8. VALUING MACHINERY OVER TIME

CHAPTER OBJECTIVES:

- ***To introduce the reader to the use of the list price for calculating certain components of machinery costs over time;***
- ***To describe the influence of inflation on the value of machinery;***
- ***To explain the calculation of the remaining value percentage of machinery;***
- ***To validate the use of the remaining value percentage.***
- ***To validate the relationship of costs and usage.***

Machinery cost is calculated on a specific point in time. However, because it regularly involves capital investment (as in purchased machines), the calculations cover a fixed amount of time into the future, for example10 years.

*Assuming the analysis is occurring around the end of 2000, while planning for machine operations in 2001 and beyond, any machinery considered purchased is assumed purchased in 2000 (year 0). However, it is not used until 2001 (year 1). A 10-year analysis (including 10 harvests) would end following the harvest in 2010 (year 10). Variables are subscripted as needed with either an **n** (2000, 2001, …) or a **k** (0,1, …) to facilitate tracking in a spreadsheet setting. The symbols **begin** and **end** refers to beginning and ending years in an analysis, respectively (depending upon whether **n** or **k** is used to denote years, **begin** = 2000 or **begin** = 0; likewise, a 10-year study is associated with either **end** = 2010 or **end** = 10).*

8.1. CURRENT LIST PRICE

A new machine rarely sells at its list price. Rather, it sells around 80 to 90% of this price. Because machinery list prices are more readily available than prices paid, research has often been conducted on that basis, leading certain formulas to depend on list price. A current list price needs to be established whether the machine is new or used. For a new machine today, current list price is today's list price. For a used machine today, current list price is the value at which an identical machine would be listed today, if it were new.

One way to establish the current list price (in 2000) for example for a 1995 John Deere Model 9600 combine is to observe the list price at a John Deere dealer today (2000) for a 2000 John Deere Model 9600 combine. That value is the current list price for the 1995 used combine. However, the 2000 combine often contains technologically improved features over the 1995 model. Thus, it may not be identical to the 1995 model. Furthermore, models manufactured in the past may have been discontinued. In such cases, using today's list price to represent the current list price of a used machine may be inappropriate.

A second, and often more appropriate method for establishing current list price (in 2000) for the 1995 John Deere combine is to directly adjust the original list price of the combine in 1995 by a suitable measure of price inflation occurring between 1995 and 2000. A commonly used measure of price inflation for agriculture is the producer price index.

8.2. PRODUCER PRICE INDEX

Table 8.1 provides historical producer price index (PPI) values for the USA. It also provides annual inflation rates, which can be computed from successive PPI values according to:

$$Inflation = (PPI_n \div PPI_{n-1}) - 1 \qquad [8.1]$$

TABLE 8.1: PRODUCER PRICE INDEX, USA AVERAGE (ALL COMMODITIES)

Year	Index	Inflation
1980	89.89093	0.14079
1981	98.0333	0.09158
1982	100.0167	0.02023
1983	101.2500	0.01233
1984	103.6750	0.02395
1985	103.1500	-0.00506
1986	100.1667	-0.02892
1987	102.8083	0.02637
1988	106.9417	0.04020
1989	112.2417	0.04956
1990	116.2917	0.03608
1991	116.5333	0.00208
1992	117.1917	0.00565
1993	118.9083	0.01465
1994	120.4500	0.01297
1995	124.7583	0.03577
1996	127.8205	0.02455
1997	127.6000	-0.00065
1998	124.4333	-0.02482
1999	125.4750	0.00837
2000	132.6667	0.05731

Source: Federal Reserve Bank of St. Louis FRED database (http://www.stls.frb.org/fred) 1982 = 100.

The current list price in year **n**, $\mathbf{CLP_n}$, is computed from the current list price in year **m** as follows:

$$CLP_n = CLP_m \times \frac{PPI_n}{PPI_m}$$

[8.2]

Suppose the original list price (when new) for the 1995 combine discussed earlier was known to be \$100,000 ($\mathbf{CLP_{1995}}$ = \$100,000). Then the current list price (in 2000) for the same combine is:

$$CLP_{2000} = CLP_{1995} \times (PPI_{2000} \div PPI_{1995})$$

Using the values in Table 8.1:

$$CLP_{2000} = \$100,000 \times (132.7 \div 124.8)$$
$$= \$106,330$$

Because decisions based on machinery cost analysis are always forward-looking, expectations for future inflation rates are required.

