A3510

Estimating Agricultural Field Machinery Costs

R.T. Schuler and G.G. Frank

Agricultural engineers and economists use a variety of engineering and economic principles in calculating a machine's use and costs. An effective farm manager must also know these principles, and apply them when deciding to buy, lease, rent or share machinery.

The most accurate method of determining machine costs is complete records of the actual costs incurred. Estimating costs is an alternative. This bulletin is designed to provide farm managers with an additional tool for their management decisions. We have developed a series of tables and two worksheets, one for tractors and one for other machines, to help determine machine costs. Once you can accurately determine a machine's costs, you can select the lowest cost machine that will be adequate for your operation.

A discussion of the various components of machinery costs and the procedures for calculating them follows. When you purchase a machine, this will help you to systematically estimate machine costs and select the best value.

Types of Costs

Costs of agricultural machines fall into two categories.

Fixed (ownership) costs are incurred regardless of the number of acres or hours of use annually. Fixed costs include depreciation, interest, insurance, shelter, and in some cases, taxes.

Variable (operating) costs vary with the hours of machine use. They include fuel, lubricants, repair and maintenance, and labor.

Fixed costs

Machinery loses value due to wear, age and obsolescence. The loss in value due to age and obsolescence is called depreciation. Machines depreciate each year regardless of the hours of use, and therefore depreciation is considered a fixed cost. The change in a machine's value divided by the number of years of ownership can be considered annual depreciation.

NOTE: Depreciation for tax purposes must be determined differently, and is not discussed here.

You can use various methods to determine a machine's value at the end of a specific period of time. This bulletin uses a schedule that considers the value of machinery on the open market.

Table 1. Annual fixed costs in percent of list price by machine category and age (Interest rate is 8 percent and housing, etc. is 2 percent)

	Equipment Categories			
Age (years)	**1 Tractors**	**2 Combines S.P.Windrowers**	**3 Forage Harvester Balers, Blowers**	**4 Mower Tillage**
1	44.31	50.53	57.96	54.25
2	8.38	9.67	8.46	9.01
3	7.71	8.56	7.49	7.91
4	7.10	7.57	6.63	6.95
5	6.53	6.70	5.87	6.11
6	6.01	5.93	5.19	5.37
7	5.53	5.25	4.59	4.72
8	5.08	4.65	4.07	4.15
9	4.68	4.11	3.60	3.64
10	4.30	3.64	3.18	3.20
11	3.96	3.22	2.82	2.81
12	3.64	2.85	2.49	2.47
13	3.35	2.52	2.21	2.17
14	3.08	2.23	1.95	1.90
15	2.84	1.98	1.73	1.67

Interest on money spent on machinery is another fixed cost. This may be a cash cost when you borrow money, or an opportunity cost when you buy machinery with money that you've saved. Since interest cost does not vary with machine use, it is a fixed cost. A rate of 8 percent of the remaining machine value is used here for estimating interest cost.

Housing and insurance are also fixed costs. We use a rate of 2 percent of the machine's list price.

Table 1 allows you to estimate fixed machine costs based on the machine's age and category. To determine the fixed cost, multiply the percentage for the appropriate machine age and category from Table 1 times the purchase price. For example, a new $30,000 tractor would have an estimated fixed cost of $13,293 ($30,000 times 0.4431, from Table 1) for the first year. During the sixth year of ownership the fixed cost is $1,803 ($30,000 times 0.0601, from Table 1).

To determine average fixed costs for a selected machine life, you must average these costs over the machine life. The average fixed costs per year for a machine with a 7-year life is the sum of the first seven values in Table 1, divided by 7 and multiplied by the machine's value. An example: For a tractor, the sum of the first seven values is 85.57. Dividing by 7, the average annual rate is 12.22 percent.

A wear-out life, based on the number of hours of operation listed in Table 2, estimates the useful life of a machine that has had average care and maintenance. Beyond this life, repair and maintenance costs become excessive.

Table 2. Remaining value groups, wear-out life and total repairs to wear-out life.

