Economic Efficiency Adjusted for Risk Preferences

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Abstract

This study investigates the impact of risk preferences on economic efficiency scores. Risk averse individuals may be less likely to adopt new technologies and have lower production levels than individuals with other risk preferences. Nonparametric techniques are used to estimate cost and revenue efficiency for a sample of Kansas farms. Each farm had a risk preference score and the scores in the sample ranged from 5 to 86 where a smaller value represents greater risk aversion. Efficiency estimates were first calculated using traditional input and output measures. Efficiency was re-estimated including the inverse risk preference score as a non-discretionary input. Comparisons were made between the characteristics of the farms with an observed efficiency score change and farms without an efficiency score change with the inclusion of inverse risk preferences. As expected, risk preference plays a role in explaining farm inefficiency. Failure to account for risk preferences overstates inefficiency and the improvements in efficiency that can be made.

Keywords: *Cost Efficiency, Revenue Efficiency, Risk Preference*

Classification Codes: C14, D22, D81

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Efficiency analysis will continue to increase in importance as the amount of land devoted to production agriculture decreases and the demand for food and other commodities increases. Risk preferences affect production decisions and need to be accounted for in efficiency analysis. Risk averse producers may choose to produce less than risk neutral or risk preferring individuals and be incorrectly deemed inefficient when it is only the risk preferences that differ (Robison and Barry 1987; Mester 1996). Knowing this, it is imperative to consider risk preferences when estimating and comparing efficiency scores among farms. Previous literature has failed to adjust efficiency scores for differences in risk preferences among farms. This study adds to the existing literature by providing a justification for adjusting efficiency scores for risk preferences, a method to do so, and provides a comparison of standard efficiency scores and efficiency scores adjusted for risk preferences.

Nonparametric efficiency estimates are favored in many instances because they do not impose restrictions on the underlying technology set that would be imposed if a functional form was specified and the parametric approach was used (Chavas and Aliber 1993; Featherstone, Langemeier and Ismet 1997). One of the major criticisms of the nonparametric approach, heterogeneity among firms is not introduced, is controlled for in this study through the introduction of risk preferences.

The inclusion of a risk or risk preference variable in efficiency estimates has not been addressed sufficiently in the agricultural economics literature. A handful of studies have examined risk, risk preferences, or undesirable outputs in the banking and environmental literature and provide motivation for this research (Mester 1996; Chang 1999; Färe, Grosskopf, and Weber 2004; Färe and Grosskopf 2005).

Reliable risk preference estimates are needed to estimate risk adjusted efficiency scores (Young 1979). Hoag and Keske (2010) described a method of eliciting risk preferences from individuals that used a psychology-based quiz to gather information on how respondents might react to different hypothetical situations. Using a similar approach, Pope (2009) surveyed Kansas Farm Management Association members with a whole-farm analysis and cowherd in 2008. Five questions in the survey were related to risk and used to create a risk preference score for each individual farm. This dataset is addressed in more detail below.

Methods

Cost and revenue efficiency are estimated using the nonparametric approach data envelopment analysis (DEA). Both measures are more generally known as economic efficiency. The nonparametric approach is chosen because it allows inputs to be transformed into outputs without specifying a functional form thus eliminating errors associated with imposing an inappropriate model structure (Färe and Grosskopf 1996).

The efficiency measures are relative to the other farms in the data set. Only focusing on the inputs and outputs necessary in production attributes all differences from the optimal as inefficiency. This overstates firm inefficiency and overstates the potential improvements that can be made. Risk averse producers operate with different cost and revenue functions than those with other preferences. With this in mind, risk preferences are introduced to the efficiency analysis to identify if those individuals are also relatively less efficient.

Cost or input-based efficiency measures are often used when analyzing production agriculture because of the information available on input prices and a belief that producers are cost minimizers. Cost efficiency (CE) is a short-run efficiency measure that allows firms to operate under variable returns to scale. Farms with an economic efficiency of 1 are producing on the production possibility frontier and are using the optimal input mix. CE can be determined by dividing the minimum cost under variable returns to scale by the actual cost observed by the farm.

