher technical change indices, efficiency change indices, and financial efficiency ratios. The top group received a larger percentage of their income from oilseeds, feed grains, and swine than the other farms on average. Conversely, the top group received relatively less of their income from small grains.

References

Ariyaratne, C.B., A.M. Featherstone, and M.R. Langemeier. "What Determines Productivity Growth of Agricultural Cooperatives?" *Journal of Agricultural and Applied Economics.* 38,1 (April 2006): 47-59.

Ball, V.E., C. Hallahan, and R. Nehring. "Convergence of Productivity: An Analysis of the Catch-up Hypothesis within a Panel of States." *American Journal of Agricultural Economics.* 86 (Number 5, 2004): 1315-1321.

Clark, P., and M. Langemeier. "Productivity and Farm Size." 16th International Farm Management Association Congress – UCC, Cork, Ireland. 15-20 July 2007: 321-328.

Färe, R., and S. Grosskopf. *Intertemporal Production Frontiers: With Dynamic DEA.* Kluwer Academic Publishers, USA, 1996.

Langemeier, M.R. "Kansas Farm Management SAS Data Bank Documentation." Department of Agricultural Economics, Staff Paper No. 03-02, June 2003.

Table 1. Summary Statistics for Sample of Kansas Farms, 1979- 2008.	Mean	Standard Deviation
Inputs		
Labor Index	83,911	51,553
Purchased Input Index	188,681	157,265
Capital Index	207,844	117,018
Outputs		
Crop Index	271,059	223,498
Livestock Index	116,419	165,957
Farm Characteristics		
Value of Farm Production (VFP)	200,754	136,926
Total Farm Income (TFI)	201,525	163,532
Crop Farm Income (CFI)	106,379	96,862
Percent of CFI from Feed Grain Income (corn & grain sorghum)	31.73%	13.02%
Percent of CFI from Small Grain Income (primarily wheat)	34.41%	25.19%
Percent of CFI from Hay and Forage Income	4.42%	10.92%
Percent of CFI from Oilseed Income (soybeans and sunflowers)	29.43%	18.75%
Crop Diversification Index	0.306	0.152
Livestock Farm Income (LFI)	95,146	140,618
Percent of LFI from Beef Income	48.35%	40.52%
Percent of LFI from Dairy Income	24.17%	28.90%
Percent of LFI from Swine Income	27.47%	29.47%
Livestock Diversification Index	0.292	0.389
Crop and Livestock Aggregate Diversification Index	0.502	0.168
Total Acres	1,566	977
Total Crop Acres	974	566
Number of Operators	1.13	0.45
Number of Workers (includes hired, family, and operator labor)	1.63	0.95
Crop Labor Percentage	62.47%	20.33%
Productivity Indices		
Pure Technical Efficiency Change (PTEC)	1.0004	0.0092
Scale Change (SCC)	1.0015	0.0103
Efficiency Change (EFFC)	1.0019	0.0140
Input Biased Technical Change (IBTECH)	1.0114	0.0158
Output Biased Technical Change (OBTECH)	1.0044	0.0075
Magnitude Component (MATECH)	0.9877	0.0197
Technical Change (TECH)	1.0031	0.0109
Malmquist Productivity Index (MPI)	1.0050	0.0188
Financial Efficiency Ratios		
Profit Margin	0.155	0.145

Asset Turnover Ratio	0.247	0.116
Return on Investments	0.038	0.035

Note: The means for percent of TFI from the respective income sources, CFI from the respective income sources, LFI from the respective income sources, diversification indices and financial efficiency ratios represent a weighted average.

Table 2. Farm Characteristics of Kansas Farms in the bottom, middle, and top thirds by Malmiquist Productivity Indices, 1979-2008.

