

Machinery Cost Evaluation

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Objective of the study

Studies have shown that production cost in agriculture is one of the determining factors of the profitability of different enterprises. The last two years have been a good example to demonstrate that the difference in farm profitability is closely correlated to cost control. Some production costs are fairly easy to identify; direct crop cost is one of them. Other costs that are more difficult to accurately quantify are overhead and machinery costs.

The objective of this study is to identify and quantify the level of machinery cost required to produce different crops in Kansas. One alternative in determining machinery cost would be to use a budget. The difficult part of budgeting is the allocation of indirect costs. Repairs for example, how should they be allocated between different enterprises? What about the depreciation of a piece of machinery that is used on multiple crops? The answer to these questions is not easy and requires more than a simple budget method approach. This study is based on data collected by the six regional Farm Management Associations across Kansas to estimate a model linking acres of various crops produced and total machinery cost. To achieve our objective, we have constructed a model which, based on the different crops grown on the farm and how much income is generated from custom work, will estimate a benchmark of overall machinery cost for the specific farm.

Presentation of the variables

The data used in this research is from the Kansas Farm Management Association (KFMA) database. This database is actual farm record data collected across Kansas. Every year for each of the farms in the data set, the acreage of the different crops planted is collected as well as the expenses related to machinery. The variables used in this study are described as follows:

Crop acreage:

Acreage planted to each of the individual crops used in the study: irrigated wheat, non-irrigated wheat, irrigated corn, non-irrigated corn, irrigated sorghum, non-irrigated sorghum, irrigated soybeans, non-irrigated soybeans, irrigated alfalfa hay, non-irrigated alfalfa hay, irrigated other hay, non-irrigated other hay, irrigated other cash crop, and non-irrigated other cash crop.

Machine Work Receipts:

Total income generated from machine work performed for other people.

Machinery Cost:

Machinery cost is in fact an aggregated variable generated from other variables. In this study machinery cost is defined as: crop share of machinery repairs, gas-fuel-oil, farm auto expense, motor vehicle depreciation, machinery-equipment depreciation plus crop

machine hire and lease expenses, plus opportunity interest charge on crop machinery investment.

Machinery cost can vary significantly from year to year due to unexpected repair expenses or the purchase of an expensive piece of machinery. Therefore, to minimize the effects of this problem, a three-year average (1999-2001) has been generated for each farm in the data set. Machinery cost can also be affected by the allocation between livestock and crop enterprises. Farms with more than 90% of the labor devoted to crop production were selected for this study to reduce the effect of livestock enterprise allocation issues.