(1) CE = $c_i{}'x_i^* / c_i{}'x_i$,

where c is a vector of input prices, x is a vector of input levels used, *i* signifies the firm of interest, and $*$ indicates the optimal value (Färe, Grosskopf and Lovell 1985; Coelli, et al. 2005).

The denominator in equation (1) is the actual cost for the individual firm, the numerator is determined using the following linear program:

(2) $\text{Min}_{x^*}\ c_i{}'x_i^*$

subject to:

$x_{11}z_1 + x_{12}z_2 + \cdots + x_{1k}z_k \leq x_{1i}^*$

$x_{21}z_1 + x_{22}z_2 + \cdots + x_{2k}z_k \leq x_{2i}^*$

...

$x_{n1}z_1 + x_{n2}z_2 + \cdots + x_{nk}z_k \leq x_{ni}^*$

$y_{11}z_1 + y_{12}z_2 + \cdots + y_{1k}z_k - y_{1i} \geq 0$

...

$y_{m1}z_1 + y_{m2}z_2 + \cdots + y_{mk}z_k - y_{mi} \geq 0$

$z_1 + z_2 + \cdots + z_k = 1.$

The notation is as previously defined and y is a vector of outputs, $z_k \in \Re^+$and measures the intensity of use of the *k*-th firm's technology, the subscript *k* denotes the number of firms, the subscript *n* is the number of inputs, and the subscript *m* is the number of outputs (Färe, Grosskopf and Lovell 1985; Coelli, et al. 2005).

Revenue or output-based efficiency measures are less commonly observed. This may be attributed to data limitations or the belief that in production agriculture producers may have less control over the quantity of outputs actually produced than the inputs used in production (Coelli, et al. 2005). Revenue efficiency (RE) is a short-run efficiency measure that allows firms to operate under variable returns to scale. Farms with a revenue efficiency of 1 are producing on the production possibility frontier and are producing the optimal output mix.

(3) RE = $p_i'y_i / p_i'y_i^*$,

where the variables are as defined previously and p is a vector of output prices (Färe, Grosskopf and Lovell 1985; Coelli, et al. 2005).

The numerator in equation (3) is the actual revenue for the individual firm. The denominator is determined using the following linear program:

(4) $\mathrm{Max}_{y^*}\; p_i'y_i^*$

subject to:

$$x_{11}z_1 + x_{12}z_2 + \cdots + x_{1k}z_k \leq x_{1i}$$

$$x_{21}z_1 + x_{22}z_2 + \cdots + x_{2k}z_k \leq x_{2i}$$

...

$$x_{n1}z_1 + x_{n2}z_2 + \cdots + x_{nk}z_k \leq x_{ni}$$

$$y_{11}z_1 + y_{12}z_2 + \cdots + y_{1k}z_k - y_{1i}^* \geq 0$$

...

$$y_{m1}z_1 + y_{m2}z_2 + \cdots + y_{mk}z_k - y_{mi}^* \geq 0$$

$$z_1 + z_2 + \cdots + z_k = 1.$$

One of the most notable differences between the cost and revenue efficiency measures is the fact the values used in their estimation are inverted. This is necessary to constrict the revenue efficiency measures to range from 0 to 1, consistent with the cost efficiency measures.

Efficiency scores are first estimated for each firm using the standard analysis only concerned with inputs and outputs. The efficiency scores are estimated a second time including the risk preference score as a non-discretionary input. A non-discretionary input is equivalent to a "bad output" and represents an input the manager has little to no control over. Therefore, the model is only structured to seek a reduction in the inputs over which the manager does have control (Coelli, et al. 2005). The example below illustrates how the minimum cost under variable returns to scale is modified with the inclusion of an additional constraint, the risk preference score.

(5) $\text{Min}_{x^*}\ c_i{}'x_i^*$

subject to:

$x_{11}z_1 + x_{12}z_2 + \cdots + x_{1k}z_k \leq x_{1i}^*$

$x_{21}z_1 + x_{22}z_2 + \cdots + x_{2k}z_k \leq x_{2i}^*$

...

