Profitability and Economic Evaluation of Projects

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ECH 380 – Process Simulation Modeling

Lesson Objectives

By the end of this activity, students should be able to:

- Define gross profit, depreciation, taxable income, and net cash flow in relation to the total capital investment, sales, and cost of operations for a project.
- Calculate the gross profit, depreciation, taxable income, taxes paid, and cash flow of a project.
- Utilize the Breakeven Point, Simple Pay-Back Time, and Return on Investment Methods of project analysis to describe the profitability of a project.
- Generate a Net Present Value (NPV) Cash Flow Table for a particular project and determine the efficacy of a project based upon the NPV.

General Cash Flow Calculations

When depreciation is added to the net profit, the equation for the cash flow becomes:

$$A_j = (s_j - c_{oj})(1 - \phi) + d_j \phi$$

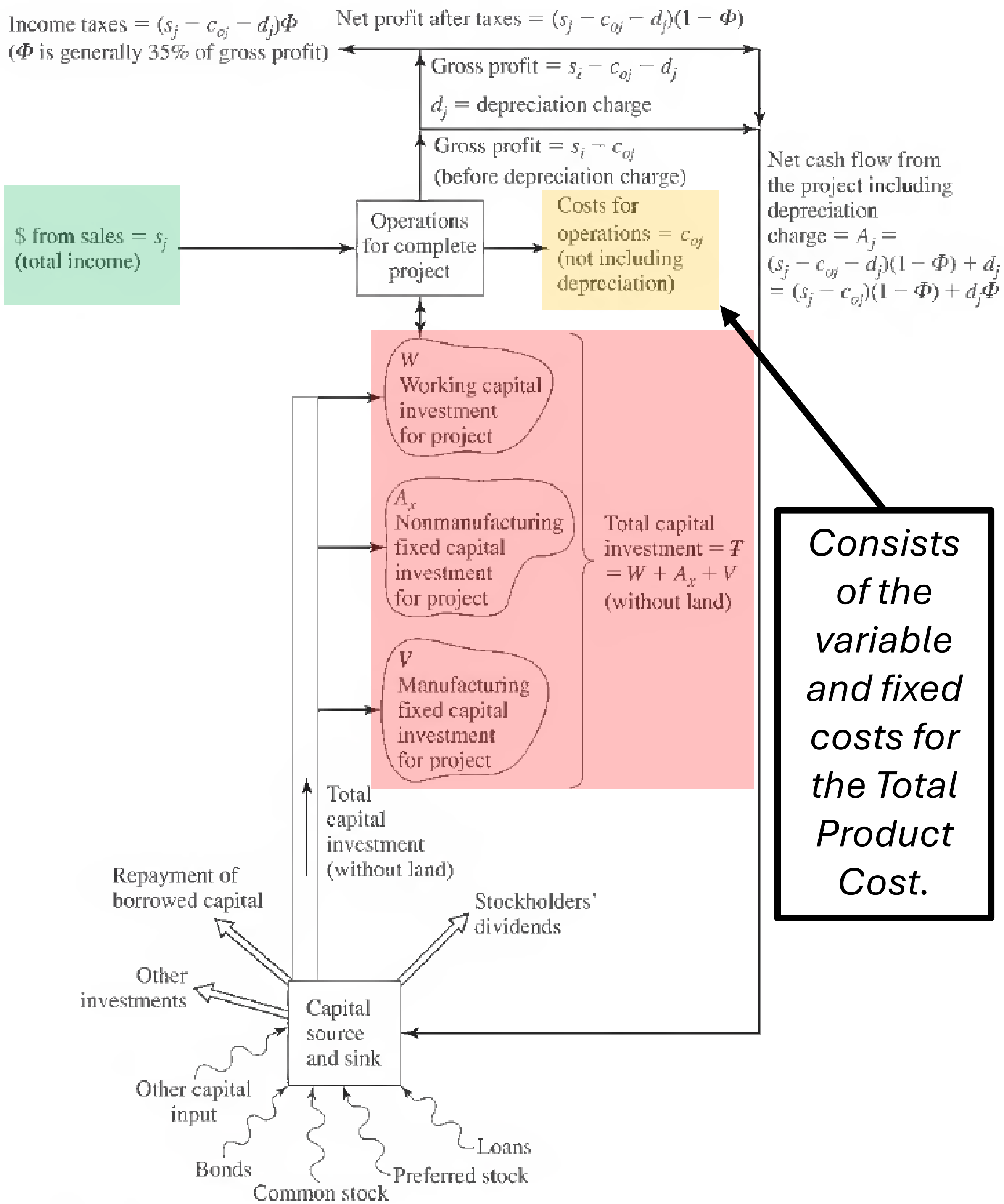
A_j = cash flow from the project to the corporate capital reservoir resulting from the operation in year j in dollars

