A complete line of machinery is one of the largest investments that a farm business can make. Yet, unlike land or buildings, machinery must be constantly monitored, maintained, and eventually replaced. How and when equipment is replaced can mean a difference of thousands of dollars in annual production costs.

REPLACING MACHINERY

PART IV

10. REPLACEMENT STRATEGIES

CHAPTER OBJECTIVES:

- ***To introduce the reader to the factors that influence the replacement decision;***
- ***To describe the general strategies that farmers can follow for replacing machinery;***
- ***To explain the costs that must be considered when replacing a machine;***
- ***To discuss a replacement model that determines the optimal replacement time of a machine.***

Farm machinery eventually wears out or become obsolete and must be replaced. Should they be replaced only when they are fully worn or could an earlier replacement be more economical?

To answer this question, several more questions have to be answered:

- How can it be determined which year in an asset's useful life represents the best time to replace that asset with a new or used one?
- What effect do rising prices have on this decision?
- Does the risk associated with reliability lengthen or shorten the length of time the asset should be kept before replacing it?

The basic idea is to find the replacement policy that has the lowest present value of the replacement cost. If the asset is replaced too soon or if the farmer waits too long, he will limit the growth of his farm as well as his potential financial position.

10.1. INFLUENCING FACTORS

It is necessary to evaluate the replacement decision regularly as it is influenced by changing factors such as interest rates, expected repair & maintenance costs, tax rates, prices and resale value. The decision to replace machinery can therefore be made for several reasons.

Cost minimization

The standard rule for minimizing the long-run cost of equipment is to make a change when the annualized total cost of owning and operating the machine begins to increase. At this point repair costs begin to increase faster than depreciation while interest cost decreases. However, the rate at which total costs rise is often very gradual, as shown in Chapter 7. Being able to anticipate when large repair costs will be needed is a key consideration in deciding when to replace a machine.

Reliability

Besides the standard machinery costs, most farmers also consider timeliness cost in their replacement decisions. Timeliness cost, as already discussed in previous chapters, occurs when crops are not planted or harvested at the optimal time. If a machine breaks down at a critical time, timeliness cost can be quite high. Reliability is related to the age of the machine. Owning older machinery that has a high probability of breaking down increases the risk of crop losses and will therefore be an important reason to replace the machinery.

A common belief is that an older machine is less reliable than a new one. Reliability is however not necessarily influenced by the age of a machine. Initially there is a short period during which so-called "*burn-in*" failures occur, followed by a long period during which failures take place at a low intensity. For the largest part of its life a tractor's reliability remains constant. At the end of its useful life a stage is reached where reliability declines at a fast rate and where the so-called "*wear-out failures*" occur. Given normal operating conditions and maintenance, an old tractor can remain as reliable as a new one for a very long time.

Pride of ownership

Many farmers take pride in owning and operating new, modern machinery. They may be willing to accept higher long-run costs in return. If the farm business is financially able to bear this cost, there is probably merit in buying a new machine.

Technology

Major technological changes may occur at certain times. In some cases a machine may be in a perfectly good working order, but the introduction of new technology has made it obsolete. Newer models may do a better job of harvesting or planting, or operate more efficiently. Care should be taken to distinguish new technology that can increase profits from changes that simply provide more convenience and comfort.

Labor requirements

Any labor savings that can be achieved by using new machinery should be taken into account.

Need for capacity

When the number of hectares of crops being produced increases significantly, farmers may need to replace machinery with models that have higher capacity to complete planting and harvesting without serious timeliness losses. Likewise, when farm size is reduced, it may be possible to cut costs by downsizing the machinery set.

The farm machinery market

The market for farm machinery is subject to changes in supply and demand, just as for any other product. In particular, the demand for both new and used machinery is strongly affected by ups and downs in the farm economy. The farmer who maintains a good capital reserve or borrowing capacity may be able to reduce long-run ownership cost by replacing machinery when dealers have excess inventory and are willing to offer discounts to make a sale. When the farm economy is below average, there may be bargains available in used machinery.

10.2. GENERAL STRATEGIES

There are at least four general strategies that farmers can follow for replacing machinery.

Replace frequently

The frequent approach minimizes the risk of breakdowns and costly repairs by trading key machines every few years. Even when repairs occur, they often will be covered by the original warranty.