Descriptive statistics

Table 1: Comparison of Selected Variables for Average and Six Associations

1999-2001 Average	All	Northwest	Southwest	North Central	South Central	Northeast	Southeast
<i>Crop Acres</i>	1,418	1,739	1,877	1,034	1,371	1,098	1,309
<i>Harvested Acres</i>	1,241	1,256	1,291	1,013	1,314	1,082	1,462
<i>Net Farm Income</i>	\$ 35,781	\$ 47,333	\$ 41,771	\$ 21,741	\$ 32,891	\$ 33,990	\$ 37,358
<i>Crop Labor Percentage</i>	98.8%	99.1%	99.6%	97.9%	99.0%	98.2%	98.2%
<i>Total Crop Machinery Investment</i>	\$159,347	\$ 168,938	\$ 160,017	\$120,163	\$169,898	\$157,120	\$ 163,779
<i>Motor Vehicle Depreciation</i>	\$ 11,555	\$ 11,799	\$ 11,227	\$ 10,078	\$ 10,036	\$ 13,464	\$ 14,340
<i>Machinery-Equipment Depreciation\</i>	\$ 9,444	\$ 11,552	\$ 11,202	\$ 7,250	\$ 9,627	\$ 8,437	\$ 7,361
<i>Machinery Repairs</i>	\$ 17,990	\$ 17,135	\$ 19,724	\$ 13,862	\$ 20,537	\$ 15,464	\$ 17,829
<i>Irrigation Repairs</i>	\$ 1,772	\$ 2,865	\$ 4,243	\$ 333	\$ 1,740	\$ 412	\$ 69
<i>Machine Hire</i>	\$ 12,961	\$ 19,522	\$ 16,941	\$ 11,414	\$ 13,937	\$ 6,338	\$ 8,304
<i>Gas/Fuel/Oil</i>	\$ 10,390	\$ 10,472	\$ 12,028	\$ 7,765	\$ 11,132	\$ 9,016	\$ 10,589
<i>Adjusted Total Crop Machinery Cost ¹</i>	\$ 75,604	\$ 87,186	\$ 88,882	\$ 53,957	\$ 79,716	\$ 63,911	\$ 70,358
<i>Machine Work Receipts, Dollars</i>	\$ 6,868	\$ 7,887	\$ 5,562	\$ 3,706	\$ 8,933	\$ 6,432	\$ 6,418
<i>Wheat, Total Irrigated Acres</i>	29.1	69.4	91.7	2.9	9.3	1.2	-
<i>Wheat, Total Non-irrigated Acres</i>	436.1	511.7	515.9	437.3	607.3	55.5	387.9
<i>Corn, Total Irrigated Acres</i>	125.0	259.6	262.9	13.4	113.2	47.9	2.7
<i>Corn, Total Non-irrigated Acres</i>	115.1	122.5	47.7	41.3	46.8	311.6	153.3
<i>Grain Sorghum, Total Irrigated Acres</i>	7.1	2.8	25.2	2.6	6.2	0.2	-
<i>Grain Sorghum, Total Non-irrigated Acres</i>	199.1	98.7	241.0	217.9	269.8	73.9	250.3
<i>Soybeans, Total Irrigated Acres</i>	46.9	40.2	51.4	13.9	75.8	46.6	4.0
<i>Soybeans, Total Non-irrigated Acres</i>	186.8	2.4	3.9	140.7	72.8	498.9	562.8
<i>Alfalfa Hay, Total Irrigated Acres</i>	9.1	8.3	24.2	9.7	8.5	0.0	-
<i>Alfalfa Hay, Total Non-irrigated Acres</i>	24.0	2.2	0.4	78.6	46.0	3.9	7.6
<i>Other Grain, Total Irrigated Acres</i>	0.2	0.7	-	0.2	0.5	-	-
<i>Other Grain, Total Non-irrigated Acres</i>	1.5	2.2	0.9	1.1	2.2	0.9	1.1
<i>Other Hay, Total Irrigated Acres</i>	4.9	22.9	6.1	0.3	2.8	0.1	-
<i>Other Hay, Total Non-irrigated Acres</i>	22.2	15.7	9.8	37.9	13.9	36.6	32.5
<i>Other Cash Crops², Total Irrigated Acres</i>	5.2	37.3	0.6	-	1.2	-	-
<i>Other Cash Crops², Total Non-irrigated Acres</i>	23.6	54.4	3.2	8.0	30.0	2.3	58.7
<i>Percentage of Farms in the data</i>		12.9%	18.5%	11.4%	28.8%	18.1%	10.4%

¹ Adjusted Total Crop Machinery Cost is Total Machinery Cost as defined by the Kansas Farm Management guide plus machine hire receipts (which are subtracted from machinery cost originally).

² Pinto Beans, Sunflowers, Cotton, etc.

A summary of selected characteristic variables of the 603 farms in the study is presented in Table 1. The “Average” column represents the average for all the farms included in the study. The Association columns represent the average value for the farms from the specific associations included in the study. For example, the Machinery Investment average for all Associations is \$159,347, while Machinery Investment varies from \$120,163 to \$169,898 for North Central and South Central respectively. The crop acreage variables have been used also to generate the graphs presented in Appendix 1³. These pie charts represent the crop mix of the average crop farm in each of the Associations. Moving from West to East across Kansas the irrigated acreage decreases out of the crop mix and is replaced by non-irrigated crops such as milo or soybeans. It is important to notice that in the western associations the unused acres represent about one third of the total acres on the farm, which is supportive of the observed common practice of a three-year rotation.