$x_{n1}z_1 + x_{n2}z_2 + \cdots + x_{nk}z_k \leq x_{ni}^*$

$r_1z_1 + r_2z_2 + \cdots + r_kz_k \leq r_i$

$y_{11}z_1 + y_{12}z_2 + \cdots + y_{1k}z_k - y_{1i} \geq 0$

...

$y_{m1}z_1 + y_{m2}z_2 + \cdots + y_{mk}z_k - y_{mi} \geq 0$

$z_1 + z_2 + \cdots + z_k = 1,$

where r represents the risk preference score. Note the risk preference score is included as an input constraint, but it is not a choice variable in the optimization. In other words, the level of the non-discretionary variable is not allowed to change.

In the sample of risk preference scores, lower values indicate greater risk aversion. Lower risk aversion is expected to be desirable. Therefore, the use of the inverse risk preference score is necessary to remain consistent with traditional inputs in efficiency analysis where less input is better.

Data

The 258 farms included in this study were members of the Kansas Farm Management Association (KFMA) and had completed a survey sent to all KFMA farms with a whole-farm analysis and a cowherd in 2008. Five questions in the survey were related to risk: how a respondent's neighbor would describe their risk taking behavior, retained ownership strategies, best and worst case calf return strategies, and questions related to investing in an innovative business with the chance for a large gain, but a significant chance of loss (Pope 2009). The risk preference scores generated from the survey responses could range from 5 to 113 with a smaller risk preference score indicating more risk aversion. The scores for the 258 farms in the analysis ranged from 5 to 86. Pope (2009) broke the scores down further: 5 to 21, strongly risk averse; 22 to 38, slightly risk averse; 39 to 86, all other risk preference levels.

Five inputs were used in the analysis: labor, crop input, fuel, livestock input, and capital. All costs were annualized. Labor was represented by the number of workers (paid and unpaid) on the farm and labor price was obtained by dividing labor cost by the number of workers. Implicit input quantities for the crop input, fuel, the livestock input, and capital were computed by dividing the respective input costs by USDA input price indices (USDA 2008). Crop inputs consisted of seed; fertilizer; herbicide and insecticide; crop marketing and storage; and crop insurance (Langemeier 2010). Fuel was comprised of fuel, auto expense, irrigation energy, and utilities. Livestock inputs included dairy expense; purchased feed; veterinarian expense; and livestock marketing and breeding. The capital input included repairs; machine hire; general farm insurance; property taxes; organization fees, publications, and travel; conservation; interest; cash farm rent; and interest charge on net worth (Langemeier 2010).

Outputs in the analysis consisted of crops and livestock. Implicit crop and livestock quantities were computed by dividing crop income and livestock income by Kansas crop price and livestock price indices (USDA 2008). Summary statistics are presented in Table 1.

The average value of farm production of the farms in the sample was $420,572. Net farm income was $113,480. Average total acres were 2,208. On average, approximately 70 percent of farmers' time was spent on crop production. The largest source of crop income was feed grains (corn and grain sorghum). Beef income comprised almost all of livestock income. The average profit margin and asset turnover ratios were 0.1883 and 0.3291, respectively. The average risk preference score for the 258 farms was 25.82 indicating slight risk aversion. The diversification index is a standard Herfindahl index computed by summing the squared share of income from each enterprise. A value of 1 indicates all income was coming from one source. A smaller value indicates the farm was diversified and income was coming from several enterprises. The crop diversification index was 0.5172. The livestock diversification index was 0.9648. The farms were not very diversified on their livestock income and in most cases livestock income came solely from the beef enterprise.

Table 1: Summary Statistics for Sample of Kansas Farms.