s_j = the sales rate in year j in dollars

c_{oj} = the cost of operation (depreciation not included) in year j in dollars

d_j = the depreciation charge in year j in dollars

ϕ = the fractional income tax rate



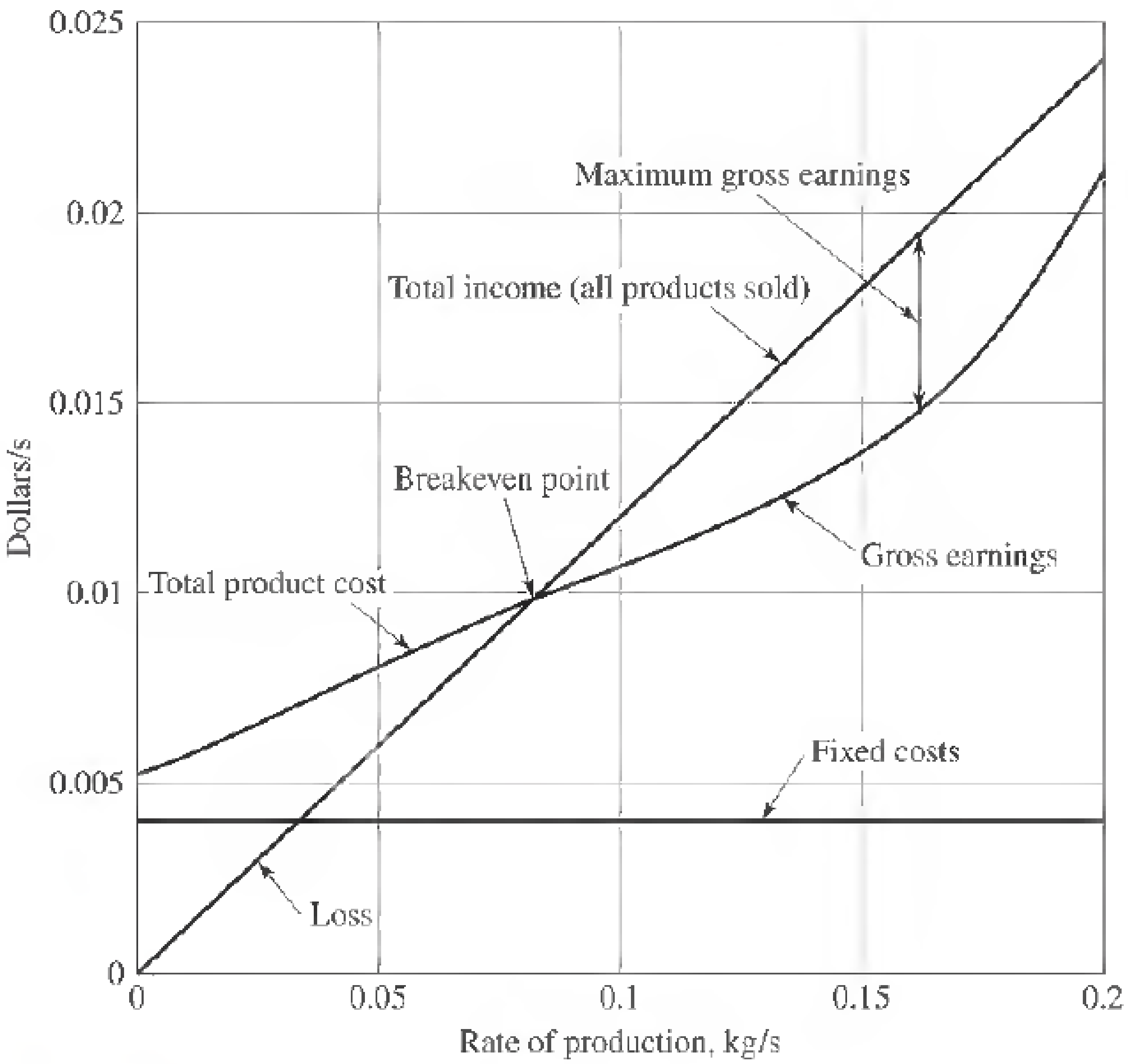
Breakeven Point

Point at which the gross profit is zero. The company just breaks even, and annual sales of products equals the annual costs of production.