The level of specialization of the farms in the various crops grown in Kansas is shown in Appendix 2. Wheat, as expected, is a crop present at a fairly high level in most of the farms in the data set.

Net farm income, total acreage, and machinery cost distributions are presented in Appendix 3. These graphs show a wide diversity in size, which contributes to a wide diversity in net farm income as well as machinery cost. However, there remains a level of diversity in machinery cost as well as net farm income among farms after the influence of size is reduced by evaluating on a per cropped acres basis. These relationships on a per acre basis are displayed in Appendix 4.

Presentation of the model

The model estimated in this study uses the total crop machinery cost as a function of the acres of the different crops as well as a variable defined as the logarithm of the sum of the crop acres. Total machine work income is included as an independent variable to quantify the influence machine work activities have on total machinery cost. The model can be written as:

$$\begin{aligned} CropMachCost = & a_{IW} \times IrrWheat + a_{NIW} \times NIrrWheat + a_{IC} \times IrrCorn + a_{NIC} \times NIrrCorn + \\ & a_{ISg} \times IrrSorg + a_{NISg} \times NIrrSorg + a_{ISy} \times IrrSoy + a_{NISy} \times NIrrSoy + a_{IA} \times IrrAlfalfa + \\ & a_{NIA} \times NIrrAlfalfa + a_{IOH} \times IrrOtherHay + a_{NIOH} \times NIrrOtherHay + a_{IOCC} \times IrrOtherCashCrop + \\ & a_{NIOCC} \times NIrrOtherCashCrop + a_{MWI} \times MachWorkInc + a_{ISA} \times \ln(SumAcres) \end{aligned}$$

The coefficients being estimated are presented in Table 2. The estimation of the coefficients has been done under certain constraints so that the variables with limited observations were not skewed one way or the other. For the purpose of this study, the machinery cost of irrigated crops was limited to twice the machinery cost of non-irrigated crops. Irrigated corn machinery costs were constrained at a ratio 2.5. Finally, the lower bound for machinery costs was set at \$20 per acre.

The model's coefficients and relevant statistics are presented in Table 2. The Root Mean Squared Error (RMSE) of the model is \$23,941, which means the predicted Total

³ The graphs represent the 6 Farm Management Associations and are located on the sheet appropriately to the location of the association on the Kansas map.

Crop Machinery Cost is expected to be +/- \$23,491 68% of the time. All coefficients are statistically different than zero at the 5% level with the exception of other hay, both irrigated and non-irrigated.

Table 2, Coefficients Estimate table :

Parameter	Estimate	Std Err	t Value	Pr > t
a_{IW}	60.77	11.4134	5.32	<.0001
a_{NIW}	40.02	2.9033	13.78	<.0001
a_{IC}	117.52	5.1517	22.81	<.0001
a_{NIC}	47.01	2.0607	22.81	<.0001
a_{ISg}	57.00	8.6192	6.61	<.0001
a_{NISg}	28.50	4.3096	6.61	<.0001
a_{ISy}	52.47	10.1773	5.6	<.0001
a_{NISy}	41.37	2.9462	14.04	<.0001
a_{IA}	91.57	20.2942	4.51	<.0001
a_{NIA}	47.80	10.7959	4.43	<.0001
a_{IOH}	22.92	38.0084	0.60	0.5468
a_{NIOH}	20.00	0	-	-
a_{IOCC}	40.00	1.59 E-15	2.52 E16	<.0001
a_{NIOCC}	20.00	3.22 E-16	6.21 E16	<.0001
a_{MWI}	.88	0.0410	21.37	<.0001
a_{ISA}	1568.6	286.9	5.47	<.0001

The interpretation of this table is fairly simple. First there is an overhead machinery cost of 1568 times the logarithm of the total acreage of the crops used in this study. Then if you earned \$1,000 as machine work, you should expect your machinery cost to increase by about \$876. Finally, depending of your crop mix, each crop acre would increase your machinery cost by the value of the coefficient as presented in Table 2. One acre of non-irrigated wheat costs \$40.02, on the average, whereas one acre of irrigated corn costs \$117.52.

