In the name of Allah

Amirkabir University of Technology
(Tehran Polytechnic)
Industrial Engineering Department

Course Title:
Engineering Economics

14. After-tax Economic Analysis

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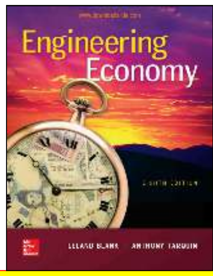
Learning Stage 4: Rounding Out the Study

- Chapter 14
  - Effects of Inflation
- Chapter 15 *not covered in this course
  - Cost Estimation and Indirect Cost Allocation
- Chapter 16
  - Depreciation Methods
- Chapter 17
  - After-Tax Economic Analysis
- Chapter 18
  - Sensitivity Analysis and Staged Decisions
- Chapter 19
  - More on Variation and Decision Making under Risk



Chapter 17 of EE (BT) book 8th edition

LEARNING OUTCOMES

- Purpose:
  - Perform an after-tax economic evaluation considering the impact of pertinent tax regulations, income taxes, and depreciation.

1. Terminology and rates; marginal tax tables
2. Determining cash flows before taxes(CFBT) and after taxes (CFAT)
3. Effects of depreciation on taxes
4. Depreciation recapture and capital gains
5. Performing an after-tax analysis
6. Performing after-tax replacement studies
7. Economic value-added analysis

Income Tax Terms and Relations (Corporations)

- Income taxes:
  - real cash flow payments to governments from income/profits.
  - The (noncash) allowance of asset depreciation is used in income tax computations.

- There are two fundamental relations: NOI and TI
  - Net operating income = gross revenue − operating expense

    $$\mathbf{NOI = GI - OE}$$ (only actual cash involved)

    - NOI is also called EBIT (earnings before interest and taxes)

  - Taxable income = gross revenue − operating expenses − depreciation

    $$\mathbf{TI = GI - OE - D}$$ (involves noncash item)

Note: All terms and relations are calculated for each year t, but the subscript is often omitted for simplicity

Tax Terms and Relations – Corporations

- Gross Income (GI) or operating revenue (R)
  - Total income for the tax year realized from all revenue producing sources
- Operating expenses (OE)
  - All annual operating costs (AOC) and maintenance & operating (M&O) costs incurred in transacting business; these are tax deductible; depreciation not included here
- Income Taxes and tax rate (T)
  - Taxes due annually are based on taxable income (TI) and tax rates, which are commonly graduated (or progressive) by TI level.

$$\textbf{Taxes} = \textbf{tax rate} \times \textbf{taxable income}$$
$$= T \times (\textbf{GI} - \textbf{OE} - \textbf{D})$$

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Tax Terms and Relations – Corporations

- Net operating profit after taxes (NOPAT)
  - Money remaining as a result of capital invested during the year; amount left after taxes are paid.

$$\textbf{NOPAT} = \textbf{taxable income} - \textbf{taxes} = \textbf{TI} - T \times (\textbf{TI})$$
$$= \textbf{TI} \times (1 - T)$$

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US Corporate Federal Tax Rates - 2010

If Taxable Income (TI) is:

Over, $	But not over, $	Tax is, $ and %	Of the amount over, $
0	50,000	15%	0
50,000	75,000	7,500 + 25%	50,000
75,000	100,000	13,750 + 34%	75,000
100,000	335,000	22,250 + 39%	100,000
335,000	10,000,000	113,900 + 34%	335,000
10,000,000	15,000,000	3,400,000 + 35%	10,000,000
15,000,000	18,333,333	5,150,000 + 38%	15,000,000
18,333,333	No limit	35%	0

- US rates provide a slight tax advantage for small businesses
- Income tax rates are graduated or progressive as TI increases
- Each rate bracket is the marginal tax rate for the TI range

Flat, Average and Effective Tax Rates

- Flat Tax rate
  - Tax rate which is the same for all amounts of TI.
- Marginal tax rates change as TI increases.
  - Tax rates which are applicable to one extra dollar of TI.
- Calculate an average tax rate using:
  - $$\text{Average tax rate} = \frac{\text{total taxes paid}}{\text{taxable income}} = \frac{\text{taxes}}{\text{TI}}$$
- To approximate a single-figure tax rate that combines local (e.g., state) and federal rates
  - calculate the effective tax rate (T_e)
  - T_e = local rates + (1 − local rates) × federal rate
  - Therefore, $\mathbf{Taxes = T_e \times TI}$