Production of Units Method

n = number of units produced per year
S = sales price, \$/unit of product
V = variable cost, \$/unit of product
F = annual fixed cost, \$/year

$$n_{BE} = \frac{F}{S-V}$$



Peters, Figure 6-3; Chapter 6.

Example Problem: Breakeven Point – Production of Units Method

The annual variable production costs for a plant operating at 70 percent capacity are $280,000. The sum of the annual fixed charges, overhead costs, and general expenses is $200,000, and may be considered not to change with production rate. The total annual sales are $560,000, and the product sells for $4/kg.

What is the breakeven point in kilograms of product per year?

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$$n_{BE} = \frac{F}{S-V}$$

Units Produced in One Year:

$$n = \frac{Total\ Annual\ Sales}{Sales\ Price} = \frac{\$560{,}000}{\frac{\$4}{kg}} = 140{,}000\ kg$$

Variable Cost:

$$V = \frac{Total\ Variable\ Costs}{n} = \frac{\$280{,}000}{140{,}000\ kg} = \frac{\$2}{kg}$$

Example Problem:
Breakeven Point – Production of Units Method

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What is the breakeven point in kilograms of product per year?

n = number of units produced per year $140{,}000\ kg$

S = sales price, \$/unit of product

V = variable cost, \$/unit of product $\frac{\$2}{kg}$

F = annual fixed cost, \$/year

$$n_{BE} = \frac{F}{S-V}$$

Breakeven Point:

$$n_{BE} = \frac{\$200{,}000}{\left(\frac{\$4}{kg}\right)-\left(\frac{\$2}{kg}\right)} = 100{,}000\ kg$$

Need to produce 100,000 kg of product to have enough sales to pay off costs and break even.

Gross Profit and Average Cost

Can utilize the same information to determine the gross profit and average cost per unit of product:

$$Z = annual\ gross\ profit\ \left(\frac{\$}{year}\right) = nS - (nV + F) \rightarrow n(S - V) - F$$

$$Average\ Cost\ Per\ Unit\ of\ Product\ \left(\frac{\$}{unit}\right) = \frac{nV + F}{n} \rightarrow V + \frac{F}{n}$$