Application of Model

Four different example farms are included in Table 3. These farm examples are representative of farms included in the Northwest Association data. These sample farms will help illustrate how the model works and might be applied. A blank column is included so you may estimate the machinery cost for any farm using this model. To do so, multiply the Coefficient Multiplier by the acres for each specific crop and sum these numbers.

Farm 1, is a large farm totaling 2630 crop acres. The acres under irrigation equal 91.1% of the crop acres. There is a small sampling of summer fallow acres on the non-irrigated land. This farm has relatively new machinery and aggressively maintains a good line of machinery. Timeliness is important to this operation. Two men operate this farm and they harvest all the acres with one combine and trucking is hired--a unique combination, but efficient. Several capital purchases have been made using capital lease purchase agreements.

Farm 2 is a modest sized irrigation farm totaling 1087 acres. The acres under irrigation represent 54.7% of the total crop acres. This is more typical of irrigated farms in Northwest Kansas. This farm uses a continuous no-till crop rotation on the non-irrigated acres. Machinery cost for this farm is the fourth largest of the Northwest Association three-year average. Repair cost on this farm averages over \$50,000 per year. These are farm operators that have a real desire to “work” on things to make them better, in other words “shop junkies”. Or we could have a farm with old machinery that requires considerable repairs, but major repairs should be capitalized.

Table 3, Four Example Farms from Northwest Association

Crop	Coefficient multiplier	Farm 1	Farm 2	Farm 3	Farm 4	Your farm
<i>Wheat, Total Irrigated Acres</i>	60.77	1190				
<i>Wheat, Total Non-irrigated Acres</i>	40.02	232	245	1380	364	
<i>Corn, Total Irrigated Acres</i>	117.52	1208	595			
<i>Corn, Total Non-irrigated Acres</i>	47.01		247	128		
<i>Grain Sorghum, Total Irrigated Acres</i>	57.00					
<i>Grain Sorghum, Total Non-irrigated Acres</i>	28.50			1202		
<i>Soybeans, Total Irrigated Acres</i>	52.47					
<i>Soybeans, Total Non-irrigated Acres</i>	41.37					
<i>Alfalfa Hay, Total Irrigated Acres</i>	91.57					
<i>Alfalfa Hay, Total Non-irrigated Acres</i>	47.80					
<i>Other Hay, Total Irrigated Acres</i>	22.92					
<i>Other Hay, Total Non-irrigated Acres</i>	20.00				34	
<i>Other Cash Crops, Total Irrigated Acres</i>	40.00					
<i>Other Cash Crops, Total Non-irrigated Acres</i>	20.00				124	
<i>Machine Work Receipts, Dollars</i>	0.88					
<i>Total Acres of the included crops</i>	0	2630	1087	2710	522	
<i>Logarithm of the total acres variable</i>	1569	7.87	6.99	7.90	6.26	
<i>Total Estimated Machinery cost</i>		\$ 235,920.57	\$ 102,309.93	\$ 107,904.36	\$ 27,545.56	
<i>Estimated Machinery Cost per Acre</i>		\$ 89.70	\$ 94.12	\$ 39.82	\$ 52.77	
<i>Actual Machinery Cost per Acre</i>		\$ 82.26	\$ 136.86	\$ 34.96	\$ 69.14	

Farm 3 is a larger non-irrigated farm that operates 2710 acres. This farm is a typical wheat/no-till milo/fallow farm. A smaller acreage of no-till corn is involved as well. This farm maintains “good” machinery without keeping the paint brand new. They have older combines (14XX & 16XX series rotary IH), that harvest most of their acreage. Tractors and critical implements are less than 10 years old. They do almost all of their own spraying. This has been an important contributor to cost savings in no-till farming in Northwest Kansas.