Farmers who cover a large number of hectares each year and would be severely hampered by extended down time are most likely to follow this strategy. Although this is probably a more expensive approach over the long run, some of the extra costs are offset by fewer timeliness losses, the ability to farm more hectares, and less need to invest in repair and maintenance tools or facilities.

Replace something every year

A second approach is to try to replace one or two machines every year. The goal is to spend about the same amount on new equipment each year. This avoids having to make a very large cash outlay in any one year. However, it also could result in replacing machinery before it is really necessary.

Farmers who prefer to finance machinery purchases out of their annual cash flow rather than with borrowed money often use this strategy. It works best when the net cash income of the operation is fairly constant from year to year or when significant cash reserves are available.

Replace when cash is available

A third approach is to postpone major machinery purchases until a year when cash income is higher than average. This keeps the machinery purchase from using funds needed for other purposes such as family living and debt servicing. It can also help to distribute income for income tax purposes.

The biggest disadvantage of this strategy is that it is very hard to predict when extra cash will be available. Furthermore, a machine may become seriously unreliable before the farm business has sufficient funds to replace it.

Keep it forever

Some farmers simply hang on to machinery until it reaches the point where it can no longer perform its intended function and is not worth renovating. This may be the least-cost approach in the long run, but it runs the risk of a machine failing at a crucial time, or having to arrange financing on short notice. The farmer also must be willing to use less than the latest technology. Some older items can be relegated to less critical uses, such as keeping a second planter for a backup unit, or using an older tractor for jobs such as powering an auger or moving wagons.

This strategy works best for farmers who have considerable flexibility in when they complete key field operations, and who have the skill, patience and facilities to do their own repair and maintenance work.

10.3. CONSIDERING THE COST

The cost of owning and operating farm machinery is in most cases a major cost component. Machinery replacement decisions can exert a major influence on both the total cost and the total income of a farming enterprise. A decision to buy a new machine influence a farmer's cash flow over a couple of years and a wrong decision can have drastic effects. Income tax rebates on the purchase of machinery complicate the issue even further.

A replacement decision must be based on the same sound economic principles on which any management decision should be based. As the correct cost and income associated with the decision to replace machinery are not known in advance, the decision is more complex than for other decisions. Apart from some personal factors, the main reason to replace a machine should be an economical one. This means that at some point in the machine's lifetime, it will be cheaper to buy a new one than to keep on repairing the old one. There are quite a number of mathematical models available to determine this specific point and certain information is needed when calculating the best time to replace a machine.

Annual repair cost

As discussed in Chapter 7, the Allen Rotz model for predicting repair and maintenance costs for agricultural machinery was used to develop model parameters for South African conditions. An additional parameter was added to the model to account for management policy and farmer skills. With the use of this model a repair factor can be calculated over the lifetime of the machine.

Annual depreciation

The annual depreciation depends on the expected economic life for the machine and a salvage value at the end of the economic life. It is very difficult to determine the expected salvage value at the end of the machine's life. Therefore, the trend is to use an annual percentage of depreciation that will write of the total purchase value over the expected life span of the machine.

Interest factor

The prices of spare parts for maintenance and repairs will increase over the lifetime of the machine because of inflation. Inflation will also influence the list price of the machine. An interest factor is therefore required to calculate the rate of change in these prices.

Purchase price

The current price of the machine is also recorded in the replacement calculations.

Other expenses

The present value of additional allowances or expenses can be accommodated in a replacement model.

Income tax effects

In many countries, allowances for the accelerated depreciation of machinery exist. This means that the purchase of a tractor can result in a significant tax saving in the first and following years. The tax-effect of a specific decision should also be taken into account. It is especially important to study the tax effect in following years.

10.4. THE REPLACEMENT MODEL

A number of mathematical models have been designed to determine the optimal time of replacing agricultural machinery. In the end they all come down to comparing the cost of keeping the old machine with the cost of buying a new one. The model discussed in this section was taken from Penson, *et al*, and adapted according to some of the principles and methods discussed in earlier chapters of this book.