<u>Important Assumptions:</u>

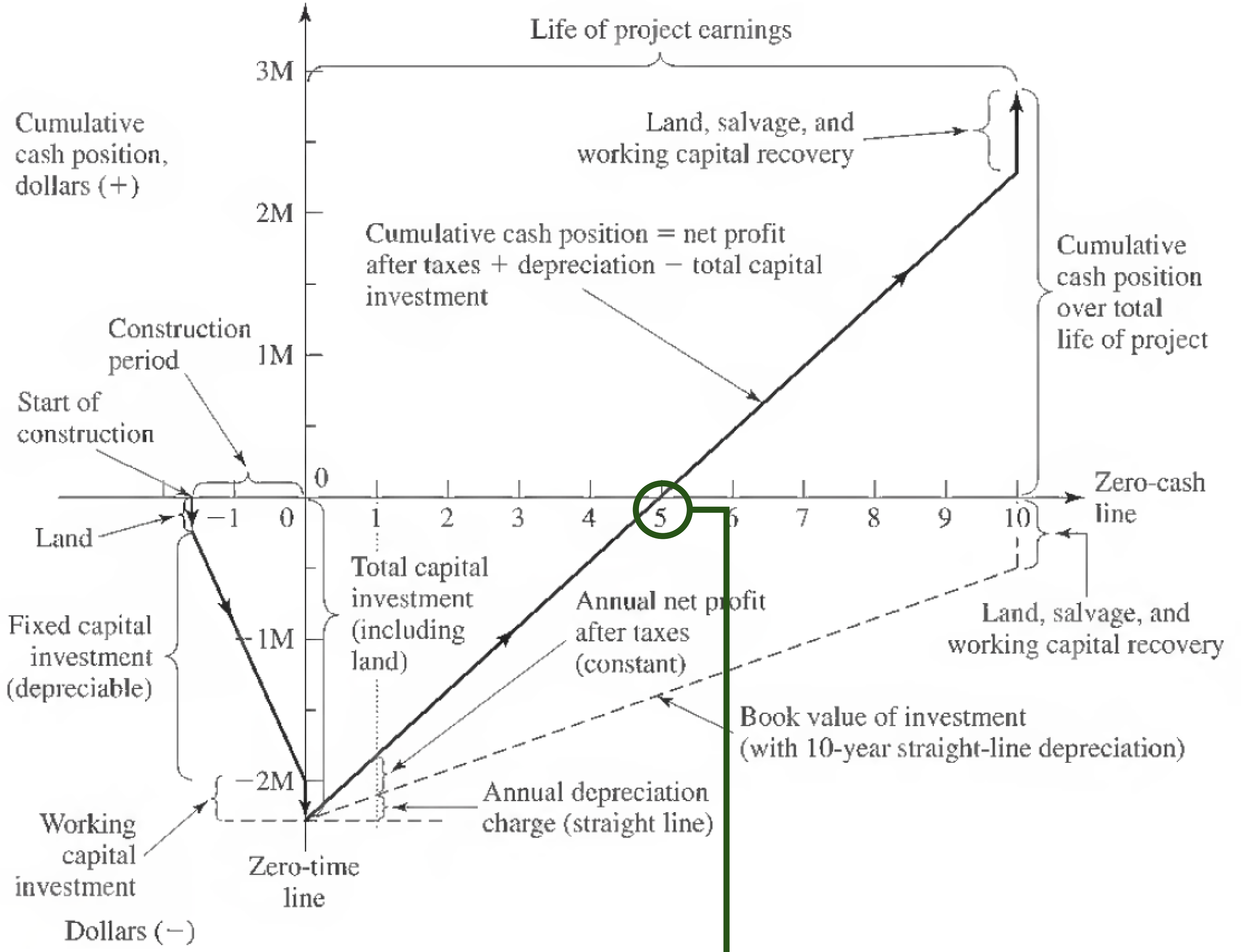
1. Variable costs are proportional to the production rate over 0-100% of plant capacity.
2. Fixed charges are constant and independent of annual production.
3. There are no financial or other costs.
4. The only income is from sales of products.

Breakeven Point

Point at which the cumulative cash flow exceeds the capital investment and total product costs of the project.

The time to reach this break-even point is called the **pay-back time**.

In this project, it takes five years to reach the breakeven point and pay back the capital investment.



Peters, Figure 6-2; Chapter 6.

Example Problem: Breakeven Point – Pay-Back Time

The annual variable production costs for a plant operating at 70 percent capacity are $280,000. The sum of the annual fixed charges, overhead costs, and general expenses is $200,000, and may be considered not to change with production rate. The total annual sales are $560,000, and the product sells for $4/kg.

What is the Pay-back Time for this project if the Capital Investment was $500,000?

$$Z\ (Annual\ Gross\ Profit) = \left(140{,}000\,\frac{kg}{year}\right)\left(\left(\frac{\$4}{kg}\right) - \left(\frac{\$2}{kg}\right)\right) - 200{,}000 = \frac{\$80{,}000}{year}$$

$$\frac{Capital\ Investment}{Annual\ Gross\ Profit} = Pay - Back\ Time = \frac{\$500{,}000}{\frac{\$80{,}000}{year}} = 6.25\ years$$

