Kansas Farm Profitability Persistence: Do Top Farms Remain Top Farms?

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Selected Paper prepared for presentation at the Southern Agricultural Economics Association (SAEA) Annual Meeting, San Antonio, Texas, February 6-9, 2016

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Abstract

Estimating absolute farm profitability is a difficult task as there are uncontrollable factors (i.e., weather) that influence the profit level in addition to the management factors that can be observed and measured. Estimating the relative farm profitability to other farms is an easier task and can still provide important information about how the farm is performing. The probability of remaining in the highest (lowest) profitability state can be estimated using ranks across multiple years. We used a panel of 425 Kansas Farm Management Association (KFMA) farms for the years 1994 through 2014 to estimate the probability of a farm remaining in their current profitability state or transitioning to another profitability state. We evaluated farms by profitability quintiles and by levels of financial stress. For quintiles, farms were ranked in order of accrual per acre net farm income for each year and then uniformly assigned to one of five profitability states. For the financial vulnerability states, we assign farms to a state based on ERS estimation of vulnerable farms. We apply Markov chain processes to estimate one-step transition probability matrices from one profitability state to another profitability state in a single step. Preliminary results suggest moderate transition stability of farms to remain in their respective profitability states of the world. Ultimately we address the question of how persistent whole farm profitability is over time. The results indicate that better farm management skills can improve a farm's position, eliminating the assumption of luck as a factor.

Keywords: net farm income, persistence, Markov, profitability, farm management

JEL Codes: Q10 , Q15

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Our overall goal was to report the probability of Kansas farms transitioning between profitability ranking categories. Specifically, we determine if farms in the higher profitability categories are more likely to remain in the current profitability category than the lower profitability categories. Substantially higher levels of persistence in the high profitability categories compared to the low profitability categories would indicate management, rather than luck, are leading to the difference between the two groups of farmers. In addition we emphasize the likelihood of farms in the highest profitability category transitioning to lowest profitability category in a single year; these results indicate how quickly farms switch from appearing profitable to being financially vulnerable.

Farms strive to maintain or improve their financial positions in the presence of controllable (seed choice, fertilizer, marketing) and uncontrollable (weather, soil properties) factors. Many of the controllable factors can be attributed to management while many of the uncontrollable factors can be attributed to weather and farm location. Farms that are more profitable relative to their peers have a greater likelihood of succeeding in the long-run. These farms typically have a greater probability of earning a profit in bad years and will enjoy greater income in good years. By contrast, farms that are less profitable relative to their peers have a greater likelihood of becoming insolvent. These farms are less likely to earn a profit, and in a bad year could lose enough to exhaust their equity. An important question is whether a farm can improve, or at least maintain, its profitability ranking compared to other farms; and what the probabilities are that farms may switch to another profitability ranking. The probability of Kansas farms remaining in a specific profitability rank or switching to another ranking was evaluated using Kansas Farm Management Association (KFMA) data. The probability of transitioning between profitability ranks is important so that farmers and their advisors understand how quickly farms can switch from financial security to vulnerability.

When the probability that a farm remains in its current profitability ranking is higher than the probability that it switches to another profitability ranking, it is said to be persistent. If farm profitability is based on random luck, then farms will freely transition between profitability categories just as often as remaining in the current profitability category. Persistence is a desirable characteristic when a farm is in one of the higher profitability categories; and may be interpreted as the farm being managed with above average skills. However, a farm with better than average soils or in a region with higher annual rainfall amounts could also show persistence in the higher profitability categories relative to other farms. Conversely, persistence in the lower profitability categories is not a desirable characteristic; and can be attributed to poor farm management, poor soils, or annual rainfall that is less than adequate. The lack of persistence across all profitability categories indicates factors outside the control of the farmer.

Background and Literature Review

Agriculture in the past five years has experienced unprecedented gains for farm profitability (Park et al., 2010). This in turn has led many producers to increase their production sizes and make sizeable investments in long-term assets such as land; and therefore taking upon different financial risk exposure. Naturally, with the increased farm expansion land values soared potentially creating an asset bubble. According to Burns et al. (2015) an environment similar to the 1980s farm crisis

could potentially arise under the specific conditions. They cite falling land prices in 2014 coupled with lower commodity prices and smaller net farm incomes as potential sources of distress. However, the USDA report indicated that estimates for farm debt to equity and debt to asset ratios would continue to decrease allowing farms to maintain financial stability (Park et al., 2010). Additionally, lower interest rates and stronger debt management skills have prevented another farm crisis.

