

CH402 Chemical Engineering Process Design

Class Notes L19

Profitability

CH402 WPR 2

7 March 2025 during class

11 multiple choice questions, 55 minutes, open FE reference manual only.

FEE Manual pp. 230-237 and 257-258 in v10.4 (posted)

DP3, DP4, PS7, PS8, PS9, Quizzes 1-5

Reading Assignments from Peters, Timmerhaus, and West

Discount factors and cash flow patterns: Meaning of P, F, A, and G

(F/P) and (P/F) (A/P) and (P/A) (A/F) and (F/A) (P/G), (F/G) and (A/G)

Continuous, compound, and simple interest

Capitalized cost

Profitability: PBP, ROI, NPW, and DCFR

Flow diagrams (I/O, functions, process, and P&ID)

Safety (FEE page 14 Hazard Assessments / Fire Diamond)

Methods that do not consider time value of money

- Return on investment (ROI)
 - Payback period (PBP)
-

Methods that do consider time value of money

- Net present worth (NPW)
- Discounted cash flow rate of return (DCFR)

Profitability Standards in Common Use

Four primary methods

Evaluation Method	Percentage Use	
	Small Companies	Large Companies
Payback Period	43	52
Return on Investment	22	34
Net Present Worth	16	80
Discounted Cash Flow Rate of Return	11	78

Costs of externally financed capital

Source of capital	Indicated interest or dividend rate, %/yr	Interest or dividend rate before taxes, %/yr	Interest or dividend rate after taxes, %/yr
Bonds	5 [†]	5 [†]	3.25
Bank or other loans	8	8	5.2
Preferred Stock	8 [‡]	12.3	8 [‡]
Common stock	n/a ^{††}	13.8	9

[†]Interest paid to bond holders is paid before taxes.

[‡]Dividends on preferred stock must be paid from net profits after taxes.

^{††} Common stock dividends might vary or be zero.

Risk Management

Table 8-1, page 322

Investment description	Level of risk	Minimum acceptable return m_{ar} (after income taxes), %/yr
Basis: Safe corporate investment opportunities or cost of capital	Safe	4-8
New capacity with established corporate market position	Low	8-16
New product entering into established market, or new process technology	Medium	16-24
New product or process in a new application	High	24-32
Everything new; high R&D and marketing effort	Very high	32-48+

Minimum Acceptable Rate of Return, m_{ar} or MARR

This is a judgment call. No hard fast rule or formula.

Some Definitions

Gross Earnings or Gross Profit:

$$G_j = s_j - c_j - d_j$$

s_j = \$ from sales in year j

c_j = \$ spent on operations in year j

d_j = depreciation charge in year j

Net Profit or Net Profit After Taxes:

$$N_{p,j} = (s_j - c_j - d_j) \cdot (1 - \phi)$$

ϕ = income tax rate ≈ 0.35

Annual Cash Flow from Process:

$$A_j = (s_j - c_j - d_j) \cdot (1 - \phi) + d_j$$

$$= (s_j - c_j) \cdot (1 - \phi) + d_j \cdot \phi$$

$$= N_{p,j} + d_j$$



Needed for Problem 8-2

Return on Investment (ROI)

8-1a, p. 323

$$ROI_j = \frac{N_{P,j}}{T}$$

Changes from year to year

8-1c

$$ROI = \frac{N_{P,\text{ave}}}{T}$$

Constant from year to year

N_p is net annual profit and T is total capital investment (TCI)

Basis: Completely consistent with m_{ar} – use direct comparison with Table 8-1

Can also use gross profit or fixed capital investment, but not as common

8-1b

$$ROI = \frac{(1/N) \sum_{j=1}^N N_{p,j}}{\sum_{j=-b}^N T_j}$$

Payback Period (PBP)

Time required for cash flow to equal original FCI.

$$PBP = \frac{V + A_x}{A_j} = \frac{FCI}{A_j} \quad 8-2a, \text{ p. 324}$$

$$PBP = \frac{V + A_x}{(A_j)_{ave}} = \frac{FCI}{(A_j)_{ave}} \quad 8-2b$$

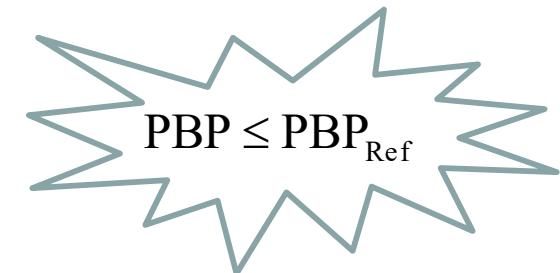
V is manufacturing fixed capital investment

A_x is nonmanufacturing fixed capital investment

A_j is annual cash flow

Basis: $PBP_{Ref} = \frac{0.85}{m_{ar} + 0.85 / N_{P,j}}$ 8-2c

m_{ar} is from Tables 7.1 and 8.1



Net Present Worth (NPW)

8-4, p. 327

$$NPW = \sum_{j=-b}^N PWF_j \left[(s_j - c_j - d_j)(1 - \Phi) + rec_j + d_j - T_j \right]$$

Basis: discount rate is m_{ar}

Continuous model:

$$r_{ma} = \ln(1 + m_{ar})$$

Discounted Cash Flow Rate of Return (DCFR)

8-5, p. 328

$$0 = \sum_{j=-b}^N PWF_j \left[(s_j - c_j - d_j)(1 - \Phi) + rec_j + d_j - T_j \right]$$

rec_j is the recovery of working capital or sales of assets

Basis: $NPW=0$

Solve for discount rate (interest rate)

Problem 8-1

What total amount of funds before taxes will be available 10 years from now if \$10,000 is placed in a savings account earning an interest rate of 6 percent compounded monthly? How many years will be required for this amount to double at the same interest rate compounded semiannually? What is the shortest time in years for the doubling to occur if continuous compounding is available?

Problem 8-2

A proposed chemical plant will require a fixed-capital investment of \$10 million. It is estimated that the working capital will be 25 percent of the total investment. Annual depreciation costs are estimated to be 10 percent of the fixed-capital investment. If the annual profit will be \$3 million, determine the percent return on the total investment and the payout (payback) period.

Problem 8-4

Two pumps are being considered for pumping water from a reservoir.

Installed cost and salvage value for the two pumps are given below:

	Pump A	Pump B
Installed cost	\$20,000	\$25,000
Salvage value	\$2,000	\$4,000

Pump A has a service life of 4 years. Determine the service life of pump B at which the two pumps are competitive if the annual effective interest rate is 15%. Competitiveness in this context means the capitalized cost must be the same for the two pumps.

Problem 8-6

A design engineer is evaluating two pumps for handling a corrosive solution. The information on the pumps is the following:

	Pump A	Pump B
Installed cost	\$15,000	\$22,000
Service life, years	2	5

Determine the annual interest rate at which the two pumps are considered competitive. Neglect salvage value. See Problem 8-4 for the definition of competitiveness. Which pump would you recommend?

Questions?