	Mean	Standard Deviation

Inputs		
Labor	1.31	0.71
Crop	98,572	90,937
Fuel	29,336	25,283
Livestock	30,971	63,295
Capital	193,025	145,210
Outputs		
Crop	279,969	289,922
Livestock	77,881	100,482
Risk Measure		
Risk Preference Score	25.82	11.57
Farm Characteristics		
Value of Farm Production	420,572	392,307
Net Farm Income	113,480	171,106
Feed Grain Income	111,751	165,288
Hay and Forage Income	17,294	51,663
Oilseed Income	84,000	127,642
Small Grains Income	95,806	121,993
Beef Income	74,816	105,167
Dairy Income	1,229	16,394
Swine Income	435	4,447
Total Acres	2,208	1,654
Crop Labor Percentage	70.14%	20.04%
Crop Diversification Index	0.5172	0.1969
Livestock Diversification Index	0.9648	0.1611
Financial Efficiency Ratios		
Profit Margin	0.1883	0.4996
Asset Turnover	0.3291	0.2525
Rate of Return on Investment	0.0620	0.1239

Source: Adapted from Yeager (2011).

Results

The average cost and revenue efficiency for the 258 farms in this study are included in Table 2. Table 2 first presents results using the five inputs (labor, crop, fuel, livestock, and capital) and two outputs (crops and livestock) followed by the average cost and revenue efficiencies adjusted for risk preference. Because smaller risk preference values are indicative of more risk averse farmers, the inverse of the risk preference score was included as a non-discretionary input.

Table 2: Average Efficiency Measures for Sample of Kansas Farms.

		Cost (Economic) Efficiency	Revenue (Economic) Efficiency
Efficiency	Average	0.5691	0.6735
	Std Dev.	0.1509	0.1939
	Minimum	0.2170	0.1842
	Number equal to one	6	31
	Average for strongly risk averse (94 farms)	0.5286	0.6419
	Number equal to one strongly risk averse	0	10
	Average for slightly risk averse (131 farms)	0.5798	0.6789
	Number equal to one slightly risk averse	3	17
	Average for all other risk preferences (33 farms)	0.6423	0.7423
	Number equal to one other risk preferences	3	4
Efficiency w/inverse risk preference score (RPS)	Average	0.6043	0.6987
	Std Dev.	0.1444	0.1959
	Minimum	0.2432	0.1842
	Number equal to one	13	46
	Average for strongly risk averse (94 farms)	0.5286	0.6987
	Number equal to one strongly risk averse	0	10
	Average for slightly risk averse (131 farms)	0.6206	0.7045
	Number equal to one slightly risk averse	4	23
	Average for all other risk preferences (33 farms)	0.7554	0.8377
	Number equal to one other risk preferences	9	13
Portion of Inefficiency Attributed to RPS	Average	0.0817	0.0772
Number of Farms Impacted by Inclusion of RPS		111	108
Portion of Inefficiency Attributed to RPS if Impacted	Average	0.1943	0.1778

Source: Adapted from Yeager (2011).