8.3. REMAINING VALUE PERCENTAGE, ECONOMIC DEPRECIATION AND MARKET VALUE

Remaining value percentage (**RVP**) is the percentage that a machine's market value is of its current list price (both evaluated in the same year). **RVP** helps determine a machine's economic depreciation, which is the amount of market value lost each year due to age, wear, and obsolescence and must not be confused with its tax depreciation. For a particular class of machinery, remaining value percentage is often assumed to be determined by its age and not its rate of use, using a constant rate of market value depreciation. The American Society of Agricultural Engineers (ASAE) uses the following formula:

$$RVP_n = RVP1_n = dep1 \times dep2^{AGEn}$$
$$\text{if } AGE_n \geq 1, \text{ and } 0.85 \text{ if } AGE_n < 1; \qquad [8.3]$$

Where:

- RVP_n is **RVP** in year **n** (the **1** following **RVP** distinguishes the ASAE formula from an alternative presented later);

- AGE_n is a machine's age in years in year n;

Depreciation factors for different machinery classes, **dep1** and **dep2**, are presented in Table 8.2.

TABLE 8.2: FACTORS FOR CALCULATING REMAINING VALUE PERCENTAGES BY MACHINERY CLASS

Machinery class	Dep1	Dep2
Tractor	0.67	0.94
Combines	0.65	0.93
Mowers	0.67	0.90
Harvesters	0.56	0.90
Balers	0.66	0.92
Planters/Tillage	0.66	0.96

Source: Machinery Replacement Strategies, by Wendell Bowers, Deere and Company, 1994, p.9
Notes:

- *Factors used to calculate remaining value from age: RVP=dep1 x $dep2^{AGE}$.*
- *When age is 0 RVP is assumed to be 0.85.*

Formula 8.3 states that with 0 inflation a machine depreciates annually at the rate of **1-dep2**. This means that each year it is worth **dep2** as much as it was the year before.

Factors **dep1** and **dep2** were computed with and are designed to be used with machinery that is at least 1 year old. Thus, a conditional statement follows the equation in Formula [8.3]. Without that conditional statement, because $\mathbf{dep2^0 = 1}$, new machines would be estimated to cost **dep1** of current list price. The **dep1** values in Table 8.2 are too low to appropriately value new machines. Instead, new machines are assumed to cost 85% of their list prices.

Market value in year **n** ($\mathbf{MV_n}$) is the remaining value percentage times current list price:

$$MV_n = CLP_n \times RVP_n \qquad [8.4]$$

Economic depreciation is the change in market value across any 2 years, or $\mathbf{MV_n - MV_{n-1}}$. Because current list price is affected by inflation, and because remaining value percentage is a measure of economic depreciation, formula 8.4 shows that both inflation and economic depreciation affect current market value of machinery. If inflation is high enough to offset economic depreciation, causing **CLP** to rise rapidly over years, a used machine may sell for more than what it was new.

Continuing with the combine example, the 1995 remaining value percentage is:

$$\begin{aligned} RVP1_{1996} &= dep1 \times dep2^{(2000\text{-}1995)} \\ &= 0.65 \times 0.93^{5} \\ &= 0.4522 \end{aligned}$$

Inserting the $109,700 value for **CLP₁₉₉₆** computed earlier, market value in 1995 is:

$$MV_{1996} = \$106{,}330 \times 0.4522 = \$48{,}082$$

Formula 8.4 depicts economic depreciation as a fixed cost relating to age. However, because wear is a function of rate of use, if rate of use varies across machines and years, depreciation may have both variable and fixed cost components. For some machines, most notably for combines, rate of use may be as important for determining market value as is age. This is likely due to the number of used combines that have been originally owned by custom harvesters. Such machines are typically used more intensely and traded more often than farmer-owned machines.