Farm 4 is a smaller non-irrigated farm with 522 acres of crop production. This farm operates in a more “old fashioned” way by producing mostly wheat and fallow, with a small amount for cane feed and sunflower. Farm 4 operates aged equipment from the 80’s and hires all harvesting. Contributors to higher machinery cost for farm 4 are the lack size efficiency and high auto expenses.

The farms listed in Table 3 were selected as representative of the variation found in Northwest Kansas. The goal here was to show the ability of the model to accurately predict the machinery cost of selected farms when only the acres of crops produced and the machine work income are taken into consideration. Farm 1 and farm 3 had machinery costs that were accurately predicted by the model. Both Farm 1 and 3 represent farms where the size is larger and the operators do most of their own work, especially harvesting. Farm 2 has abnormally large repair cost and farm 4 is not representative of a full time farm for Northwest Kansas.

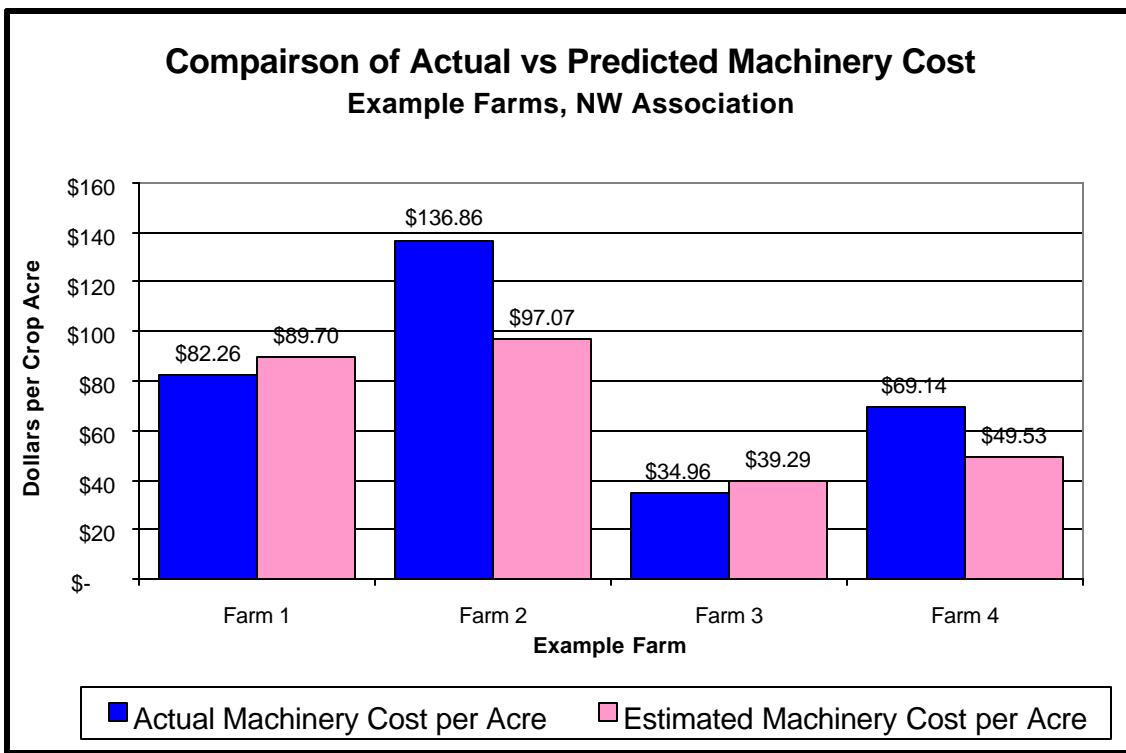


Figure 1

The same four farms are displayed in Figure 1. This bar chart shows the actual machinery cost in the darker shaded bar and the predicted machinery cost in the lighter shaded bar. The model predicted with reasonable accuracy the machinery cost of farm 1 and farm 3, but underestimated machinery costs when compared to actual for farms 2 and farm 4.