Machinery	Remaining Value & fixed cost group number	Estimated Wear-out Life, hours	Total Repairs in wear-out life % of list price
Tractor			
two wheel drive	1	10,000	120
four wheel drive	1	10,000	100
Tillage			
moldboard plow	4	2,000	150
offset disk	4	2,000	60
tandem disk	4	2,000	60
chisel plow	4	2,000	100
field cultivator	4	2,000	80
spring tooth harrow	4	2,000	80
rolling packer	4	2,000	40
rotary hoe	4	2,000	60
rolling harrow	4	2,000	40
row cultivator	4	2,000	100
Planting			
planter	4	1,200	80
grain drill	4	1,200	80
Harvesting			
picker-sheller	4	2,000	70
combine			
pull-type	2	2,000	90
self-propelled	2	2,000	50
mower-conditioner	4	2,000	80
rake	4	2,000	100
baler	3	2,000	80
forage harvester			
pull-type	3	2,000	80
self-propelled	3	2,500	60
potato	4	2,500	70
Other			
fertilizer spreader	4	1,200	120
sprayer, boom	4	1,500	70
blower	3	2,000	50
wagon	4	3,000	80

Source: 1990 Standards, American Society of Agricultural Engineers

Table 1 can also be used to estimate the fixed costs of used machinery. The average fixed costs for the period of ownership can be estimated by using the average percent for the period. For example, if you buy the $30,000 tractor used at 5 years of age and plan to own it for 7 years, then the average annual fixed cost is based on the average for years 6 through 12 from Table 1. In this case the annual fixed percent is 4.74 percent and the costs are $1,422 ($30,000 times 0.0474).

Table 3 was developed from Table 1 to provide the cumulative average annual fixed costs, in percent. For the $30,000 tractor, the average fixed cost would be $3666 per year ($30,000 times 0.1222 from Table 3) for the first 7 years of ownership. You would use this value in the machine's cost calculations.

Since you will use most tractors for several different operations, you must know the fixed costs per hour in order to distribute these costs among all operations. To do this, divide the tractor's fixed costs by the estimated hours the tractor is used for all purposes during the year. Multiply the result by the number of hours the machine requires the tractor each year.

Table 3. Cumulative average annual fixed costs in percent of list price by machine category and age.

	Equipment Categories			
Age (years)	**1 Tractors**	**2 Combines S.P.Windrowers**	**3 Forage Harvester Balers, Blowers**	**4 Mower Tillage**
1	44.31	50.53	57.96	54.25
2	26.35	30.10	33.21	31.64
3	20.14	22.92	24.64	23.72
4	16.88	19.08	20.14	19.53
5	14.81	16.61	17.28	16.85
6	13.34	14.83	15.27	14.93
7	12.22	13.46	13.74	13.47
8	11.33	12.36	12.53	12.31
9	10.59	11.44	11.54	11.35
10	9.96	10.66	10.70	10.53
11	9.42	9.99	9.99	9.83
12	8.94	9.39	9.36	9.22
13	8.51	8.86	8.81	8.67
14	8.12	8.39	8.32	8.19
15	7.77	7.96	7.88	7.76

Variable costs

Repair costs

Repair costs depend on hours of annual use, and are difficult to predict because operators differ greatly in the levels of repair and maintenance they do. Table 4 estimates repair costs based on annual use and length of ownership. The values in the table are hourly costs per $1,000 of list price.

For example, consider a $7,500 moldboard plow that is used 100 hours per year. From Table 4, the average repair cost for a 7-year life is $0.32 per hour for each $1,000 of list price. For this plow, the repair cost is $2.40 per hour ($0.32 times

$7,500 divided by $1,000). The annual cost is 100 hours times $2.40, or $240. Repair costs beyond the wear-out life are not included in Table 4.

In order to determine repair costs, you must estimate annual hours of use. Divide the total acres for the operation by the effective field capacity of the machine in acres per hour. To estimate field capacity, multiply forward speed in miles per hour by the machine width in feet and by the field efficiency, and then divide by 8.25. Typical forward speeds and field efficiencies are listed in Table 5.

For tractors, the repair cost per hour must be calculated for the entire year and then divided by the total annual use in hours. Then find the tractor repair costs charged to a given machine, by multiplying the tractor repair costs per hour by the total time the tractor is used with that machine.

Table 4. Average hourly repair costs per $1,000 of list price.