Recently, economists have begun to derive formulas that attempt to quantify the relationship between rate of use and market value, especially for tractors and combines, where hour meters have been standard for many years. However, for tillage and planting equipment, historical rate of use is difficult to quantify. For other classes, such as balers, it may come about because of bale counters. Cross and Perry* examined auction sale prices reported monthly from January 1984 to June 1993 in the Farm Equipment Guide (Hot Line, Inc.). Equipment manufactured between 1971 and 1993 were considered. Their study resulted in the following formula relating market value to age and rate of use:

$$\begin{gathered} RVP_n = RVP2_n = [a+(b \times (AGE_n)^{c})+(d \times (HPY_n)^{e})]^{f}, \\ \text{if } AGE_n \geq 1 \\ \text{and } 0.85 \text{ if } AGE_n < 1 \end{gathered}$$

[8.5]

Formula 8.5 depicts an alternative method to formula 8.3 for computing remaining value percentage that considers rate of use as well as age.

* *Cross, T.L. & Perry, G.M.. 1995: "Depreciation Patterns for Agricultural Machinery." American Journal of Agricultural Economics, 77.*

Note:

- Like $\mathbf{RVP1_n}$ in formula 8.3, $\mathbf{RVP2_n}$ is the proportion (ranging between 0 and 1) that the projected market value in year **n** is of the current list price in year **n**.
- $\mathbf{AGE_n}$ is machine age in years at year **n**.
- $\mathbf{HPY_n}$ is the average hours per year that the machine was used since it was new, evaluated in year **n**, or $\mathbf{AH_n \div AGE_n}$, where $\mathbf{AH_n}$ denotes the accumulated hours on the machine as of year **n**.
- The small letters, **a**, **b**, **c**, **d**, **e**, and **f** are factors required of the formula.

Factor values for several brands of tractors, combines, disks, planters, swathers, and balers are in Table 8.3*.

* *For tractors, in order to allow for horsepower to affect remaining value, the factor as reported in Table 8.3 must be modified slightly before using in formula 8.5. Specifically, for 60-112 kW tractors, the value, 0.00062 x pto kW, must be subtracted from the associated **a** values before they can be used in formula 8.5. For 112+ kW tractors, the value, 0.00125 x pto kW, must be subtracted from the associated **a** values. For all other machinery classes in Table 8.3, the **a**'s are used as they appear. Formulas reported by Cross and Perry included several additional measures besides age and usage to determine remaining value. Formula 8.5 was deduced by holding these other measures constant. Thus, it depicts the remaining value percentage for equipment in good condition (contrasted with excellent, fair, or poor) sold at retirement auctions (contrasted with consignment, bankruptcy, or dealer closeout) in the Middle Great Plains (South Dakota, Nebraska, and Kansas).*

TABLE 8.3: CROSS & PERRY ADJUSTMENT FACTORS FOR SELECTED MACHINERY CLASSES AND MANUFACTURES

	ADJUSTMENT FACTORS					
	a*	b	c	d	e	f
60-112 kW Tractors						
AC	0.969772	-0.02725	0.76	-0.00236	0.6	3.846154
Case	1.000787	-0.03277	0.76	-0.00120	0.6	3.846154
Ford	1.029438	-0.02768	0.76	-0.00275	0.6	3.846154
JD	1.035260	-0.02301	0.76	-0.00120	0.6	3.846154
IH	0.989220	-0.02765	0.76	-0.00203	0.6	3.846154
MF	0.997552	-0.02909	0.76	-0.00261	0.6	3.846154
White	1.032797	-0.02891	0.76	-0.00371	0.6	3.846154
112+ kW Tractors						
AC	1.305504	-0.22785	0.35	-0.01187	0.39	2.222222
Case	1.462469	-0.30023	0.35	-0.01020	0.39	2.222222
Ford	1.238971	-0.11517	0.35	-0.01500	0.39	2.222222
JD	1.405956	-0.22231	0.35	-0.00766	0.39	2.222222
IH	1.340365	-0.26484	0.35	-0.00547	0.39	2.222222
MF	1.282532	-0.26106	0.35	-0.00155	0.39	2.222222
White	1.408643	-0.25439	0.35	-0.01413	0.39	2.222222
Combines						
AC	0.843972	-0.03779	0.87	-0.00244	0.72	2
Case	0.893689	-0.04679	0.87	-0.00091	0.72	2
Ford	1.746431	-0.12208	0.87	-0.00771	0.72	2
JD	0.946917	-0.04551	0.87	-0.00182	0.72	2
IH	0.925632	-0.04411	0.87	-0.00243	0.72	2
MF	0.753825	-0.03811	0.87	-0.00117	0.72	2
White	0.792664	-0.03479	0.87	-0.00373	0.72	2
NH	0.905448	-0.06141	0.87	-0.00105	0.72	2
Disks						
JD	0.364825	0.60697	-0.85	0	0	2.040816
IH	0.445666	0.55410	-0.85	0	0	2.040816
MF	0.216219	1.95014	-0.85	0	0	2.040816
Kewanee	0.031970	3.06544	-0.85	0	0	2.040816
Krause	0.215375	1.39979	-0.85	0	0	2.040816
Planters						
JD	0.867382	-0.01939	0.89	0	0	1.960784
IH	0.924203	-0.04245	0.89	0	0	1.960784
Swathers						
JD	0.855234	-0.04564	0.5	0	0	5.263158
IH	1.077101	-0.10692	0.5	0	0	5.263158
NH	1.062699	-0.10301	0.5	0	0	5.263158
Hesston	0.959780	-0.06955	0.5	0	0	5.263158
Balers						
JD	0.814355	-0.05939	0.57	0	0	2.77778
IH	1.152865	-0.08524	0.57	0	0	2.77778
NH	0.774934	-0.06093	0.57	0	0	2.77778
Hesston	0.895971	-0.10806	0.57	0	0	2.77778