The model can be demonstrated by an example with the following information:

- The machine is a 100 kW John Deere tractor
- The purchase price is $76,100.00
- Depreciation rate = 10% per annum on the purchase price
- The inflation rate is 7% per annum
- The discount rate is 3% per annum
- The marginal tax rate is 30%
- The machine is used for an average of 800 hours per annum
- The useful life of the machine is 10 years
- No records of repair cost are available

The calculations and results of the model are shown in Table 10.1.

TABLE 10.1: DETERMINATION OF OPTIMAL REPLACEMENT AGE FOR AGRICULTURAL MACHINERY

Year	(1) Inflation factor	(2) Discount factor	(3) Present value factor	(4) Repair factor*	(5) Annual repair cost	(6) Annual depre-ciation	(7) Adjusted repair cost	(8) Adjusted depre-ciation	(9) Total repair cost	(10) Total depre-ciation	(11) Purchase price	(12) Remaining value**	(13) Replace-ment cost
	IF	DF	PVF	RF	YRC	YD	ARC	AD	TRC	TD	PP	RV	RC
	7	3	(1) x (2)		$	$	(3) x (5)	(6) x (2)	$	$	$	$	$
1	1.070	0.971	1.039	0.015	1141.50	7610.00	1185.83	7388.35	1185.83	7388.35	76100.00	61475.04	372556.34
2	1.145	0.943	1.079	0.031	2321.05	7610.00	2504.83	7173.15	3690.66	14561.50		57581.55	212080.12
3	1.225	0.915	1.121	0.042	3158.15	7610.00	3540.56	6964.23	7231.22	21525.73		54304.10	162912.29
4	1.311	0.888	1.165	0.051	3865.88	7610.00	4502.30	6761.39	11733.52	28287.12		51408.07	143088.28
5	1.403	0.863	1.210	0.059	4505.12	7610.00	5450.53	6564.45	17184.06	34851.57		48788.57	135717.21
6	1.501	0.837	1.257	0.067	5075.87	7610.00	6379.55	6373.26	23563.60	41224.83		46385.91	**134925.38**
7	1.606	0.813	1.306	0.074	5616.18	7610.00	7332.75	6187.63	30896.35	47412.45		44161.50	138272.87
8	1.718	0.789	1.356	0.080	6118.44	7610.00	8298.76	6007.40	39195.11	53419.86		42088.29	144470.18
9	1.838	0.766	1.409	0.087	6590.26	7610.00	9285.85	5832.43	48480.96	59252.29		40146.25	152810.06
10	1.967	0.744	1.464	0.093	7054.47	7610.00	10325.95	5662.55	58806.91	64914.84		38319.94	162949.41

* *The repair factor refers to the relationship of cost and usage discussed in Chapter 7 and is shown in Table 7.3 in that chapter.*

** *The remaining values are calculated according to the Cross & Perry factors discussed in Chapter 8 and is shown in Table 8.3 in that chapter.*

The calculations and results in Table 10.1 consists of the following steps:

STEP I Calculate the inflation, discount and present value factors (1 – 3)

The inflation and discount rate is calculated in columns (1) and (2). The inflation rate is assumed on the expected inflation rate, normally measured as the consumer price index (CPI) or the producer price index (PPI). In this example it was considered to be 7%.

The discount rate represents the risk-free opportunity rate of return. It was calculated at a rate of 3% in Table 10.1.

The inflation factor (IF) for each year was calculated in column (1) as:

$$IF_n = IF_{n-1} \times (1+(Inflation\ rate/100))$$

The discount factor (DF) for each year was calculated in column (2) as:

$$DF_n = DF_{n-1} \div (1+(Discount\ rate/100))$$

The factor for the present value (PVF) was calculated in column (3) as:

$$PVF_n = IF_n \times DF_n$$

or

$$Column\ (3) = Column\ (1) \times Column\ (2)$$

The effect of this calculation, shown in column (3), is that the current value of the cost (repair or depreciation) is firstly inflated with the inflation factor and then secondly, discounted with the discount factor to get the factor of the present value for each year.

STEP II Calculate the repair cost and depreciation (4 – 6)

The calculation of repair cost involve the relation of repair cost to the list price of the machine over its expected life span. The repair cost factor in column (4) refers to the relationship of cost and usage discussed in Chapter 7 and is shown in Table 7.4 in that chapter. Annual repair cost, calculated in column (5), is the result of the list price (in this case the purchase price in column 11), multiplied by the repair cost factor in column (4).