Machine	Annual hours	7-year life	10-year life	15-year life
Tractor, 2 wheel drive	200	$0.02	$0.02	$0.02
	400	0.03	0.05	0.07
	600	0.05	0.07	0.11
	800	0.07	0.10	*
Tractor, 4 wheel drive	200	0.01	0.02	0.03
	400	0.03	0.04	0.06
	600	0.04	0.06	0.09
	800	0.06	0.08	*
Moldboard plow	50	0.19	0.25	0.34
	100	0.32	0.43	0.59
	150	0.45	0.59	*
	200	0.56	0.75	*
Chisel plow and rake	50	0.16	0.22	0.30
	100	0.29	0.38	0.53
	150	0.40	0.53	*
	200	0.50	0.66	*
Disk	50	0.09	0.11	0.15
	100	0.14	0.18	0.24
	150	0.19	0.24	*
	200	0.23	0.29	*
Field cultivator and spring-tooth harrow	50	0.20	0.23	0.27
	100	0.26	0.30	0.35
	150	0.31	0.35	*
	200	0.34	0.40	*
Roller packer and harrow	50	0.12	0.13	0.15
	100	0.14	0.16	0.18
	150	0.16	0.18	*
	200	0.18	0.20	*

* Exceeds estimated machine life

(continued)

Table 4. (continued)

Machine	Annual hours	7-year life	10-year life	15-year life
Row cultivator	50	0.06	0.10	0.16
	100	0.14	0.22	0.36
	150	0.23	0.36	*
	200	0.33	0.51	*
Rotary hoe	50	0.15	0.17	0.20
	100	0.20	0.23	0.27
	150	0.23	0.27	*
	200	0.26	0.30	*
Planting equipment	50	0.17	0.25	0.39
	100	0.36	0.54	*
	150	0.57	*	*
	200	0.78	*	*
Corn picker and sheller	50	0.04	0.06	0.10
	100	0.09	0.14	0.24
	150	0.15	0.24	*
	200	0.22	0.34	*
Combine, pull type	50	0.05	0.07	0.12
	100	0.11	0.18	0.30
	150	0.19	0.30	*
	200	0.28	0.44	*
Combine, self-prop.	50	0.04	0.06	0.09
	100	0.08	0.12	0.19
	150	0.13	0.19	*
	200	0.17	0.26	*
Mower-conditioner	50	0.14	0.17	0.22
	100	0.21	0.26	0.33
	150	0.27	0.33	*
	200	0.32	0.39	*
Baler and pull-type forage harvester	50	0.10	0.13	0.18
	100	0.17	0.23	0.32
	150	0.24	0.32	*
	200	0.30	0.40	*
Forage harvester self-prop.	50	0.05	0.07	0.10
	100	0.09	0.12	0.17
	150	0.12	0.17	*
	200	0.16	0.21	*
Potato harvester	50	0.12	0.14	0.17
	100	0.16	0.19	0.22
	150	0.18	0.24	0.26
	200	0.22	0.25	*

* Exceeds estimated machine life

(continued)

Table 4. (continued)

Machine	Annual hours	7-year life	10-year life	15-year life
Fertilizer spreader	50	0.70	0.77	0.87
	100	0.85	0.95	*
	150	0.96	*	*
Boom sprayer	50	0.30	0.33	0.38
	100	0.37	0.41	0.46
	150	0.42	0.46	*
Blower, forage	50	0.06	0.08	0.11
	100	0.11	0.14	0.19
	150	0.15	0.19	*
	200	0.18	0.24	*
Wagon	50	0.14	0.15	0.17
	100	0.17	0.19	0.21
	150	0.19	0.21	0.24
	200	0.21	0.23	0.26

* Exceeds estimated machine life

Source: 1990 Standards, American Society of Agricultural Engineers

Fuel costs

Fuel costs depend on the hours of operation and the size of the tractor or power unit. To determine hourly fuel consumption, multiply the tractor power-take-off horsepower by a constant that provides a value in gallons per hour. That value is 0.06 for gasoline engines and 0.044 for diesels.

For example, a tractor or self-propelled machine with a 120 horsepower diesel engine will use an estimated 5.28 gallons of fuel per hour (120 times 0.044). By knowing the price of fuel and the number of annual hours of operation, you can estimate the annual fuel cost.

Lubricant costs

To estimate lubricant costs, multiply the fuel costs by 0.15.

Labor costs

To estimate the annual labor cost to run a machine, multiply the hourly wage by the total hours required for the operation. The hourly labor cost may be the hourly wages of hired help, or an estimate of the operator's time based on the skill required to operate the machine and perform other tasks, such as management.

