

# Chapter 9

# Depreciation

# **Systematic Economic Analysis Technique**

- 1. Identify the investment alternatives**
- 2. Define the planning horizon**
- 3. Specify the discount rate**
- 4. Estimate the cash flows**
- 5. Compare the alternatives**
- 6. Perform supplementary analyses**
- 7. Select the preferred investment**

# Questions about Depreciation

- *What is depreciation?*

Depreciation is a bookkeeping method reflecting the reduction in the value of an asset based on age, use, or output.

- *Is depreciation a cash flow?*

Depreciation is not a cash flow.

- *Why do we consider depreciation?*

Depreciation is of interest to us because of its impact on income taxes (which are cash flows!)

*Engineers need to learn about depreciation because their design decisions can affect the way investments and annual operating costs are treated from an income tax perspective.*

# Depreciation Amount

“The amount of the annual depreciation depends upon several factors, including

- (1) cost basis or investment in the property,
- (2) date placed in service,
- (3) property class or estimated useful life,
- (4) salvage value for certain methods, and
- (5) method of depreciation used.”

**Department of Treasury  
Internal Revenue Service**

- Business expenditures are either *expensed* or *depreciated*. Expensing an expenditure is akin to depreciating it fully in the year in which it occurs.
- Expenditures for labor, materials, and energy are examples of items that are fully deducted from taxable income.
- Expenditures for production equipment, vehicles, and buildings, on the other hand, cannot be fully deducted from taxable income in the year in which they occur; instead, they must be spread out or distributed over some allowable recovery period.

# Depreciable Assets

## Depreciable property:

- (1) must be used in business or be held for the production of income,
- (2) must have a life longer than a year and be determinable,
- (3) must be something that wears out, decays, is consumed, becomes obsolete, or loses value from natural causes.

Depreciable property may be *tangible* or *intangible*; tangible property may be *real* or *personal*. Land is “never” depreciable.

# Depreciation Terminology

*Cost basis*: taxpayer's investment (purchase price plus improvements, additions, and/or installation) – also called *unadjusted basis*.

*Depreciation allowance*: the depreciation charge or deduction for a given year.

*Book value*: cost basis less capital recovered, such as depreciation allowances – also called *unrecovered investment*, *adjusted cost basis*, and *adjusted basis*



# Depreciation Terminology (cont'd)

*Recovery period*: time over which the cost basis can be recovered, keyed to 3, 5, 7, 10, 15, 20, 27.5, or 31.5 years, depending on type of property involved.

*Salvage value*: estimated market value at the end of the asset's useful life.

*Useful life*: estimate of duration of use of the asset by the taxpayer

# Straight-Line (SLN) Depreciation

Let

$P$  = cost basis

$F$  = salvage value

$n$  = recovery period

$d_t$  = depreciation allowance for year  $t$

$B_t$  = book value at the end of year  $t$

$d_t = (P - F)/n = \text{SLN}(P, F, n)$

$B_t = P - td_t$

## Example 9.2

A surface mount placement machine is being purchased for \$500,000; it has an estimated useful life of 10 years and a salvage value of \$50,000 at that time. Determine the depreciation allowance for the 5<sup>th</sup> year and the book value at the end of the 5<sup>th</sup> year using SLN.

$$P = \$500,000; F = \$50,000; n = 10; t = 5$$

$$d_5 = (\$500,000 - \$50,000)/10 = \$45,000$$
$$= \text{SLN}(500000, 50000, 10) = \$45,000$$

$$B_5 = \$500,000 - 5(\$45,000) = \$275,000$$

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Notice: no  
minus signs



# Declining Balance (DB) Depreciation

In addition to the previously defined notation, let

$p$  = declining balance percentage, rate, or fraction, e.g.  $1.5/n$ ,  $2/n^*$

**=-RATE(n,,-P,F)**

$$d_t = pP(1 - p)^{t-1} = (1 - p)d_{t-1}$$

$$B_t = P(1 - p)^t$$

**DB(cost,salvage,life,period,month)**

**DDB(cost,salvage,life,period,month)**

**VDB(cost,salvage,life,start\_period,end\_period,factor,no\_switch)**

**\*When  $p = 2/n$ , called double declining balance (DDB)**

## Example 9.3

A surface mount placement machine is being purchased for \$500,000; it has an estimated useful life of 10 years and a salvage value of \$50,000. Determine the depreciation and the book value at the end of 5 years.