General Cash Flow Calculations

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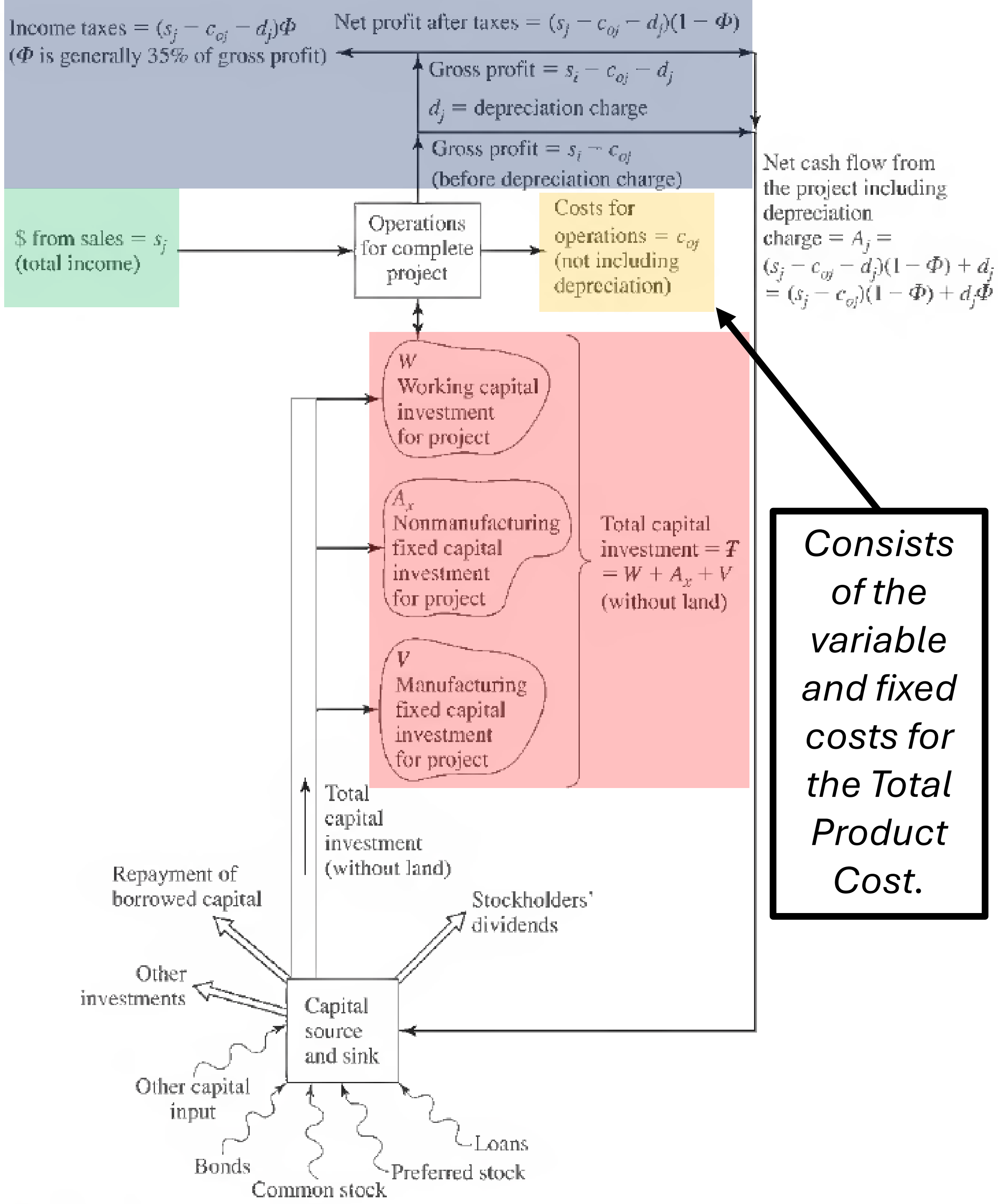

Consists of the variable and fixed costs for the Total Product Cost.

Importance of Understanding Taxes for Projects

Individuals and corporations must pay income tax in most countries, and changes to tax laws occur every year. Most companies have a retained tax specialist or consultant to assist with this, so the design engineer doesn't need to know this level of depth.

Why are taxes important for the design engineer?

Taxes can have a significant impact on the cash flows from a project. Basic understanding of taxation and tax allowances assist in the economic evaluation of a project.

Especially important if you are considering projects in different countries, such as starting new plants.

Three Categories of Income Taxes:

Federal Income Tax

Every corporation must pay federal income taxes in the USA.

Current federal income tax rate for corporations is 21%.

State Income Tax

Approximately 44 states levy state taxes on corporations.

Some states levy graduated tax rates [charge changes based on income level] while others have a flat rate.

New York State corporate income tax ranges between 6.5-7.25%.

Local Income Tax

Counties within each state may also require payment of a local income tax.

This value can vary depending upon the city/town within the county.

$$Taxable\ Income = Gross\ Profit\ - Tax\ Allowances$$

This is where Depreciation comes in

Depreciation Charges

Depreciation charges are the most common type of tax allowance used by the government as an incentive for investment. Depreciation rates are therefore set by governmental tax law.