Despite the 2010 USDA report's expected stability recent changes to the financial environment farmers are exposed to have brought about uncertainty. Now considerable interest has been exhibited to identify farms with above average managerial performances. However, identifying and quantifying managerial performances provides a unique set of problems. Sonka et al. (1989) attempted to identify proxies for a managerial variable using statistical analysis of Illinois farm data from 1976-1983. Ford and Shonkwiler (1994) used maximum likelihood estimators to find variables of interest and confirmatory factor analysis. Featherstone et al. (2002) used Kansas farm data with two goals in mind: determining the roles that experience and learning plays in determining yield performance and quantifying the magnitude of these variables of interest and their impact upon yield performance. Yeager and Langemeier (2011) applied nonparametric data analysis to Kansas farm data while focusing on operator age and its relationship to technical efficiency. Research by Mishra, Wilson, and Williams (2009) utilized returns on assets as measure of managerial performance with a focus on farm operator characteristics, farm production and marketing efficiency, and other management techniques. Zech and Penderson (2003) utilized regression analysis to find characteristics linked to loan repayment ability while comparing their results to previous studies with a logit model. These research articles identification of managerial variables and their impacts lend themselves to our work. One of the first metrics useful in evaluating farm management performance is the persistence with which farm business remain profitable.

Farm profitability persistence has been evaluated in Illinois (Kuethe et al. 2015; Li and Paulson, 2014; Urcola et al., 2004) and Kansas (Herbel and Langemeier, 2012; Ibendahl, 2013). Urcola et al. (2004) focused on agronomic yield rather than profitability. Urcola et al. (2004) and Ibendahl (2012) evaluated management skill versus stochastic process under the guise of 'luck'. These previous studies of farm management association records programs can be considered comparative analyses, comparing and contrasting characteristics of the most and least profitability groups. Li and Paulsen (2014) continued the use of Illinois FBFM data by expanding the time horizon of Urcola et al. (2004) and correcting for survivor bias. In Kansas, Langemeier and DeLano (1999) applied data envelopment analysis to a 24-year panel from the KFMA databank. Ibendahl (2012) expanded upon the Kansas study by evaluating farms allocated to decile groups based on profitability. Given the comparisons between most and least profitability states, the next logical question to address is the probability of farms transitioning between profitability states or remaining in their current state. An exhaustive review of the literature revealed no studies estimating the transition probabilities with respect to persistence or movement between profitability states.

The probability of remaining in the highest (lowest) profitability state can be estimated using ranks across multiple years. Markov chain transition probabilities (Eddy, 1998) have been applied to 1) soil erosion classification (Skaggs and Ghosh, 1999), 2) livestock farm size (Gillespie and Fulton, 2001), 3) health and medicine (Jung, 2006), and 4) land use changes (Muller and Middleton, 1994).

Data and Methods

Persistence was tested on the 425 farms present in the Kansas Farm Management Association dataset for all years from 1994 through 2013. The KFMA databank is suitable for estimating transition probabilities due to the ample number of farms. Even when considering only farms that exist for all 20 years in the database, there were 425 farms available for analysis. The data were also subset for each of the six KFMA Associations (see Figure 1 for map of Kansas KFMA Associations). Each KFMA Association differed by number of farms; ranging from a high of 165 in the Southeast Association to a low of 18 in the Northwest Association (Figure 2 presents the number of farms for each KFMA Association).