Example: Income Tax Calculations

- Annual operating revenue is \$1.2 million with expenses of \$0.4 million and \$350,000 depreciation on assets.
  - The state imposes a flat rate of 5% of all TI. Determine
  - (a) actual taxes and (b) approximate taxes using T_e.
- Solution:
- (a) $TI = GI - OE - D = 1.20 - 0.40 - 0.35 = \$0.45$ million
  - Use TI bracket \$335,000 to \$10 million; $Tax\ rate = 0.34$
  - Federal taxes $= 113{,}900 + 0.34(450{,}000 - 335{,}000) = \$153{,}000$
  - State + federal taxes $= 0.05(450{,}000) + 153{,}000 = \$175{,}500$
- (b) Effective federal rate for TI bracket is 34%
  - $T_e = 0.05 + (1 - 0.05)(0.34) = 0.373$
  - Taxes $= 0.373\ (450{,}000) = \$167{,}850$

Approximation Underestimates actual by 4.4%

Cash Flow After Taxes (CFAT)

- Net Cash Flow (NCF) = cash inflows – cash outflows.
  - Now, consider taxes and deductions, such as depreciation
- Cash Flow Before Taxes (CFBT)
  - CFBT = gross income − expenses − initial investment + salvage value
  - $= GI - OE - P + S$
- Cash Flow After Taxes (CFAT)
  - CFAT = CFBT − taxes
  - $= GI - OE - P + S - (GI - OE - D)(T_e)$
- Once CFAT series is determined,
  - economic evaluation using any method is performed the same as before taxes, now using estimated CFAT values

Cash Flow After Taxes (CFAT)

- Suggested Column Headings for Calculation of CFAT

Year	Gross Income GI	Operating Expenses OE	Investment and Salvage *P* and *S*	CFBT	Depreciation *D*	Taxable Income TI	Taxes	CFAT
	(1)	(2)	(3)	(4) = (1) + (2) + (3)	(5)	(6) = (1) + (2) − (5)	(7) = T_e(6)	(8) = (4) − (7)

  - In column (3), use negative sign for P and positive sign for S.

- Economic evaluation of a project within a corporation
  - A negative TI value is considered a tax savings for the project

- Economic evaluation of a project alone
  - A negative TI value is considered as a zero tax

Example of CFAT

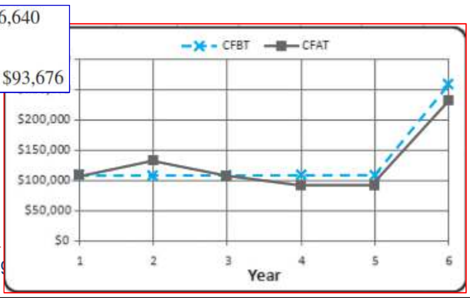
- A Co. plans to purchase an equipment for a 6-year contract.
  - This equipment is expected to cost $550,000 now and have a resale value of $150,000 after 6 years.
  - This equipment will increase contract revenue by $200,000 per year and require an additional M&O expense of $90,000 per year.
  - MACRS depreciation allows recovery in 5 years, and the effective corporate tax rate is 35% per year.
  - Tabulate and plot the CFBT and CFAT series.
- Solution
  - MACRS depreciates to a salvage value of S = 0 and
  - Since MACRS n = 5, for using VDB function d= 2.
  - Or we may use the following rates.
    - $d_1 = 20\%$, $d_2 = 32\%$, $d_3 = 19.2\%$, $d_4 = 11.52\%$, $d_4 = 11.52\%$, $d_6 = 5.76\%$.

Example of CFAT

- Note: For your calculation, use zero tax for year 2.
- As an example for year 4:

	A	B	C	D	E	F	G	H	I
1	Year	GI	OE	P and S	CFBT	D	TI	Taxes	CFAT
2	0			-550,000	-550,000		0	0	-550,000
3	1	200,000	-90,000		110,000	110,000	0	0	110,000
4	2	200,000	-90,000		110,000	176,000	-66,000	-23,100	133,100
5	3	200,000	-90,000		110,000	105,600	4,400	1,540	108,460
6	4	200,000	-90,000		110,000	63,360	46,640	16,324	93,676
7	5	200,000	-90,000		110,000	63,360	46,640	16,324	93,676
8	6	200,000	-90,000	150,000	260,000	31,680	78,320	27,412	232,588
9	Totals					550,000			
10									
11	Functions				'= $B8 +$C8 +$D8	'= VDB(550000 ,0.5,MAX(0,$A8-1.5),MIN(5,$A8-0.5),2)	'= $B8 +$C8 -$F8	'= G8 *0.35	'= B8 +C8+D8 -H8

$$TI_4 = GI - OE - D = 200{,}000 - 90{,}000 - 63{,}360 = \$46{,}640$$
$$Taxes_4 = (0.35)\,(TI) = (0.35)\,(46{,}640) = \$16{,}324$$
$$CFAT_4 = GI - OE - taxes = 200{,}000 - 90{,}000 - 16{,}324 = \$93{,}676$$