Depreciation = non-cash charge reported as an expense, which reduces income for taxation purposes. It is an allowance for the “wear and tear, deterioration or obsolescence of the property”.

No cash is transferred to any fund or account, so depreciation is added back into the net income after taxes to give the total cash flow from operations.

Typically, only fixed capital investments [plant, equipment, buildings, software, intellectual property] are depreciated and not total capital, since working capital can be recovered. The cost of land must be removed from the fixed capital investment as land is assumed to retain its value and cannot be depreciated.

Straight-Line Depreciation

Simplest method (or schedule) of depreciation. The depreciable value (C_d) is depreciated over n years with an annual depreciation charge D_i in year i, where:

$$D_i = \frac{C_d}{n}$$

The depreciable value of the asset is the initial cost of the fixed capital investment (C), minus the salvage value (if any) at the end of the depreciable life.

$$C_d = C - Salvage\ Value$$

Many chemical plants report a salvage value of $0.00 as the plant usually continues to operate for many years beyond the end of the depreciable life. However, if an asset still has value and is sold, a salvage value can be reported.

The period over which the use of an asset is economically feasible is the *service life* of the property. The period over which the depreciation of the asset is charged is the *recovery period*, which is established by the governmental tax codes.

Example Problem: Depreciation, Taxable Income, and Cash Flows

A chemical plant with a fixed capital investment of $100 million generates an annual gross profit of $50 million. Calculate the depreciation charge, taxes paid, and after-tax cash flows for the first 10 years of plant operation using straight-line depreciation over 10 years. Assume the plant is built at time zero and begins operation at full rate in year 1. Assume the rate of corporate income tax is 21% and taxes must be paid based on the previous year's income.

<u>Straight Line Depreciation</u>

Year	Gross profit (MM$)	Depreciation charge (MM$)	Taxable income (MM$)	Taxes paid (MM$)	Cash Flow (MM$)
0	0	0	0	0	–100
1	50	10	40	0	50
2	50	10	40	8.4	41.6
3	50	10	40	8.4	41.6
4	50	10	40	8.4	41.6
5	50	10	40	8.4	41.6
6	50	10	40	8.4	41.6
7	50	10	40	8.4	41.6
8	50	10	40	8.4	41.6
9	50	10	40	8.4	41.6
10	50	10	40	8.4	41.6

Year	Depreciation Charge	Book Value
0	0	100
1	10	90
2	10	80
3	10	70
4	10	60
5	10	50
6	10	40
7	10	30
8	10	20
9	10	10
10	10	0

Example Problem

Straight-Line Depreciation:

$$D_i = \frac{C_d}{n} = \frac{\$100{,}000{,}000 - \$0}{10\ years} = \frac{\$10{,}000{,}000}{year} = \frac{10\ MM\$}{year}$$

$$Taxable\ Income = Gross\ Profit\ - Tax\ Allowances = 50\ MM\$\ - 10\ MM\$ = 40\ MM\$$$

$$Taxes\ Paid = Taxable\ Income\ * Income\ Tax\ Rate = 40\ MM\$\ * 0.21 = 8.4\ MM\$$$

$$Cash\ Flow = P(1 - t_r) + Dt_r = 50\ MM\$\ (1 - 0.21) + (10\ MM\$\ * 0.21) = 41.6\ MM\$$$

$$Book\ Value = Initial\ Cost\ - Accumulated\ Depreciation$$

$$Book\ Value = C - \frac{mC_d}{n}$$

Schedule Tables from Towler Chapter 9, Example 9.1

Return on Investment (ROI)

Another measure of economic performance is the Return on Investment or the ROI:

$$ROI = \frac{net\ annual\ profit}{initial\ investment} * 100$$

If the ROI is calculated as an average over the whole project, then a cumulative net profit is applied:

$$ROI = \frac{cumulative\ net\ profit}{plant\ life * initial\ investment} * 100$$

Calculation of the after-tax ROI [from net profit or net income] can be difficult if the depreciation term is less than the plant life and if an accelerated method of depreciation is used.

Due to this, a "pre-tax" ROI is often utilized instead:

$$pretax\ ROI = \frac{pretax\ cash\ flow}{total\ investment} * 100$$

Example Problem:
ROI and Pre-Tax ROI

Suppose we have the same chemical plant from the previous example on Depreciation, Taxable Income, and Cash Flows. What is the Return on Investment (ROI) and Pre-Tax ROI?