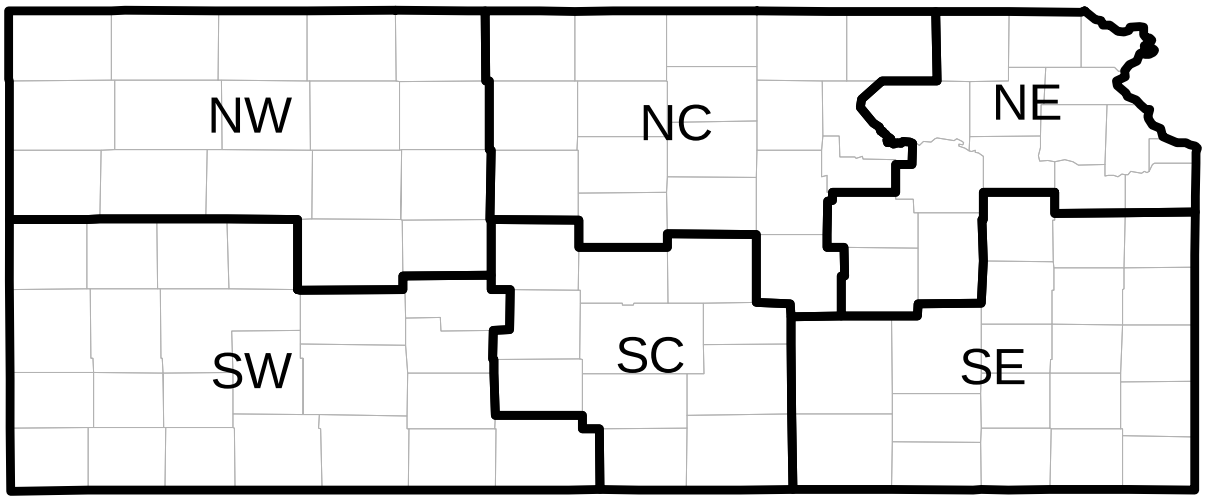

Figure 1. Map of KFMA regions within Kansas

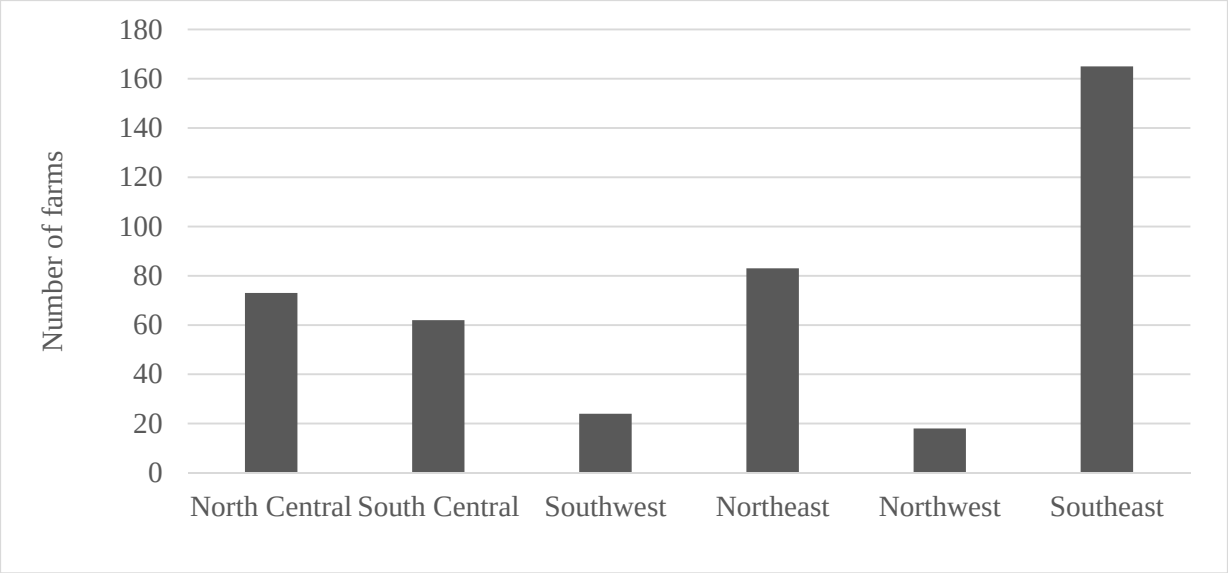

Figure 2. Number of Farms by KFMA Association

Accrual per acre annual net farm income (NFI) was calculated for each farm for each of the 20 years. KFMA farms calculate net farm income using accrual accounting and also use management depreciation instead of tax depreciation. The management depreciation is an attempt to match depreciation to the actual decline in asset value. Management depreciation lowers the asset value slower than would tax depreciation. For each year, farms were ranked in order of NFI and then evenly assigned to one of five states of the world based on profitability, or quintiles, such that each state contained 20% of all farms. These quintiles were named Quintile 1 to Quintile 5. Quintile 1 contains the top 20% of farms with respect to the highest NFI, farms with 20th to 40th percentile NFI were assigned to Quintile 2, and so on with the lowest 20% NFI farms assigned to Quintile 5. All farms were reassigned each year based on NFI rankings; therefore a given farm may change from any one quintile to any other quintile from year to year. Only farms that were in the dataset the entire 20-year timeframe were used for the analysis. The probability of transitioning from one quintile to any other quintile was estimated using the 1994 to 2013 KFMA dataset.

Each year the percentage of farms that stayed in the same quintile or moved to another were calculated. Therefore, each of the 425 farms contributed 19 observations over the 20-year period. An ergodic Markov chain was utilized to build the transitional matrix. From this, probabilities were calculated and observed that in any given year a farm would stay in the same profitability quintile or change to a different quintile. A one-step transition probability matrix, P, from one profitability state to another profitability state were estimated. The transition probability matrix, P, is the matrix consisting of one-step transition probabilities, p_{ij}, defined as

$$p_{ij} = Pr\{X_t = j | X_{t-1} = i\}$$

where p_{ij} is one-step transition probabilities equal to the probability of being in profitability state j given the individual farm was in profitability state i in previous year, t. The underlying assumption of Markov chain models is that the state of world today (time t) is only a function of the previous time period (time t-1).

Markov transition stability or the probability of a farm remaining in a given profitability state is referred to as persistence. The probability of transitioning from one state to any other state was estimated for all farms that were in the KFMA database for all years from 1994 to 2013.

Results