Annual depreciation is calculated by dividing the purchase price of the machine by the expected economic life span of the machine, in this case ten years. It results in a 10% annual depreciation of $7,610.00.

STEP III Calculate the present value of repair cost and depreciation (7 – 8)

The expected annual repair cost must be adjusted by the inflation factor as well as the discount factor. This adjustment is shown in column (7) after the normal repair cost in column (5) is multiplied by the present value factor in column (3) for each of the ten years.

The depreciation needs not to be adjusted with the inflation factor as it is a fixed amount for the total period and price increase will not influence this calculation. It does however need to be adjusted with the discount factor. The adjustment is shown in column (8) by multiplying the discount factor in column (2) by the normal depreciation in column (6).

STEP IV Calculate the total present value of repair cost and depreciation (9 – 10)

The total present value of repair cost or depreciation for each year is calculated by adding the cost of the previous years to that of the current year, resulting in a cumulative amount. The result is shown in columns (9) and (10).

STEP V Calculate the remaining value of the machine (12)

The remaining value is the expected selling price for this machine at the end of each year if it is to be replaced at that stage. In this example it was calculated according to the formula described in Chapter 8 that uses the Cross & Perry factors:

$$RVP_n = [a+(b \times (AGE_n)^c)+(d \times (HPY_n)^e)]^f$$

The following factors were used for this specific machine:

a	b	c	d	e	f
1.03526	-0.02301	0.76	-0.0012	0.6	3.846154

AGE was changed for each year and HPY (hours per year) were fixed on 800 hours.

STEP VI Calculate the replacement cost of the machine (13)

The replacement cost (RC) for each year is calculated as follows in column (13):

$$RC_n = (PP-(RV_n \times PVF_n)+((1-(MTR/100)) \times TRC_n)-((MTR/100) \times TD_n))/(1-DF_n) \quad [10.1]$$

Where:

- **PP** is the Purchase price in column (11);
- **RV** is the Remaining value in column (12);
- **PVF** is the Present value factor in column (3);
- **MTR** is the Marginal tax rate giving as 30%;
- **TRC** is the Total repair cost in column (9);
- **TD** is the total depreciation in column (10);
- **DF** is the Discount factor in column (2);
- **n** is the age (in years) of the machine.

If studied carefully, the formula:

- Subtracts the remaining value from the purchase price;
- Subtracts the total depreciation from the total repair cost after taking the effect of the marginal tax rate into account; and

- Subtract the difference between total repair cost and total depreciation from the purchase price before bringing the discount factor into effect.

STEP VII Find the replacement age of the machine

The replacement cost, calculated in column (13), reflects the present value of the stream of cost and income over different life spans of the machine, starting from one year and ends at ten years. According to Table 10.1 the present value of the replacement cost in column (13) declines until year six. Beyond this year the replacement cost increases again. The optimal replacement age of this machine is therefore after six years where the replacement cost is the lowest.

A higher discount rate does not have a major influence on the replacement age of the machine but the inflation rate does. A higher inflation rate would have lengthened the replacement age. Lowered expectations about future repair cost at present prices would also have increased this replacement age. Also, timeliness cost wasn't taken into account in this model. It can have an influence in accelerating the time of replacement.

Tractors are usually the most expensive machinery a farmer owns. In this section the replacement of a specific tractor was calculated. The principles explained can also be used to analyze the replacement of any other machinery.

10.5. CONCLUSION

The replacement policy must be evaluated regularly as it will be influenced by changing factors such as interest rates, expected repair & maintenance costs, tax rates, prices and resale value. There are several strategies that a farmer can follow for replacing machinery namely replacing it frequently, replace something every year, replace when cash is available or lastly, keep it forever.

Machinery replacement decisions have a major influence on the net profit of a farming enterprise and the cost of owning and operating farm machinery is in most cases a major cost component. On the other hand, machinery also generate income and a decision to buy a new machine influence a farmer's cash flow over a couple of years. A wrong decision can have drastic effects on the future of the farm business.

The replacement cost reflects the present value of a stream of cost and income over different life spans of a machine. The optimal replacement age of a machine is therefore that year where the replacement cost is the lowest.

10.6. REFERENCES

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