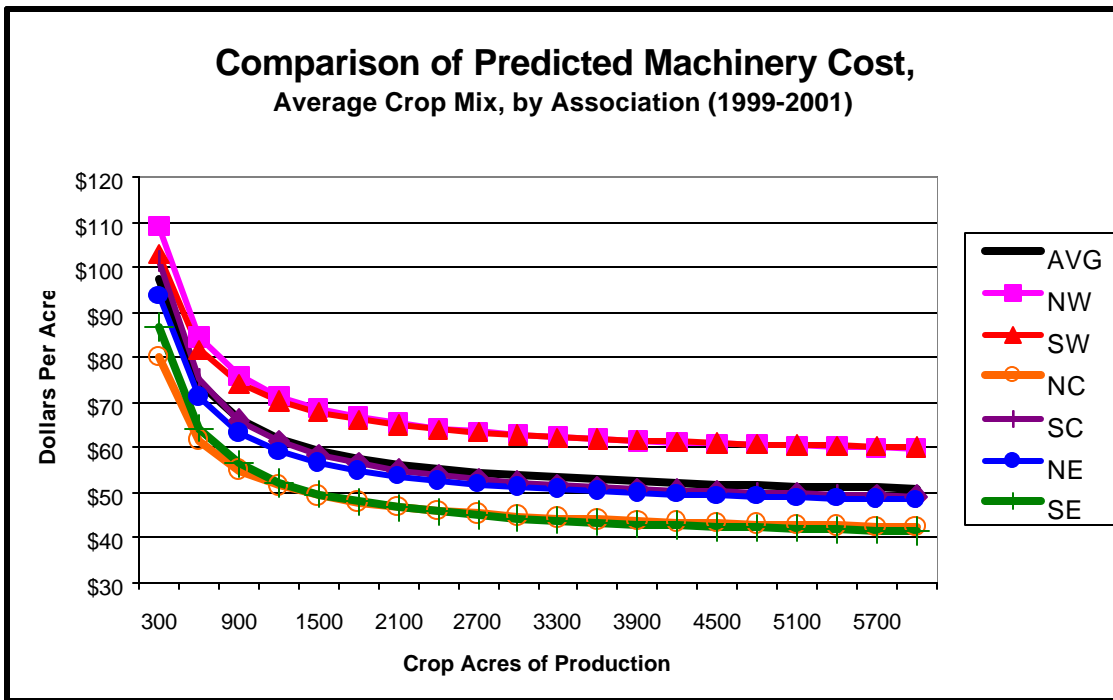


Figure 2

The relationship of machinery costs and crop acres is illustrated for the six associations and the average of all associations in Figure 2. The average crop production acreage mix for each Association (Table 1) was used across the acreage size categories along the bottom of the chart. Essentially all the data in Figure 2 decreases at a decreasing rate based on the logarithm of the total crop acres in a particular farm example. Northwest and Southwest Associations have the crop mix with the most expensive machinery cost. These two Associations also represent the majority of the irrigated acreage represented in the Association data. Northcentral and Southeast Associations compete for the lowest machinery cost. Northeast and Southcentral most closely follow the average line in the middle of the chart.

The decreasing machinery cost displayed in Figure 2 is dramatic from 300 acre to 1200 acres. The shaded columns of Table 4 show the predicted machinery cost savings of moving from 300 to 600 acres, 600 to 1200 acres and from 1200 to 2400 acres. The economic benefit of doubling the crop production acres from 300 to 600 is nearly double that of moving from 600 to 1200 acres and the same is true as the size increases from 1200 to 2400.