Effects on Taxes of Depreciation Method and Recovery Period

- Goal is to minimize PW of taxes, which is equivalent to maximizing PW of depreciation
- Depreciation Method
  - All methods have the same amount of total taxes due
  - Accelerated depreciation methods result in lower Pw_{taxes}
  - General observation for SL, DDB and MACRS methods:
    - PW_{taxes} for MACRS < PW_{taxes} for DDB < PW_{taxes} for SL
    - Note: with same single tax rate, recovery period and salvage value
- Recovery Period
  - All lengths have the same amount of total taxes due
  - Shorter recovery periods result in lower Pw_{taxes}
  - General goal: use shortest (MACRS) recovery period allowed
    - Note: with same single tax rate, depreciation method and salvage value

Example 17.3 of the book

- An after-tax analysis for a new $50,000 machine proposed for a fiber optics manufacturing line is in process.
  - The CFBT for the machine is estimated at $20,000.
  - If a recovery period of 5 years applies, use the present worth of taxes criterion, an effective tax rate of 35%, and a return of 8% per year to compare the following:
    - straight line, DDB, and MACRS depreciation.
    - Use a 6-year period for the comparison to accommodate the half-year convention imposed by MACRS.
- Solution
  - For DDB method, d = 2/n = 2/5 = 0.4

Example 17.3 of the book

		Straight Line			Double Declining Balance			MACRS		
Year	CFBT	Dt	TI	Taxes	Dt	TI	Taxes	Dt	TI	Taxes
1	20,000	10,000	10,000	3,500	20,000	0	0	10,000	10,000	3,500
2	20,000	10,000	10,000	3,500	12,000	8,000	2,800	16,000	4,000	1,400
3	20,000	10,000	10,000	3,500	7,200	12,800	4,480	9,600	10,400	3,640
4	20,000	10,000	10,000	3,500	* 5,400	14,600	5,110	5,760	14,240	4,984
5	20,000	10,000	10,000	3,500	5,400	14,600	5,110	5,760	14,240	4,984
6	20,000		20,000	7,000	0	20,000	7,000	2,880	17,120	5,992
Total		50,000		24,500	50,000		24,500	50,000		24,500
PW of Taxes				16,985			17,802			18,162

*Switching DDB with SL in year 4

- In the text book, the switching DDB with SL has no been done.

Depreciation Recapture (DR) and Capital Gain (CG) and Capital Loss (CL)

- DR, also called ordinary gain, in year t occurs when an asset is sold for more than its BV_t

$$\textbf{DR} = \textbf{selling price} - \textbf{book valuet} = \textbf{SP} - \textbf{BV}_t$$

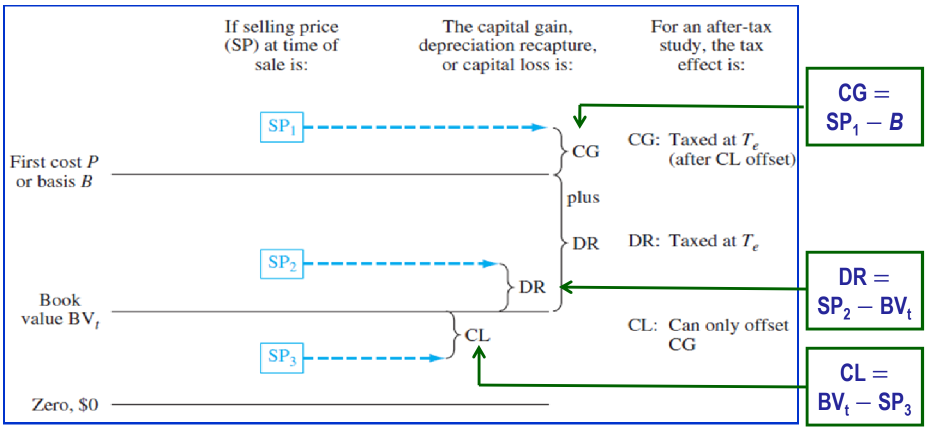
- CG occurs when an asset is sold for more than its unadjusted basis *B* (or first cost *P*)

$$\textbf{CG} = \textbf{selling price} - \textbf{basis} = \textbf{SP} - B$$

- CL occurs when an asset is sold for less than its current BV_t

$$\textbf{CL} = \textbf{book value} - \textbf{selling price} = \textbf{BV}_t - \textbf{SP}$$