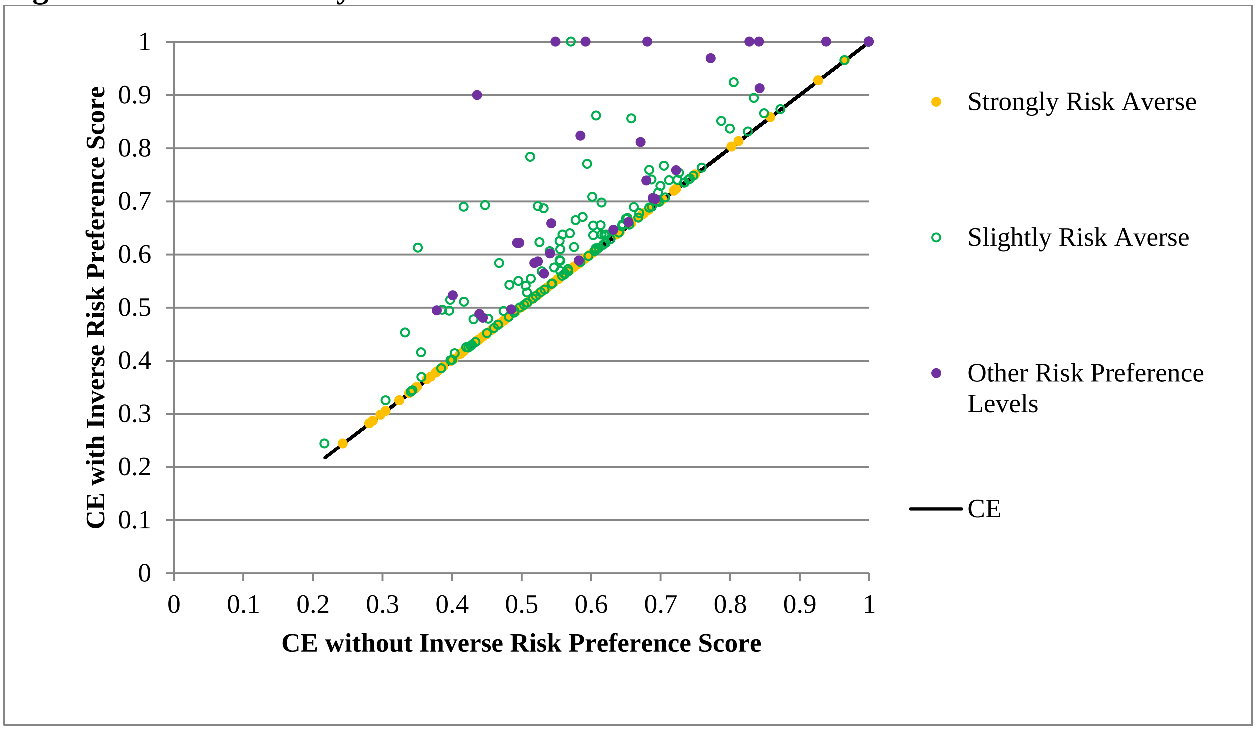
The average cost efficiency for the 258 farms was 0.5691 and ranged from 0.5286 for the strongly risk averse to 0.6423 for the least risk averse. The average difference in efficiency scores between the strongly risk averse and other risk preference farms was 0.1137. The consequence of the additional risk aversion is $51,704 in terms of average costs. On average, revenue efficiency was higher than cost efficiency for all of the farms. The average revenue efficiency was 0.6735 and ranged from 0.6419 for the strongly risk averse to 0.7423 for the farms with other risk preferences. Over 40 percent of the farms experienced an increase in cost and revenue efficiency with the inclusion of the inverse risk preference score as a non-discretionary input. For those impacted, the portion of inefficiency attributed to the inverse risk preference score was 19.43 percent for cost efficiency and 17.78 percent for revenue efficiency (Table 2).

None of the farms categorized as strongly risk averse (risk preference score of 21 or less) were cost efficient before or after including the inverse risk preference score in the efficiency estimates and their average cost efficiency was 0.5286. The average revenue efficiency for the strongly risk averse group increased from 0.6419 to 0.6987. One additional farm became cost efficient and six additional farms became revenue efficient for the slightly risk averse group after including the inverse risk preferences. For the other risk preferences, the number of cost efficient farms increased from 3 to 9 and the number of revenue efficient farms increased from 4 to 13 with the inverse of risk preferences included.

It was expected the more risk averse farms would be less efficient due to their reluctance to adopt new technologies or taking on what they perceive to be additional risk. However, the inclusion of risk preferences in the estimation further illustrated how inefficient the strongly risk averse farms really are. Risk preference is a characteristic of the producer that is difficult to change. In order to improve the efficiency of the strongly risk averse group they will have to better utilize their current input usage and outputs.