Of the 425 farms in the databank, 289 or nearly two-thirds were ranked in Quintile 1 at least once (Table 1). Substantially more farms were ranked in the lowest four quintiles at least once. The highest number of farms visiting any quintile occurred in Quintile 3 with 390 or 92% of farms. Two farms remained in the Quintile 1 in all 20 years. The most number of times a given farm was in Quintiles 2, 3, or 4 was 13 or 14. Some farms remained in Quintile 5 for 19 of the 20-year period. Although fewer farms persistently visited Quintiles 1 and 5, at least a few farms remained in these top and bottom profitability categories longer than in the middle three quintiles.

Table 1. Distribution of 425 KFMA farms by quintiles over time (1994 to 2013)

	Number farms visiting quintile at least once	Maximum number of times that an individual farm visits quintile
Quintile 1	289	20
Quintile 2	360	13
Quintile 3	390	14
Quintile 4	383	14
Quintile 5	352	19

The transition probabilities for all 425 KFMA farms ranked across quintiles are presented in Table 2 and graphically represented in Figure 3. The values on the principal diagonal indicate the probability that a farm will remain in their current quintile, with other values indicating the likelihood of them transitioning into a different quintile. For example, farms initially in Quintile 1 are likely to remain in Quintile 1 about half the time (probability equal to 0.52). Similarly, farms in Quintile 5 have a moderate chance (probability = 0.42) of remaining in the lowest profitability category. There is a slight chance (probability = 0.09) that a farm in Quintile 1 in a given year can transition to Quintile 5 the next year. Likewise, there is a similar chance (probability = 0.07) that a farm can transition from Quintile 5 to Quintile 1 within one year.

Table 2. NFI ranked by quintile transition probabilities, all KFMA associations, N=425

	1	2	3	4	5
1	**0.52**	0.20	0.12	0.08	0.09
2	0.23	**0.29**	0.22	0.16	0.11
3	0.11	0.23	**0.27**	0.24	0.16
4	0.07	0.15	0.24	**0.30**	0.24
5	0.07	0.12	0.16	0.23	**0.42**

The highest values in each row indicates whether farms are likely to remain in their current quintile rather than switching to another quintile (highest probability bolded for emphasis). When the highest value in each row corresponds to values along the principal diagonal from upper left to lower right, i.e. the probability of beginning in and remaining in the same quintile, then persistence is expected. When the highest values in each row are not along the principal diagonal then persistence is not expected and may be considered instable. Even when transition probabilities are persistent, an individual farm may transition from any quintile to any other quintile from one year to the next; as signified by the absence of zeros in the transition probability tables.