Year	Gross profit (MM$)	Depreciation charge (MM$)	Taxable income (MM$)	Taxes paid (MM$)	Cash Flow (MM$)
0	0	0	0	0	–100
1	50	10	40	0	50
2	50	10	40	8.4	41.6
3	50	10	40	8.4	41.6
4	50	10	40	8.4	41.6
5	50	10	40	8.4	41.6
6	50	10	40	8.4	41.6
7	50	10	40	8.4	41.6
8	50	10	40	8.4	41.6
9	50	10	40	8.4	41.6
10	50	10	40	8.4	41.6

$$Cumulative\ Net\ Profit\ = \\ Sum\ of\ Net\ Cash\ Flows\ for\ Project\ Life = \\ 424.4\ \$MM$$

Return on Investment =

$$\frac{cumulative\ net\ profit}{plant\ life * initial\ investment} * 100 = \frac{424.4\ \$MM}{10 * 100\ \$MM} * 100 = 42.44\%$$

Pre-tax ROI =

$$\frac{pretax\ cash\ flow}{total\ investment} * 100 = \frac{50\ \$MM}{100\ \$MM} * 100 = 50\%$$

Present Value Methods and the Time Value of Money

The simple methods in the prior slides are not able to capture the time dependence of cash flows during the project.

The timing of cash flows is important for two reasons:

1. Not all the capital has to be financed immediately
2. Capital that is repaid sooner can be put back to work in another investment

The present value methods account for the time value of money and are preferred over the simple methods when evaluating large investments.

Future Worth and Inflation

The future worth of an amount of money (P) invested at interest rate (i) for (n) years is:

$$Future\ worth\ in\ year\ n = P(1+i)^n$$

Which means the present value of a future sum is:

$$present\ value\ of\ future\ sum = \frac{future\ worth\ in\ year\ n}{(1+i)^n}$$

The interest rate used in discounting future values is known as the <u>discount rate</u>. It is chosen to reflect the earning power of money.

In most companies, the discount rate is set at the cost of capital (weighted average of cost of debt and cost of equity).

Discounting future cash flows is <u>*not*</u> the same as allowing for price inflation.

Inflation = increase in prices and costs, usually caused by imbalances in supply and demand. It raises the costs of feed, products, utilities, labor, and parts, but does *not* affect depreciation, which is based on the original cost.

Discounting = comparing the value of money that is available now [to be reinvested] with money that will become available in the future.

Most projects do not factor inflation as companies assume that while prices suffer from inflation, margins and cash flows are relatively insensitive to inflation.

Net Present Value

The net present value (NPV) of a project is the sum of the present values of the future cash flows:

More useful than simple pay-back or ROI because it allows for time value of money and for annual variation in expenses and revenues.

$$NPV = \sum_{n=1}^{n=t} \frac{CF_n}{(1+i)^n}$$

The NPV method is more appropriate when considering after-tax income with accelerated depreciation schedules.

Where:

$(1+i)^{-n} = discount\ factor$

$CF_n = cash\ flow\ in\ year\ n \qquad t = project\ life\ in\ years$

$i = interest\ rate\ \left(= cost\ of\ capital, \frac{percent}{100}\right)$

The NPV is always less than the total future worth of the project because of the discounting of the future cash flows.

NPV is a strong function of the interest rate used and the periods studied.

Discounted Cash Flow Rate of Return (DCFROR)

Also referred to as the Internal Rate of Return (IRR) or Interest Rate of Return [since it can be compared to interest rates]. By calculating the NPV at different interest rates, it is possible to find an interest rate at which the cumulative NPV at the end of the project is zero. This interest rate is called the discounted cash flow rate of return (DCFROR). It is a measure of the maximum interest rate that a project could pay and still break even by the end of the project life.

Found with trial and error functions

$$\sum_{n=1}^{n=t} \frac{CF_n}{(1+i')^n} = 0$$

More profitable project = able to pay a higher DCFROR = "best bang for your buck"

[Want DFROR > i_c]

Where:

$CF_n = cash\ flow\ in\ year\ n$ $\qquad t = project\ life\ in\ years$

$i' = discounted\ cash\ flow\ rate\ of\ return\ \left(\frac{percent}{100}\right)$

DCFROR is more useful than NPV when comparing projects of different sizes. DCFROR provides a way of comparing performance of capital for different projects, independent of the amount of capital used, the life of the plant, or the actual interest rates prevailing at any time.