Table 4, Comparison of Predicted Machinery Cost, by Association, (data for Figure 2)

ACRES	300	600	300 to 600	1200	600 to 1200	2400	1200 to 2400
AVG	\$ 97.52	\$ 74.39	\$ 23.13	\$ 61.93	\$ 12.47	\$ 55.24	\$ 6.69
NW	\$ 109.28	\$ 84.67	\$ 24.61	\$ 70.92	\$ 13.74	\$ 64.25	\$ 6.67
SW	\$ 103.06	\$ 81.84	\$ 21.22	\$ 69.53	\$ 12.30	\$ 63.89	\$ 5.64
NC	\$ 80.14	\$ 61.63	\$ 18.51	\$ 53.51	\$ 8.11	\$ 46.44	\$ 7.07
SC	\$ 101.45	\$ 75.31	\$ 26.14	\$ 60.17	\$ 15.13	\$ 53.57	\$ 6.60
NE	\$ 93.78	\$ 71.29	\$ 22.49	\$ 60.55	\$ 10.74	\$ 52.97	\$ 7.58
SE	\$ 86.82	\$ 64.36	\$ 22.47	\$ 49.95	\$ 14.41	\$ 45.03	\$ 4.92

These results of the machinery cost model could be useful in determining if a farmer can justify paying a premium to increase the acres in his farm. The additional benefit in predicted machinery cost savings per acre could be considered as part of the land acquisition package. For example, the farm that has 300 acres in Northeast Kansas could, according to the model in this study, incorporate an expected machinery cost savings of over \$20 per acre for the first 300 additional acres. The same evaluation of additional land for a farm with 1200 acres in Northeast Kansas could anticipate a machinery cost savings of only \$7 per acre in comparison.