Timeliness costs

Every field operation is best done at a certain time. If the operation is not done at that time, the quantity and/or quality of the crop will be reduced. For example, yield may decrease 1 percent per day if the operation is not done on the optimum date. This is called *timeliness*, and can be calculated as a cost resulting from a decrease in income. The size of the cost depends on factors such as crop value, crop yield, machine operation, weather, and hours available for work per day.

Timeliness costs become very important when you compare machines of different capacities, such as a four-bottom plow versus a five-bottom plow. To estimate these costs, use Table 5 to determine a timeliness factor.

Table 5. List of field efficiency, suggested forward speed and timeliness constants.

Machine	Field Efficiency	Suggested Speed, mph	Timeliness Factor
Moldboard plow	.7 - .9	3 - 6	0.000 - 0.010*
Chisel plow	.7 - .9	4 - 6.5	0.000 - 0.010
Disks	.7 - .9	3 - 6	0.000 - 0.010
Field cultivator	.7 - .9	3 - 8	0.000 - 0.100
Roller packer	.7 - .9	3 - 6	0.000 - 0.010
Row cultivator	.7 - .9	2.5 - 5	0.011
Planter	.5 - .75	3 - 7	0.005
Grain drill	.65 - .85	2.5 - 6	0.005
Picker sheller	.6 - .75	2 - 4	0.003
Combine	.65 - .8	2 - 5	0.003
Mower cond., pull	.55 - .85	3 - 6	0.010
Mower cond., s.p.	.6 - .9	3 - 6	0.010
Baler	.6 - .85	2 - 5	0.028
Forage harv., pull	.55 - .75	1.5 - 5	0.028
Forage harv., s.p.	.6 - .85	1.5 - 6	0.028
Boom sprayer	.6 - .75	3 - 5	0.011

* Tillage timeliness factor is dependent on its effect on planting.

Source: 1990 Standards, American Society of Agricultural Engineers

Timeliness cost is calculated using factors and crop information. The formula is:

$$\text{Timeliness Cost (Dollars per hour)} = \frac{Tc \times Acres \times Crop\ value \times Yield}{Tx \times Hours \times Passes}$$

Tc = timeliness coefficient from Table 5

Tx = 4 if operations can be balanced evenly around the optimal time. Example: cutting or harvesting forages.Tx = 2 if the operation should either start or end at the optimal time.

Hours = the average hours per day this machine can normally be used.

Crop value = dollar value of crop in $/bu, $/T.

Yield = crop yield in bu/A, T/A.

Passes = the number of trips over the field or the number of cuttings.

The following worksheets allow you to analyze machine costs using the principles and tables discuss earlier.

Worksheet 1 is designed for tractors. This allows you to determine hourly fixed costs and repair costs, which you can then apportion to the various machines used with this tractor.

Worksheet 2 is designed for machines other than tractors. To estimate costs for machines requiring a tractor, you must first calculate hourly fixed costs and repair costs for the tractor. If only tractor costs are evaluated, use Worksheet 2, but disregard items 3, 4d and 7.

This entire process has been programmed onto spreadsheet software, which allows you to make numerous calculations evaluating a variety of options. The program allows you to select an interest rate that matches your situation.

The program is available at your county UW-Extension office for the cost of the floppy disk. You will need LOTUS 123 or VP Planner spreadsheet software to run the program. The name of the file is MACHCOST. It will not operate on early versions of VP Planner.

WORKSHEET 1

For tractors only

1. Information needed:
   a. Tractor model - _____
   b. List price - _____
   c. Tractor age - _____
   d. Tractor size, pto hp _____
   e. Expected years of ownership _____
   f. Estimated hours of annual use _____

2. Annual fixed cost:

   List price times fixed factor (Table 3) divided by 100

   _____ X _____ / 100 _____

3. Repair cost

   Cost value from Table 4 times list price divided by 1,000

   _____ X _____ / 1,000 = $_____ /hr.

   Hourly cost times annual hours

   _____ X _____ = $ _____

4. Total fixed and repair annual costs (sum of 2 and 3) _____
5. Hourly tractor fixed and repair costs (divide 4 by 1f) _____

   (This cost is used when determining costs of other machines)

WORKSHEET 2

For machines other than tractors

1. Information needed:

   a. Type of machine - _____ b. List price - _____

   c. Machine age - _____ d. Machine size - _____

   e. Acres - _____ f. Tractor size, pto hp _____

   g. Expected years of ownership _____

   h. Tractor hourly fixed and repair costs (Worksheet 1) _____

2. Annual fixed cost: List price times fixed factor (Table 3) divided by 100

   _____ X _____ / 100 _____

3. Estimated use (for tractors, estimate annual hours):

   a. Effective field capacity, acres per hour (Table 5)
   Forward speed times width times field efficiency divided by 8.25