Effects of DR, CG and CL on TI and Taxes



Update of TI relation: $TI = GI - OE - D + DR + \text{net } CG - \text{net } CL$

Example: Depreciation Recapture

- A laser-based system installed for B = \$150,000 three years ago can be sold for SP = \$180,000 now.
  - Based on 5-year MACRS recovery, BV_3 = \$43,200. GI for year is \$800,000 and annual operating expenses average \$50,000.
  - Determine TI and taxes if $T_e = 34\%$ and the system is sold now.
- Solution: we have depreciation recapture (DR) & capital gain (CG)
  - DR = 180,000 – 43,200 = \$136,800
  - CG = 180,000 – 150,000 = \$30,000
  - MACRS D_3 = 0.192(150,000) = \$28,800
  - TI = GI – OE – D + DR + CG
    = 800,000 – 50,000 – 28,800 + 136,800 + 30,000 = \$888,000
  - Taxes = TI × T_e = 888,000 × 0.34 = \$301,920
  - Note: If not sold now,
    - taxes = (800,000 – 50,000–28,800) × (0.34) = \$245,208

After-Tax Evaluation

- Use CFAT values to calculate PW, AW, FW, ROR, B/C or other measure of worth using after-tax MARR
- Same guidelines as before-tax; e.g., using PW at after-tax MARR:
  - One project: if PW ≥ 0, project is viable
  - Two or more alternatives: select one ME alternative with the best (numerically largest) PW value
- For costs-only CFAT values,
  - use + sign for OE, D, and other savings and use same guidelines
- Remember: equal-service requirement for PW-based analysis
- ROR analysis is same as before taxes, except use CFAT values:
  - One project: if i* ≥ after-tax MARR, project is viable
  - Two alternatives: select ME alternative with Δi* ≥ after-tax MARR for incremental CFAT series

Approximating After-Tax ROR Value

- To adjust a before-tax ROR without details of after-tax analysis, an approximating relation is:
  - $\text{After}-\text{tax ROR} \approx \text{before} - \text{tax ROR} \times (1 - T_e)$

- Example: Estimate after-tax ROR from before-tax ROR analysis
  - P = $-50,000 GI – OE = $20,000/year n = 5 years
  - D = $10,000/year $T_e = 0.40$
- Solution: Set up before-tax PW relation and solve for i*

$$0 = -50{,}000 + 20{,}000(P/A, i^*\%, 5) \qquad i^* = 28.65\%$$

$$\text{After}-\text{tax ROR} \approx 28.65\% \times (1 - 0.40) = 17.19\%$$

  - Note: Actual after-tax analysis results in i* = 18.03%.
  - See next slide for an example as well as Example 17.7 in the book.

Example: After-Tax Analysis

- Asset: B = $90,000 S = 0 n = 5 years
- Per year: R = $65,000 OE = $18,500 D = $18,000
- Effective tax rate: $T_e = 0.184$
  - Find ROR (a) before-taxes, (b) after-taxes actual and (c) approximation

	A	B	C	D	E	F	G	H	I
1		Revenue,	Operating	Basis, B and		Depreciation,	Taxable	Taxes	
2	Year	R	Expenses, OE	Salvage, S	CFBT	D	Income, TI	at T_e = 0.184	CFAT
3	0			90,000	-90,000				-90,000
4	1	65,000	18,500		46,500	18,000	28,500	5,244	41,256
5	2	65,000	18,500		46,500	18,000	28,500	5,244	41,256
6	3	65,000	18,500		46,500	18,000	28,500	5,244	41,256
7	4	65,000	18,500		46,500	18,000	28,500	5,244	41,256
8	5	65,000	18,500	0	46,500	18,000	28,500	5,244	41,256
9									
10			(a) Before-tax ROR:		43%		(b) After-tax ROR:		36%