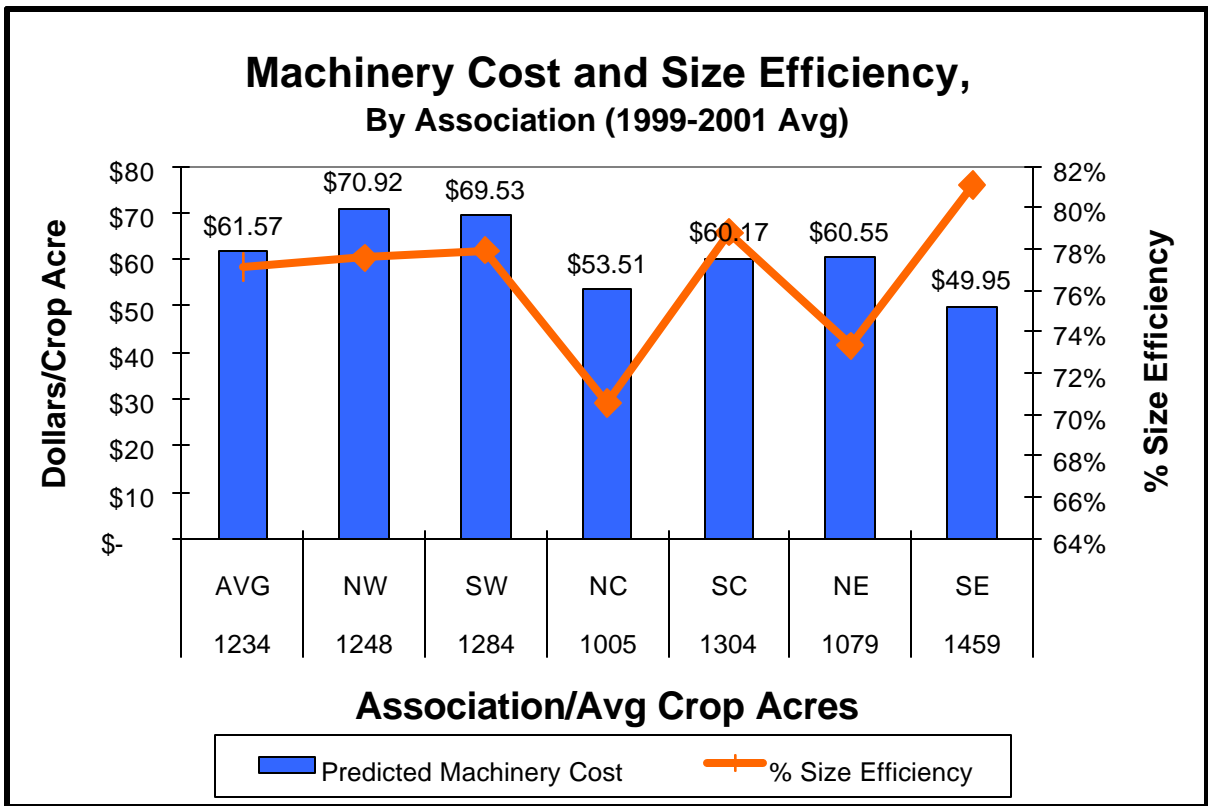


Figure 3

The relationship of the average machinery cost, as predicted by the model for crop farms in each of the six associations, is shown in Figure 3. The average cropped acres is represented in the number just below the Association abbreviation. Southeast has the lowest machinery cost predicted for the average sized farm operating with the average crop mix for that association. The Southeast Association has the largest average number of crop acres. This is accomplished by a significant number of double-cropped acres, especially soybeans. The Northcentral Association has the second lowest predicted machinery cost per acre, but they are also the smallest crop farms as measured by cropped acres. Northwest and Southwest Association farms have a significant number of acres in fallow, which are not part of the crop acres in this study. The cost of fallow is included in the machinery cost computation and is assumed part of the wheat acreage cost coefficient.

Figure 3 also presents the percent of machinery cost efficiency obtained by the average size crop farm using the average crop acreage mix in each Association. This percent is based on the function of the curved machinery cost line predicted in Figure 2. The percent size efficiency line in Figure 3 represents what percent each Association has

obtained at the average size, using the average crop mix for that association, when compared to the 6000 acre sized farm on the end of the curve in Figure 2. The objective is to observe how efficient is the average size crop farm in the Associations. The Southeast Association, with the largest cropped acres and the lowest predicted machinery cost per acre, has obtained on 1459 acres 81% of the efficiency found on a 6000 acres farm. The Northcentral Association has a low predicted machinery cost but when applied to a 1005 acres crop base the average crop farm has only reached an efficiency of 71% of the efficiency possible on a 6000 acres farm. Northwest, Southwest, and Southcentral had predicted efficiency for the average sized crop production is in the 78%, 78% and 79% levels respectively.

Conclusions

The purpose of this study is to quantify the cost of machinery involved in the production of common crops produced in Kansas. Irrigated crops, particularly irrigated corn, were predicted to have higher machinery costs than normally observed in existing budgets or enterprise summaries. Regional differences among the six Farm Management Associations add variety and perspective to the model. The Southeast Association members, with the increased farming intensity of double cropping, have found a way to push the predicted machinery cost for the average sized crop farm below the \$50 per acre level.

Efficiency due to size of farm and the utilization of machinery is a frequently discussed topic. The model developed in this study demonstrates again the decreasing at a decreasing rate nature of machinery cost per acre. It is interesting though to note that the number of acres necessary to acquire the majority of the efficiencies in predicted machinery cost is at or just below the average size crop farm in four of the six Associations. The perceived economic benefits of increasing size to lower machinery cost is very true when the farm size is below 1000 acres. The machinery cost estimated in the model for the average farm decreased from \$97.52 per acre for the 300 acres farm down to \$61.93 for the 1200 acres farm. This represents a cost savings of \$35.59 per cropped acre on the average across Kansas Farm Management Association crop farmers. This level of machinery cost savings is a significant economic factor contributing to land acquisition power of the larger farms over the smaller farms in many communities. On the contrary, those farms that have already reached a size of 1200 acres cannot expect significant machinery cost savings due to increasing the acres they already farm. The results of this study indicate that the predicted machinery cost savings to the average farm of increasing acres farmed from 1200 to 2400 would be \$6.69 per acre.

It is the intent of this study that the machinery cost coefficients developed in the model will contribute to establish benchmarks for machinery cost involved in the production of principal crops in Kansas. The machinery cost coefficients in Table 3 can be used to quantify the anticipated improvement in machinery cost efficiency when considering expanding a farm operation, especially when dealing with smaller crop farms.