Source: Cross, T.L. & Perry, G.M.. 1995: "Depreciation Patterns for Agricultural Machinery." American Journal of Agricultural Economics, 77.

* *For 60 to 112 kW tractors, the value 0.00046 x hp must be subtracted from the a factor shown in the table, where kW is the pto kW for the tractor considered. For 112+ kW tractors, subtract 0.00093 x kW. For other classes of machinery use the values as they appear.*

Like formula 8.3, formula 8.5 requires the conditional statement to value equipment properly when it is less than 1 year old.

Assume the 1995 John Deere combine had 4,000 hours on its hour meter in the year 2000 so that $HPY_{2000} = 4000 \div 5 = 800$. Using the appropriate values from Table 8.3, formula 8.5 predicts a remaining value percentage of $RVP2_{2000} = [0.94692+(-0.04551 \div 5^{0.87})+(-0.00182 \div 800^{0.72})]^2 = 0.2899$. Using the 2000 current list price computed earlier of \$109,700, along with formulas 8.4 and 8.5, the 1995 machine with 4,000 hours is expected to have a year 2000 market value of \$31,802. This is substantially less than the \$49,606 value computed from formula 8.5, partly because of the machine's high usage rate. On the other hand, if the usage rate were 200 hours per year (more typical of a farmer owned machine) rather than 800, formula 8.5 predicts a remaining value percentage of 0.4621, yielding a market value of \$50,692, much closer to the value calculated using formula 8.3.

8.4. VALIDATION OF THE MODEL

The effect of the remaining value percentage **(RVP2)** is illustrated in figures 8.1 to 8.3.

FIGURE 8.1: REMAINING VALUE AS A PERCENTAGE OF CURRENT LIST PRICE FOR DIFFERENT COMBINES WITH ANNUAL USAGE OF 200 HOURS

Figure 8.1 shows computed **RVP2** values from formula 8.5 for three brands of combines, each with an annual usage of 200 hours. Deere combines were valued more highly (as a percent of current list price) than the other two brands after 1 year of usage. New Holland combines were valued highly after one year; however, they depreciated more and at 10 years of age are valued the lowest among these combines.