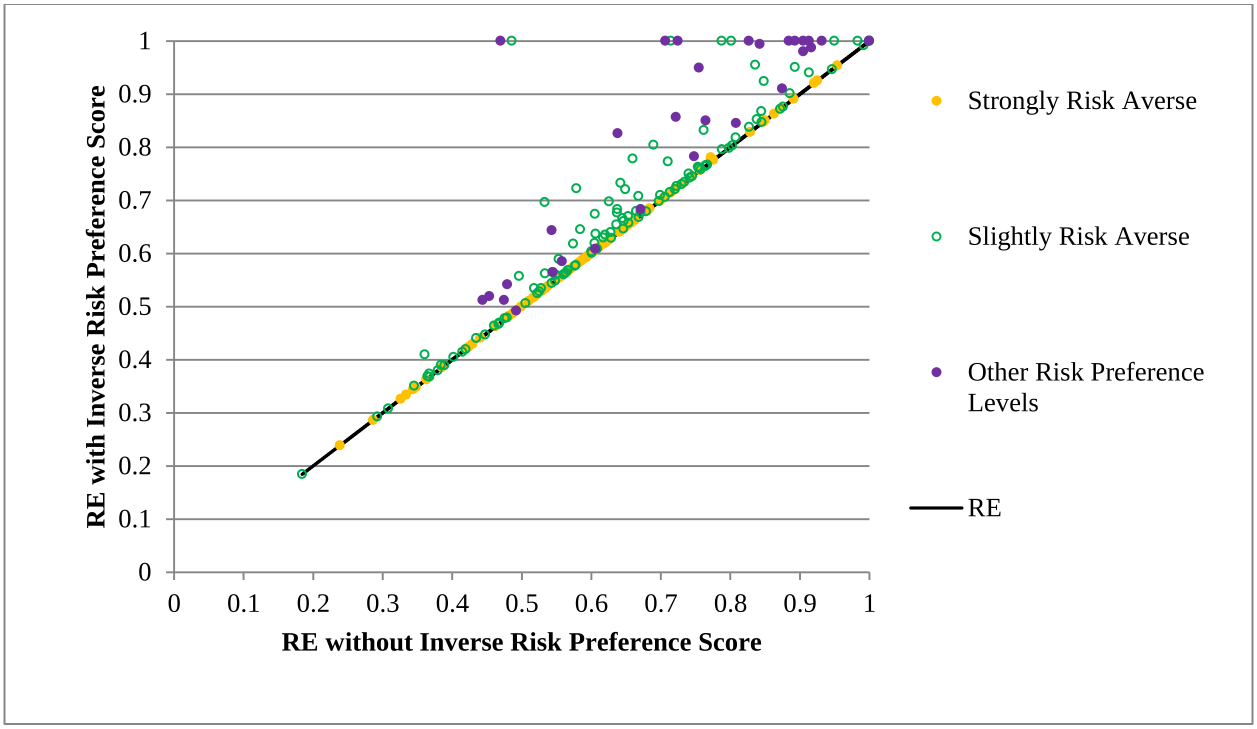
Figure 1 and Figure 2 provide an illustration of the impact of the inclusion of the inverse risk preference scores on cost and revenue efficiency, respectively. The yellow markers represent the farms with a strongly risk averse risk preference score. The farms represented by green markers are slightly risk averse and the purple markers indicate all other risk preferences. The green and purple markers reveal the most increases in efficiency with the consideration of the inverse risk preference scores because they are moving away from the original efficiency measure and approaching an efficiency score of one. The least movement is observed for the strongly risk averse farms. The strongly risk averse farms are clearly hindered by their risk preference.

Figure 1: Cost Efficiency with and without Inverse Risk Preference Score.



Source: Adapted from Yeager (2011).

Figure 2: Revenue Efficiency with and without Inverse Risk Preference Score.



Source: Adapted from Yeager (2011).

The farms were divided into categories based on their value of farm production (VFP) and t-tests were used to determine if there were any statistical differences between the efficiency measures of each group. Table 3 provides evidence that the smallest farms were strongly risk averse on average and the larger categories were slightly risk averse on average. The larger farms were more diversified and income was coming from more sources than the smaller farms. The livestock diversification indices were not significantly different among the various sizes of farms; however, it is worth noting all livestock income was beef income for the farms with a VFP under $100,000. Efficiency scores were significantly higher for the farms with a VFP of $500,000 or more.

Table 3: Efficiency by Value of Farm Production Category.