Example Problem: Discount Factor and Net Present Value

Suppose we have the same chemical plant from the previous example on Depreciation, Taxable Income, and Cash Flows. Estimate the Net Present Value (NPV) at a 12% interest rate and DCFROR for the project.

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0	0	0	0	0	-100
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2	50	10	40	8.4	41.6
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6	50	10	40	8.4	41.6
7	50	10	40	8.4	41.6
8	50	10	40	8.4	41.6
9	50	10	40	8.4	41.6
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$$NPV = \sum_{n=1}^{n=t} \frac{CF_n}{(1+i)^n}$$

$$CF_n = cash\ flow\ in\ year\ n$$
$$i = interest\ rate$$
$n = year$ and $t = project\ life$

Discount Factor = $(1+i)^{-n}$

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Discount Factor and Net Present Value

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Year	Discount Factor Formula	Discount Factor
0	$(1+0.12)^{-0}$	1
1	$(1+0.12)^{-1}$	0.893
2	$(1+0.12)^{-2}$	0.797
3	$(1+0.12)^{-3}$	0.712
4	$(1+0.12)^{-4}$	0.636
5	$(1+0.12)^{-5}$	0.567
6	$(1+0.12)^{-6}$	0.507
7	$(1+0.12)^{-7}$	0.452
8	$(1+0.12)^{-8}$	0.404
9	$(1+0.12)^{-9}$	0.361
10	$(1+0.12)^{-10}$	0.322

$$NPV = \sum_{n=1}^{n=t} \frac{CF_n}{(1+i)^n}$$

$CF_n = cash\ flow\ in\ year\ n$
$i = interest\ rate$
$n = year$ and $t = project\ life$

$$Discount\ Factor = (1+i)^{-n}$$

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0	0	0	0	0	-100	1
1	50	10	40	0	50	0.893
2	50	10	40	8.4	41.6	0.797
3	50	10	40	8.4	41.6	0.712
4	50	10	40	8.4	41.6	0.636
5	50	10	40	8.4	41.6	0.567
6	50	10	40	8.4	41.6	0.507
7	50	10	40	8.4	41.6	0.452
8	50	10	40	8.4	41.6	0.404
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10	50	10	40	8.4	41.6	0.322

$$NPV = \sum_{n=1}^{n=t} \frac{CF_n}{(1+i)^n}$$

Which in this case:

$$CF_n * (1+i)^{-n}$$

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Discount Factor and Net Present Value

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Year	Gross Profit (MM$)	Depreciation Charge (MM$)	Taxable Income (MM$)	Taxes Paid (MM$)	Cash Flow (MM$)	Discount Factor	Present Value ($MM)
0	0	0	0	0	-100	1	-100
1	50	10	40	0	50	0.893	44.6
2	50	10	40	8.4	41.6	0.797	33.2
3	50	10	40	8.4	41.6	0.712	29.6
4	50	10	40	8.4	41.6	0.636	26.4
5	50	10	40	8.4	41.6	0.567	23.6
6	50	10	40	8.4	41.6	0.507	21.1
7	50	10	40	8.4	41.6	0.452	18.8
8	50	10	40	8.4	41.6	0.404	16.8
9	50	10	40	8.4	41.6	0.361	15.0
10	50	10	40	8.4	41.6	0.322	13.4

Using the Net Present Worth, we see the value of the cash flow in today's dollars is much lower (143 $MM).

In Previous Example (for ROI Calculation) the Total Net Profit (sum of all cashflows) was 424.4 $MM after taxes in which the value of the cash flow was for the time period of each year in which the cash was collected.

In comparing projects, those with higher NPV will be more attractive to investors, since they can potentially get their invested money back sooner to then reinvest into something else.

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10	50	10	40	8.4	41.6	0.322	13.4

$$NPV = \sum_{n=1}^{n=t} \frac{CF_n}{(1+i)^n} = 0$$

Need to determine this rate in which the NPV adds up to zero.

Typically, use solving tools like Goal Seek on Excel to determine the DCFROR because each time you change the i value, you change the resulting NPV.

With Goal Seek in Excel, we see that the DCFROR is 43%. If your cost of capital is less than 43%, then your project is likely to make a future profit.

Questions?