$$d_t = pP(1 - p)^{t-1} = (1 - p)d_{t-1}$$

$$B_t = P(1 - p)^t$$

$$P = \$500,000; F = \$50,000; n = 10; t = 5$$

$$p = -\text{RATE}(10, , -500000, 50000) = 20.5672\%^{**} \text{ (equation 9.8)}$$

$$\begin{aligned} d_5 &= 0.205672(\$500,000)(1.0 - 0.205672)^{5-1} = \$40,939.70 \\ &= \text{DB}(500000, 50000, 10, 5) = \$40,937.30 \end{aligned}$$

$$B_5 = \$500,000(1.0 - 0.205672)^5 = \$163,840.00$$

## Depreciation allowances and book values for Examples 9.2 and 9.4

$t$	$SLN d_t$	$SLN B_t$	$DB d_t$	$DB B_t$	$DDB d_t$	$DDB B_t$	$VDB d_t$	$VDB B_t$
0		\$500,000.00		\$500,000.00		\$500,000.00		\$500,000.00
1	\$45,000.00	\$455,000.00	\$103,000.00	\$397,000.00	\$100,000.00	\$400,000.00	\$100,000.00	\$400,000.00
2	\$45,000.00	\$410,000.00	\$81,782.00	\$315,218.00	\$80,000.00	\$320,000.00	\$80,000.00	\$320,000.00
3	\$45,000.00	\$365,000.00	\$64,934.91	\$250,283.09	\$64,000.00	\$256,000.00	\$64,000.00	\$256,000.00
4	\$45,000.00	\$320,000.00	\$51,558.32	\$198,724.78	\$51,200.00	\$204,800.00	\$51,200.00	\$204,800.00
5	\$45,000.00	\$275,000.00	\$40,937.30	\$157,787.47	\$40,960.00	\$163,840.00	\$40,960.00	\$163,840.00
6	\$45,000.00	\$230,000.00	\$32,504.22	\$125,283.25	\$32,768.00	\$131,072.00	\$32,768.00	\$131,072.00
7	\$45,000.00	\$185,000.00	\$25,808.35	\$99,474.90	\$26,214.40	\$104,857.60	\$26,214.40	\$104,857.60
8	\$45,000.00	\$140,000.00	\$20,491.83	\$78,983.07	\$20,971.52	\$83,886.08	\$20,971.52	\$83,886.08
9	\$45,000.00	\$95,000.00	\$16,270.51	\$62,712.56	\$16,777.22	\$67,108.86	\$16,943.04	\$66,943.04
10	\$45,000.00	\$50,000.00	\$12,918.79	\$49,793.77	\$13,421.77	\$53,687.09	\$16,943.04	\$50,000.00

$$d_5 = DDB(500000, 50000, 10, 5) = \$40,960.00$$

$$d_5 = VDB(500000, 50000, 10, 4, 5, 2) = \$40,960.00$$

# Switching from DDB to SLN with VDB

Excel's VDB worksheet function includes an optional feature: it can switch from using a specified declining balance rate to a straight-line rate when optimum to do so. But, what criterion is used to define optimum?

Assuming a TVOM  $> 0\%$ , since depreciation charges can be deducted from taxable income, ATPW is maximized when the PW of depreciation charges is maximized. Hence, we prefer to depreciate an asset sooner, rather than later. Therefore, accelerated depreciation methods are preferred to SLN depreciation, but only up to a point, and VDB determines that point.



# Double Declining Balance Switching to Straight Line Depreciation

The optimum time to switch from DDB to SLN is when, for the first time, the depreciation allowance with SLN is greater than the depreciation allowance with DDB allowance, i.e., switch the first year for which

$$(B_{t-1} - F)/(n - t + 1) > pB_{t-1} \text{ where } p = 2/n \text{ for DDB}$$

## Example 9.4

For the surface mount placement machine, when should a switch from DDB to SLN occur?

Switch at the smallest value of  $t$  for which

$$(B_{t-1} - F)/(n - t + 1) > pB_{t-1}$$

$t$	$VDB B_t$	$SLN d_t$	$DDB d_t$	$SLN d_t >$ $DDB d_t?$	$VDB d_t$
0	\$500,000.00				
1	\$400,000.00	\$45,000.00	\$100,000.00	No	\$100,000.00
2	\$320,000.00	\$38,888.89	\$80,000.00	No	\$80,000.00
3	\$256,000.00	\$33,750.00	\$64,000.00	No	\$64,000.00
4	\$204,800.00	\$29,428.57	\$51,200.00	No	\$51,200.00
5	\$163,840.00	\$25,800.00	\$40,960.00	No	\$40,960.00
6	\$131,072.00	\$22,768.00	\$32,768.00	No	\$32,768.00
7	\$104,857.60	\$20,268.00	\$26,214.40	No	\$26,214.40
8	\$83,886.08	\$18,285.87	\$20,971.52	No	\$20,971.52
9	\$66,943.04	\$16,943.04	\$16,777.22	Yes	\$16,943.04
10	\$50,000.00				\$16,943.04