	Less than $100,000	$100,000 to $249,999	$250,000 to $499,999	$500,000 and more
Number of Farms	34	74	81	69
Average VFP	62,307[a]	177,077[b]	374,501[c]	912,331[d]
Average Risk Preference Score (RPS)	19.74[a]	23.68[b]	26.57[bc]	30.25[c]
Average Inverse RPS	0.0591[a]	0.0510[a]	0.0491[a]	0.0387[b]
Crop Diversification Index	0.3058[a]	0.2918[a]	0.2987[b]	0.3210[b]
Livestock Diversification Index	1.0000[a]	0.9901[a]	0.9651[a]	0.9297[a]
Average Cost Efficiency	0.5006[ab]	0.5219[a]	0.5650[b]	0.6584[c]
Number of Efficient Farms	2	0	0	4
Average Cost Efficiency with Inverse RPS	0.5351[a]	0.5738[a]	0.5932[a]	0.6841[b]
Number of Efficient Farms	3	1	3	6
Average Revenue Efficiency	0.6307[a]	0.6179[a]	0.6396[a]	0.7942[b]
Number of Efficient Farms	7	9	3	12
Average Revenue Efficiency with Inverse RPS	0.6450[a]	0.6547[a]	0.6605[a]	0.8173[b]
Number of Efficient Farms	8	14	4	20

Note: Unlike superscripts indicate the means are statistically different at the 5% level.
Source: Adapted from Yeager (2011).

The characteristics of the farms that experienced a change in efficiency scores with the consideration of the inverse risk preference score were identified and t-tests were used to determine if there were any statistical differences between the efficiency measures of each group. Table 4 provides the characteristics of the 111 farms with a change in cost efficiency compared to the 147 farms that experienced no change in efficiency. The farms that experienced a change in their efficiency score with the inclusion of the inverse risk preference score as a non-discretionary input had a higher risk preference score on average, less risk averse. On average, the VFP was higher, the percent of VFP from feed grain income was higher and the percent of VFP from beef income was lower. These farms also had a lower percent of input cost coming from labor and a larger percent of input cost coming from crop inputs.

Table 4: Average Farm Characteristics by Changes in Cost Efficiency.

	Change with Inverse RPS	No Change with Inverse RPS
Number of Farms	111	147
Farm Characteristics		
Risk Preference Score	34.91[a]	18.96[b]
Value of Farm Production (VFP)	491,452[a]	367,050[b]
Net Farm Income	137,315[a]	95,482[a]
Percent of VFP from Feed Grain Income	27.78%[a]	25.35%[b]
Percent of VFP from Hay and Forage Income	3.66%[a]	4.57%[a]
Percent of VFP from Oilseed Income	21.38%[a]	18.55%[a]
Percent of VFP from Small Grains Income	23.17%[a]	22.39%[a]
Percent of VFP from Beef Income	13.35%[a]	22.28%[b]
Percent of VFP from Dairy Income	0.51%[a]	0.07%[a]
Percent of VFP from Swine Income	0.15%[a]	0.06%[a]
Percent of Input Cost from Labor	13.43%[a]	14.21%[b]
Percent of Input Cost from Crop	27.75%[a]	24.72%[b]
Percent of Input Cost from Fuel	7.93%[a]	7.71%[a]
Percent of Input Cost from Livestock	6.15%[a]	8.42%[a]
Percent of Input Cost from Capital	44.73%[a]	44.95%[a]
Total Assets	1,308,762[a]	1,254,662[a]
Crop Labor Percentage	72.91%[a]	68.04%[a]
Crop Diversification Index	0.3081[a]	0.3005[a]
Livestock Diversification Index	0.9094[a]	0.9886[a]

Note: Unlike superscripts indicate the means are statistically different at the 5% level.

Table 5 illustrates the characteristics of the 108 farms with an improved revenue efficiency score with the consideration of risk preferences compared to the 150 farms with no change. On average, the risk preference score was higher for the farms with an observed change in their revenue efficiency with the inclusion of the inverse risk preference score in the efficiency analysis. The farms also had a higher VFP, a larger percent of VFP was from beef income, the percent of input cost from labor and capital were each lower, and the percent of input cost from crop inputs was larger. The crop diversification index was higher on average for the farms experiencing a change in revenue efficiency.

Table 5: Average Farm Characteristics by Changes in Revenue Efficiency.