	Bottom 45 Farms	Middle 45 Farms	Top 45 Farms
Farm Characteristics			
Value of Farm Production (VFP)	160,463[a]	184,044[a]	257,755[b]
Total Farm Income (TFI)	154,799[a]	184,655[a]	265,120[b]
Crop Farm Income (CFI)	78,915[a]	92,798[a]	147,422[b]
Percent of CFI from Feed Grain Income (corn & grain sorghum)	25.89%[a]	33.77%[b]	33.58%[b]
Percent of CFI from Small Grain Income (primarily wheat)	46.87%[a]	29.82%[b]	30.63%[b]
Percent of CFI from Hay and Forage Income	6.11%[a]	5.16%[a]	3.06%[b]
Percent of CFI from Oilseed Income (soybeans and sunflowers)	21.13%[a]	31.25%[b]	32.73%[b]
Crop Diversification Index	0.331[a]	0.301[a]	0.314[a]
Livestock Farm Income (LFI)	75,884[a]	91,857[a]	117,698[a]
Percent of LFI from Beef Income	61.40%[a]	44.57%[a]	42.89%[a]
Percent of LFI from Dairy Income	33.66%[a]	36.31%[a]	8.59%[a]
Percent of LFI from Swine Income	4.95%[a]	19.12%[ab]	48.52%[b]
Livestock Diversification Index	0.490[a]	0.330[a]	0.191[a]
Crop and Livestock Aggregate Diversification Index	0.500[a]	0.500[b]	0.506[b]
Total Acres	1743[a]	1417[a]	1539[a]
Total Crop Acres	964[ab]	834[a]	1124[b]
Number of Operators	1.07[a]	1.15[a]	1.18[a]
Number of Workers (includes hired, family, and operator labor)	1.48[a]	1.54[a]	1.87[a]
Crop Labor Percentage	63.88%[a]	57.93%[a]	65.60%[a]
Productivity Indices			
Pure Technical Efficiency Change (PTEC)	0.994[a]	1.002[b]	1.006[c]
Scale Change (SCC)	0.996[a]	1.002[b]	1.006[c]
Efficiency Change (EFFC)	0.990[a]	1.004[b]	1.012[c]
Input Biased Technical Change (IBTECH)	1.011[a]	1.013[a]	1.011[a]
Output Biased Technical Change (OBTECH)	1.005[a]	1.004[a]	1.004[a]
Magnitude Component (MATECH)	0.980[a]	0.986[a]	0.997[b]
Technical Change (TECH)	0.996[a]	1.002[b]	1.012[c]
Malmquist Productivity Index (MPI)	0.985[a]	1.006[b]	1.024[c]
Financial Efficiency Ratios			
Profit Margin	0.135[a]	0.131[a]	0.184[b]
Asset Turnover Ratio	0.215[a]	0.258[b]	0.264[b]
Return on Investments	0.029[a]	0.034[a]	0.048[b]

Note: The means for percent of TFI from the respective income sources, CFI from the respective income sources, LFI from the respective income sources, diversification indices and financial efficiency ratios represent a weighted average. Unlike superscripts indicate that the means are statistically different at the five percent level.

Table 3. Productivity Growth (MPI) on Initial Productivity Level and Relative Factor Intensities

	Inputs Relative to Labor	Inputs Relative to Purchased
Intercept	0.9944**	1.0232**
	(224.45)	(266.93)
logmalmi7980	0.0131**	0.0048**
	(2.86)	(2.55)
K/L	-0.0024	
	(-1.41)	
P/L	0.0095**	
	(5.62)	
K/P		-0.0043
		(-1.32)
L/P		-0.0156**
		(-2.46)
Live/Crop	-0.0012*	-0.0010
	(-1.79)	(-1.48)
R^2	0.2730	0.2126
Adjusted R^2	0.2506	0.1884

Note: The numbers in parentheses are the t-values. **indicates significance at the five percent level. * indicates significance at the ten percent level.

Table 4. Efficiency Change and Technical Change on Relative Input Ratios

	EFFC	TECH
Intercept	1.0010**	0.9888**
	(284.16)	(437.02)
K/L	-0.0022	0.0003
	(-1.61)	(0.30)
P/L	0.00316**	0.0063**
	(2.30)	(7.15)
R^2	0.0404	0.3505
Adjusted R^2	0.0259	0.3406

Note: The numbers in parentheses are the t-values. **indicates significance at the five percent level. * indicates significance at the ten percent level.

Table 5. Efficiency Change and Technical Change on Income Shares

	EFFC	TECH
Intercept	0.9939**	0.9982**
	(193.23)	(266.69)
FGI/TFI	0.00828	0.0287**
	(0.54)	(2.59)
OI/TFI	0.0105	0.0020
	(1.00)	(0.26)
HFI/TFI	0.0032	-0.0120
	(0.10)	(-0.52)
BI/TFI	0.0093	-0.0050
	(1.25)	(-0.93)
DI/TFI	0.0067	0.0026
	(0.96)	(0.49)
SI/TFI	0.0267**	0.0148
	(3.36)	(2.57)
R^2	0.0990	0.2174
Adjusted R^2	0.0568	0.1807

Note: The numbers in parentheses are the t-values. **indicates significance at the five percent level. * indicates significance at the ten percent level. Small grain income was dropped from the regression.