$$(B_{t-1} - F)/(n - t + 1) > pB_{t-1}$$

<i>t</i>	<i>VDB B<sub>t</sub></i>	<i>SLN d<sub>t</sub></i>	<i>DDB d<sub>t</sub></i>	<i>SLN d<sub>t</sub></i> > <i>DDB d<sub>t</sub></i> ?	<i>VDB d<sub>t</sub></i>
0	\$500,000.00				
1	\$400,000.00	\$45,000.00	\$100,000.00	No	\$100,000.00
2	\$320,000.00	\$38,888.89	\$80,000.00	No	\$80,000.00
3	\$256,000.00	\$33,750.00	\$64,000.00	No	\$64,000.00
4	\$204,800.00	\$29,428.57	\$51,200.00	No	\$51,200.00
5	\$163,840.00	\$25,800.00	\$40,960.00	No	\$40,960.00
6	\$131,072.00	\$22,768.00	\$32,768.00	No	\$32,768.00
7	\$104,857.60	<b>\$29,428.57 = (\$256,000 - \$50,000)/(10 - 3)</b>			0
8	\$83,886.08	\$18,285.87	\$20,971.52	No	\$20,971.52
9	\$66,943.04	\$16,943.04	\$16,777.22	Yes	\$16,943.04
10	\$50,000.00				\$16,943.04

**Since \$29,428.57 < \$51,200, don't switch!**

$$(B_{t-1} - F)/(n - t + 1) > pB_{t-1}$$

<i>t</i>	<i>VDB B<sub>t</sub></i>	<i>SLN d<sub>t</sub></i>	<i>DDB d<sub>t</sub></i>	<i>SLN d<sub>t</sub> &gt; DDB d<sub>t</sub>?</i>	<i>VDB d<sub>t</sub></i>
0	\$500,000.00				
1	\$400,000.00	\$45,000.00	\$100,000.00	No	\$100,000.00
2	\$320,000.00	\$38,888.89	\$80,000.00	No	\$80,000.00
3	\$256,000.00	\$33,750.00	\$64,000.00	No	\$64,000.00
4	\$204,800.00	\$29,428.57	\$51,200.00	No	\$51,200.00
5	\$163,840.00	\$25,800.00	\$40,960.00	No	\$40,960.00
6	\$131,072.00	\$22,768.00	\$32,768.00	No	\$32,768.00
7	\$104,857.60	\$20,268.00	\$26,214.40	No	\$26,214.40
8	\$83,886.08	\$18,285.87	\$20,971.52	No	\$20,971.52
9	\$66,943.04	\$16,943.04	\$16,777.22	Yes	\$16,943.04
10	\$50,000.00				\$16,943.04

$$\$16,943.04 = (\$83,886.08 - \$50,000)/(10 - 8)$$

**Since \$16,943.04 > \$16,777.22, switch!**

# Sum of Years' Digits (SYD) Depreciation

## Let

$P$  = cost basis

$F$  = salvage value

$n$  = recovery period

$d_t$  = depreciation allowance for year  $t$

$B_t$  = book value at the end of year  $t$

$$d_t = 2(n - t + 1)(P - F) / [n(n + 1)]$$

=SYD(cost,salvage,life,per)

$$B_t = F + (P - F)(n - t)(n - t + 1) / [n(n + 1)]$$

## Example 9.A.1

Calculate the SYD depreciation allowances and book values for the \$500,000 surface mount placement machine, including a useful life of 10 years and a salvage value of \$50,000.

$t$	SYD	
	$d_t$	$B_t$
0		\$500,000.00
1	\$81,818.18	\$418,181.82
2	\$73,636.36	\$344,545.45
3	\$65,454.55	\$279,090.91
4	\$57,272.73	\$221,818.18
5	\$49,090.91	\$172,727.27
6	\$40,909.09	\$131,818.18
7	\$32,727.27	\$99,090.91
8	\$24,545.45	\$74,545.45
9	\$16,363.64	\$58,181.82
10	\$8,181.82	\$50,000.00

# Pit Stop #9—Avoid the Pot Holes

1. True or False: Straight-line depreciation is the most popular depreciation method used in financial reporting.
2. True or False: The Modified Accelerated Cost Recovery System is the most popular depreciation method used in computing corporate income tax liabilities.
3. True or False: Based on maximizing the present worth of depreciation allowances, MACRS is preferred to SLN for recovery periods greater than 5 years.
4. True or False: Accelerated depreciation plans were adopted after World War II to stimulate capital investment.
5. True or False: Engineers seldom have an opportunity to influence the recovery period for expenditures.
6. True or False: MACRS is equivalent to DDB, switching to SLN, with a mid-year convention.
7. True or False: The most popular variation of MACRS is MACRS-ADS.
8. True or False: Sum-of-Years'-Digits depreciation is a popular depreciation method and is most often used to compute income tax liabilities.
9. True or False: When given a choice of depreciation methods to use, choose the one that maximizes the present worth of book value.
10. True or False: Sinking fund depreciation is the only depreciation method described in the book that is based on the time value of money.



# Pit Stop #9—Avoid the Pot Holes

1. True or False: Straight-line depreciation is the most popular depreciation method used in financial reporting. **True**
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