	Change with Inverse RPS	No Change with Inverse RPS
Number of Farms	108	150
Farm Characteristics		
Risk Preference Score	33.93[a]	19.99[b]
Value of Farm Production (VFP)	491,338[a]	369,620[b]
Net Farm Income	123,891[a]	105,984[a]
Percent of VFP from Feed Grain Income	26.71%[a]	26.44%[a]
Percent of VFP from Hay and Forage Income	3.38%[a]	4.81%[a]
Percent of VFP from Oilseed Income	18.98%[a]	20.92%[a]
Percent of VFP from Small Grains Income	24.74%[a]	20.90%[a]
Percent of VFP from Beef Income	18.24%[a]	17.36%[b]
Percent of VFP from Dairy Income	0.54%[a]	0.06%[a]
Percent of VFP from Swine Income	0.16%[a]	0.05%[a]
Percent of Input Cost from Labor	12.75%[a]	14.86%[b]
Percent of Input Cost from Crop	28.37%[a]	24.08%[b]
Percent of Input Cost from Fuel	8.09%[a]	7.56%[a]
Percent of Input Cost from Livestock	7.72%[a]	6.99%[a]
Percent of Input Cost from Capital	43.08%[a]	46.51%[b]
Total Assets	1,357,234[a]	1220844[a]
Crop Labor Percentage	71.83%[a]	68.91%[a]
Crop Diversification Index	0.3115[a]	0.2991[b]
Livestock Diversification Index	0.9286[a]	0.9878[a]

Note: Unlike superscripts indicate the means are statistically different at the 5% level.

Risk preference clearly impacts a farms' efficiency. This may be due to underlying human capital characteristics that cannot easily be quantified. As expected, the farms with a strongly risk averse manager were less efficient and likely not adopting the newest production technologies. The extent of the strongly risk averse farms relative inefficiency was even more troublesome when adjusting for their risk preference as few farms with a strongly risk averse manager experienced an improved efficiency score with risk preferences considered.

Conclusion

Cost and revenue efficiency scores were estimated for 258 Kansas Farm Management Association farms. The farms chosen participated in a survey used to determine a risk preference score (Pope 2009). The inverse of the risk preference score was used as a non-discretionary input to identify a portion of standard inefficiency measures that could be attributed to risk. The risk preference scores in the sample ranged from 5 to 86 where a smaller value represents stronger risk aversion. The average cost efficiency for the 258 farms was 0.5691 and increased to 0.6155 with the consideration of risk preference scores. The average revenue efficiency was 0.6735 and increased to 0.7020 with risk preference scores.

Almost all increases in efficiency were observed for the slightly risk averse and other risk preference farms. The strongly risk averse farms experienced no to little change in efficiency with the consideration of risk preference scores. Traditional efficiency measures were lower for the strongly risk averse farms. The smallest farms in terms of value of farm production were the most risk averse. The results of this study are consistent with previous research which has indicated risk averse producers will be more hesitant to adopt new technology and will produce less than under other risk preferences (Ben Jemaa 2007; Dillon and Anderson 1971; Robison and Barry 1987). However, unlike previous studies, this research examined the efficiency of farms and the impact of risk preferences on efficiency scores.

Standard efficiency measures overstate the inefficiency and corresponding improvement that could be made to increase efficiency when risk preferences are not accounted for in the analysis. Risk preferences or another risk measure need to be included to obtain more accurate efficiency scores. Risk preference scores allow heterogeneity among producers, something that is unique from most data envelopment analysis. Accounting for this heterogeneity, the efficiency of risk averse producers is lower than the efficiency of producers with other risk preferences. The inefficiency of producers with other risk preferences is partially explained by their risk preference score while it is not explained for the strongly risk averse producers. The approach taken to improve the efficiency of strongly risk averse producers should be different than the approach taken to improve the efficiency of producers with other risk preferences. Risk preferences are difficult to influence especially in the short-run. Farms managed by strongly risk averse individuals are likely to be more inefficient, so small steps should be taken to gradually increase efficiency. It is unlikely drastic changes will be made due to the management characteristics of the individuals.

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