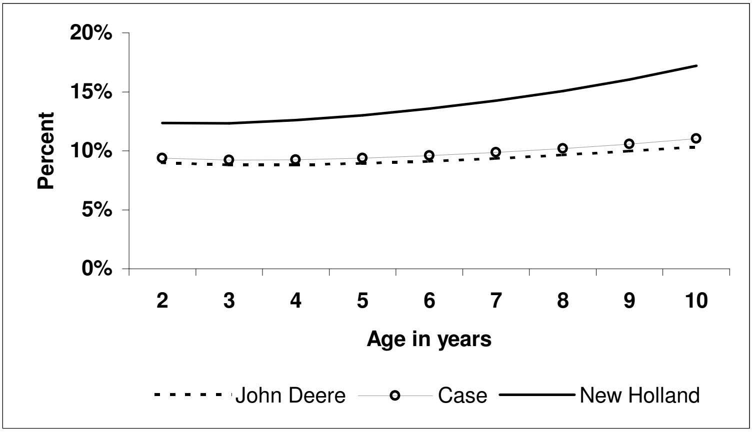

FIGURE 8.2: ANNUAL DEPRECIATION AS A PERCENTAGE OF PREVIOUS YEAR'S PRICE FOR COMBINES WITH ANNUAL USAGE OF 200 HOURS

The annual depreciation rates associated with the **RVP2** values are shown in Figure 8.2. The rapid depreciation associated with New Holland combines is immediately apparent. In addition, the sharp contrast between Cross and Perry values and the normal assumption of a fix annual depreciation is also apparent. The Cross and Perry results also show that the rate of depreciation for combines actually increases over time, and at an increasing rate. This could be due to high timeliness losses associated with breakdowns during harvest. That is, combines lose their reliability quickly.

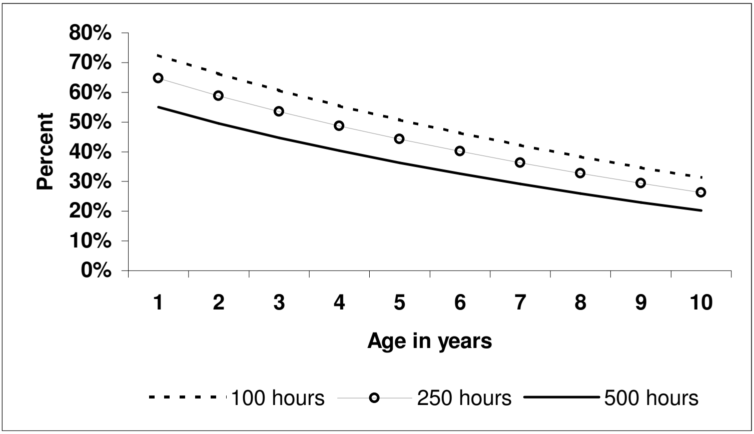

FIGURE 8.3: REMAINING VALUE AS A PERCENTAGE OF CURRENT LIST PRICE FOR A DEERE COMBINE ACROSS VARIOUS ANNUAL USAGE RATES

Remaining value percentages for a Deere combine across different annual usage rates are shown in Figure 8.3. After 1 year of use, a combine that is used for 500 hours per year is valued at only 76% of a combine used only 100 hours (55% divided by 72%). This emphasizes the potential value of using remaining value formulas that explicitly account for usage rate. An operator who plans to use a purchased combine intensively, as in custom harvesting, would be especially ill-advised to ignore usage rate as a determinant of future used combine value.

In conclusion, the use of the adjustment factors defined by Cross & Perry will result in the following:

- The remaining value as a percentage of current list price of certain brand names will be higher than others after the same amount of annual usage;

- The annual depreciation as a percentage of previous year's price of certain brand names will be more rapid than others at the same amount of annual usage;

- The remaining value as a percentage of current list price for a specific machine decreases faster when the annual usage increases.

8.5. PURCHASE PRICE AND SELLING PRICE

Machinery cost analysis must account for changes in valuation as well as any associated cash flows. One way to accomplish this is to consider a purchase (**PUR**) and a selling (**SELL**) price, each occurring at market value in the year it occurs. Even if a machine is already owned, this method accounts for changes in the machine's value over time. Although a machine is purchased only once in our analysis, it is helpful in spreadsheet formulas to think of **PUR** as being valued in each year. That is, **PUR** is valued at market value only in the year it is purchased (here, 1996), and otherwise it equals 0:

$$PUR_n = MV_n \; ; \; if\ n = begin \quad else\ 0 \qquad [8.6]$$

Similarly, the selling price in year **n**, $\mathbf{SELL}_n$, is:

$$SELL = MV \; ; \; if\ n = end \quad else\ 0 \qquad [8.7]$$

8.6. CONCLUSION

Many machinery cost calculations depend on current list price, a value readily derived from current market value using remaining value formulas. Traditionally, remaining value was considered to be determined by age. An alternative process that allows usage rate to affect remaining value, which should more accurately assess future market value for machines used at different levels of intensity is introduced by using the adjustment factors of Cross & Perry. Accurate assessment of future value is important because future value determines economic depreciation, which affects annual machinery costs.

8.7. REFERENCES

Kastens, T. 1997: *Farm Machinery Operation Cost Calculations,* Agricultural Experiment Station and Cooperative Extension Service, Kansas State University.