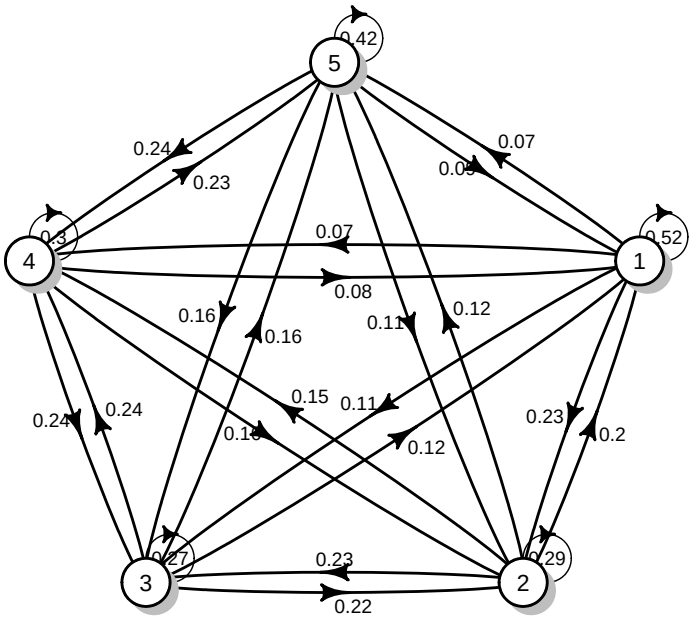

Figure 3. Probability network graph, NFI ranked by quintile transition probabilities, all KFMA associations, N=425

In Table 2, it should be noted that the second and third highest transition probabilities are immediately next to the principal diagonal indicating that when farms switch between profitability categories they are likely to transition one quintile higher or lower rather than jump across multiple profitability categories.

When considering only the farms located within individual KFMA associations some similarities and differences exist compared to Kansas-level results. These relationships varied between different regions in Kansas, as shown by the six different KFMA associations in Tables 3 through 8. Similar to the Kansas-level results, farms in North Central Association were persistent with respect to their tendency of remaining in their current quintile (Table 3). Farms in the highest and lowest profitability categories are more likely to remain in the current quintile than the middle three quintiles. As with the Kansas-level results, farms in North Central Association can transition from Quintile 1 to the Quintile 5 in one year (probability = 0.07).

Table 3. NFI ranked by quintile transition probabilities, KFMA North Central Association, N=73

	1	2	3	4	5
1	**0.50**	0.21	0.12	0.10	0.07
2	0.21	**0.27**	0.24	0.17	0.12
3	0.13	0.22	**0.29**	0.24	0.11
4	0.09	0.16	0.19	**0.29**	0.26
5	0.06	0.13	0.13	0.23	**0.45**

The South Central Association differed from the Kansas-level results in that the transition probabilities along the principal diagonal were not the highest in each row (Table 4). Although farms in the highest and lowest quintiles were likely to remain in the current quintile, the remaining quintiles did not have the expected persistence. The transition probabilities of switching form Quintile 1 to Quintile 5 (probability = 0.06) were similar to Kansas-level results.

Table 4. NFI ranked by quintile transition probabilities, KFMA South Central Association, N=62

	1	2	3	4	5
1	**0.61**	0.20	0.09	0.04	0.06
2	0.21	0.23	**0.26**	0.15	0.15
3	0.10	**0.35**	0.10	0.25	0.21
4	0.12	0.12	0.14	0.27	**0.35**
5	0.06	0.08	0.18	0.25	**0.42**

The Southwest Association also differed from Kansas-level results (Table 5). The highest and lowest profitability categories were persistent while the remaining three profitability categories were unstable. The probabilities of transitioning between Quintile 1 to Quintile 5 (probability = 0.20) and Quintile 5 to Quintile 1 (probability = 0.23) were much higher than Kansas-level results.