   _____ X _____ X _____ / 8.25 = _____ ac/hr

   b. Estimated annual time, hours
   Acres times number of trips divided by effective field capacity

   _____ X _____ / _____ = _____ hours

4. Annual variable costs:

   a. Repair cost: Cost value from Table 4 times list price divided by 1,000

   _____ X _____ / 1,000 = $ _____ /hr.

   Hourly cost times annual hours (3b)_____ X _____ = $ _____

   b. Fuel cost: Fuel factor times pto hp (1f) (0.044 for diesel, 0.06 for gasoline)

   _____ X _____ = _____ gal/hr

   Gal/hr times hours (3b) times fuel price_____ X _____ X _____ = _____

   c. Lubricant cost: Fuel cost (4b) times 0.15_____ X 0.15 = _____

   d. Tractor cost (1h): Hours (3b) times hourly tractor costs_____ X _____ = _____

   e. Labor cost: Hourly wages times hours (3b) _____ X _____ = _____

5. Total out-of-pocket cost (sum of 2, 4a, 4b, 4c, 4d and 4e): _____

6. Hourly out-of-pocket costs: Total costs (5) divided by hours (3b) _____

7. Timeliness cost

   a. Information needed:

   Crop yield - _____ Crop value - _____

   Timeliness factor - _____ Hours per day - _____

   b. Timeliness cost determination
   Crop value X yield X time. factor X acres / (hours per day X 4)

   _____ X _____ X _____ X _____ / (_____ X 4) _____

   Hourly cost times hours (3b) _____ X _____ _____

8. Total costs (sum of 5 and 7b) _____

WORKSHEET 2

For machines other than tractors

1. Information needed:
   a. Type of machine - **Mower-Cond** b. List price - **$8500**
   c. Machine age - **0** d. Machine size - **9 ft.**
   e. Acres - **100** f. Tractor size, pto hp **60**
   g. Expected years of ownership **10**
   h. Tractor hourly fixed and repair costs (Worksheet 1) **$4.72**
2. Annual fixed cost: List price times fixed factor (Table 3) divided by 100
   8500 X **10.53** / 100 **$895**
3. Estimated use (for tractors, estimate annual hours):
   a. Effective field capacity, acres per hour (Table 5)
   Forward speed times width times field efficiency divided by 8.25
   5 X **9** X **0.75** / 8.25 = **4.09** ac/hr
   b. Estimated annual time, hours
   Acres times number of trips divided by effective field capacity
   100 X **4** / **4.09** = **97.8** hours
4. Annual variable costs:
   a. Repair cost: Cost value from Table 4 times list price divided by 1,000
   0.26 X **8500** / 1,000 = $ **2.21** /hr.
   Hourly cost times annual hours (3b) **2.21** X **97.8** = $ **$216**
   b. Fuel cost: Fuel factor times pto hp (1f) (0.044 for diesel, 0.06 for gasoline)
   0.044 X **60** = **2.64** gal/hr
   Gal/hr times hours (3b) times fuel price **2.64** X **97.8** X **$.90** = **$232**
   c. Lubricant cost: Fuel cost (4b) times 0.15 **232** X 0.15 = **$35**
   d. Tractor cost (1h): Hours (3b) times hourly tractor costs **97.8** X **$4.72** = **$462**
   e. Labor cost: Hourly wages times hours (3b) **$5.00** X **97.8** = **$489**
5. Total out-of-pocket cost (sum of 2, 4a, 4b, 4c, 4d and 4e): **$2329**
6. Hourly out-of-pocket costs: Total costs (5) divided by hours (3b) **$23.81**
7. Timeliness cost
   a. Information needed:
   Crop yield - **5 T /Ac** Crop value - **$80 / T**
   Timeliness factor - **0.01** Hours per day - **8**
   b. Timeliness cost determination
   Crop value X yield X time. factor X acres / (hours per day X 4)
   $80 X **5** X **0.01** X **100** / (**8** X 4) **$12.50**
   Hourly cost times hours (3b) **12.50** X **97.8** **$1223**
8. Total costs (sum of 5 and 7b) **$3552**

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