Table 5. NFI ranked by quintile transition probabilities, KFMA Southwest Association, N=24

	1	2	3	4	5
1	**0.38**	0.15	0.11	0.16	0.20
2	0.22	0.21	0.19	**0.24**	0.14
3	0.23	**0.25**	0.24	0.14	0.14
4	0.13	0.15	0.22	0.21	**0.29**
5	0.23	0.12	0.14	0.25	**0.26**

The Northeast Association results were similar to Kansas level results (Table 6). The transition probabilities indicate persistence. The probability of transitioning from Quintile 1 to Quintile 5 (probability = 0.11) was slightly higher than the Kansas-level probabilities.

Table 6. NFI ranked by quintile transition probabilities, KFMA Northeast Association, N=83

	1	2	3	4	5
1	**0.50**	0.22	0.11	0.07	0.11
2	0.21	**0.31**	0.25	0.13	0.10
3	0.13	0.20	**0.28**	0.26	0.13
4	0.07	0.14	0.21	**0.34**	0.24
5	0.09	0.11	0.15	0.21	**0.44**

The Northwest Association has the fewest number of observations of all associations (N=18) however the transition probabilities indicate persistence (Table 7). Unlike Kansas-level results, the second and third highest transition probabilities were not adjacent to the principal diagonal. The probability of transitioning from Quintile 1 to Quintile 5 (probability = 0.19) or Quintile 5 to Quintile 1 (probability = 0.19) were nearly 20%, about twice as high as for the Kansas-level results.

Table 7. NFI ranked by quintile transition probabilities, KFMA Northwest Association, N=18

	1	2	3	4	5
1	**0.43**	0.17	0.09	0.12	0.19
2	0.21	**0.32**	0.21	0.17	0.10
3	0.12	0.15	**0.32**	0.18	0.22
4	0.13	0.17	0.20	**0.32**	0.17
5	0.19	0.11	0.13	0.23	**0.34**

The transition probabilities for the Southeast Association were similar to the Kansas-level results (Table 8). Transition probability indicated persistence. The probability of transitioning from Quintile 1 to Quintile 5 (probability = 0.07) or Quintile 5 to Quintile 1 (probability = 0.06) were similar to Kansas-level results.

Table 8. NFI ranked by quintile transition probabilities, KFMA Southeast Association, N=165

	1	2	3	4	5
1	**0.55**	0.22	0.10	0.06	0.07
2	0.23	**0.29**	0.22	0.14	0.12
3	0.10	0.22	**0.30**	0.22	0.16
4	0.07	0.12	0.22	**0.34**	0.25
5	0.06	0.13	0.16	0.23	**0.43**

Summary and Conclusions

A 20-year KFMA dataset was used to estimate transition probabilities for five profitability categories. Results indicated that farms tend to persist in their current profitability category, suggesting that operator skill and/or quality of farmland dominates random factors. In general, the transition probabilities were greater for the highest and lowest profitability categories than the three middle quintiles. That being said, switching from highest probability categories to the lowest profitability categories still occurred between 5 to 20% of the time within one year.

Farmers were likely to stay in the highest profitability group over 50% of the time which is the highest probability of staying within the same profit category. This result is positive for farmers as once a farmer reaches the most profitable group, they would like to remain there. Because this probability of remaining in the most profitable group is the greatest of all the groups, it is likely that better management is leading to at least some of this persistence.

By contrast, farmers were likely to stay in the lowest profitability group 42% of the time which is the second highest probability of staying within the same profit category. This result is not positive for farmers as they do not want to be in the least profitable group. Farms within the least profitable group are losing the most money each year (or at least earning the smallest profits). These farms are likely to be the most vulnerable to financial problems and remaining in the least profitable group year after year increases the probability that these farms could become insolvent.

Just like with the most profitable group, the least profitable group has a greater likelihood of remaining in this bottom group. Again, this could be an indication that more than just random events are causing the persistence. Whether the reason is poor management or perhaps location specific items such as poor soils, etc. remains to be determined

Southwest and South Central Associations did not exhibit strong persistence compared to the remaining four KFMA associations and Kansas-level results. In addition, persistence was indicated by the transition probabilities especially among the largest sample sizes. Persistence was not evident in South Central Association and Southwest Association potentially due to smaller number of farms and prevalence of diversified enterprises. Given the risk management aspect of diversification, it was expected that farms with both crops and livestock production would not persist at the top profitability ranking but frequently switch between quintiles.

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