Solution: (a) Using IRR function, i* = 43% (b) Using IRR function, i* = 36%

(c) By approximation: after-tax ROR = 43% × (1 – 0.1840) = 35%

After-Tax Replacement Analysis

- Consider depreciation recapture (DR) or capital gain (CG),
  - if challenger is selected over defender
- Can include capital loss (CL),
  - if trade occurs at very low trade-in/exchange for defender
- An after-tax analysis can reverse the selection compared to before-tax analysis,
  - but more likely it will provide information about differences in PW, AW or ROR value when taxes are included
- Apply same procedure as before-tax replacement evaluation once CFAT series is estimated

Example 17.10: Before- and After-Tax Replacement Study

- A company purchased an equipment 3 years ago for $600,000.
  - New equipment has been identified. If a market value of $400,000 is offered as the trade-in for the current equipment, perform a replacement study
    - a) Using Before-tax MARR = 10% per year b) After-tax MARR = 7% per year. Te = 34% and use SL depreciation with S = 0 for both alternatives.

	Defender	Challenger
Market value, $	400,000	
First cost, $		−1,000,000
Annual cost, $/year	−100,000	−15,000
Recovery period, years	8 (originally)	5

- Solution
  - a) before-tax analysis

$$AW_D = -400{,}000(A/P,10\%,5) - 100{,}000 = \$-205{,}520$$
$$AW_C = -1{,}000{,}000(A/P,10\%,5) - 15{,}000 = \$-278{,}800$$

  - b) after-tax analysis

Defender book value, year 3:	$BV_3 = 600{,}000 - 3(75{,}000) = \$375{,}000$
Depreciation recapture:	$DR_3 = TI = 400{,}000 - 375{,}000 = \$25{,}000$
Taxes on trade-in, year 0:	$\text{Taxes} = 0.34(25{,}000) = \$8500$

Example 17.10: Before- and After-Tax Replacement Study

Defender Age	Year	Before Taxes: Expenses OE, $	Before Taxes: P and S, $	Before Taxes: CFBT, $	After Taxes: Depreciation D, $	After Taxes: Taxable Income TI, $	After Taxes: Taxes* at 0.34TI, $	After Taxes: CFAT, $
Defender								
3	0		−400,000	−400,000				−400,000
4	1	−100,000		−100,000	75,000	−175,000	−59,500	−40,500
5	2	−100,000		−100,000	75,000	−175,000	−59,500	−40,500
6	3	−100,000		−100,000	75,000	−175,000	−59,500	−40,500
7	4	−100,000		−100,000	75,000	−175,000	−59,500	−40,500
8	5	−100,000	0	−100,000	75,000	−175,000	−59,500	−40,500
AW at 10%				−205,520	AW at 7%			−138,056
Challenger								
	0		−1,000,000	−1,000,000		+25,000†	8,500	−1,008,500
	1	−15,000		−15,000	200,000	−215,000	−73,100	+58,100
	2	−15,000		−15,000	200,000	−215,000	−73,100	+58,100
	3	−15,000		−15,000	200,000	−215,000	−73,100	+58,100
	4	−15,000		−15,000	200,000	−215,000	−73,100	+58,100
	5	−15,000	0	−15,000	200,000	−215,000‡	−73,100	+58,100
AW at 10%				−278,800	AW at 7%			−187,863

* Minus sign indicates a tax savings for the year.
† Depreciation recapture on defender trade-in.
‡ Assumes challenger's salvage actually realized is $S = 0$; no tax.

So, select defender both ways

Example 17.10 assuming a same GI for both Alt.

Defender Age	Year	Before Taxes: Expenses OE, $	Before Taxes: P and S, $	Before Taxes: CFBT, $	After Taxes: Depreciation D, $	After Taxes: Taxable Income TI, $	After Taxes: Taxes* at 0.34TI, $	After Taxes: CFAT, $
Defender								
3	0		−400,000	−400,000				−400,000
4	1	−100,000		GI −100,000	75,000	GI−175,000	.34GI−59,500	.66GI −40,500
5	2	−100,000		GI −100,000	75,000	GI−175,000	.34GI−59,500	.66GI −40,500
6	3	−100,000		GI −100,000	75,000	GI−175,000	.34GI−59,500	.66GI −40,500
7	4	−100,000		GI −100,000	75,000	GI−175,000	.34GI−59,500	.66GI −40,500
8	5	−100,000	0	GI −100,000	75,000	GI−175,000	.34GI−59,500	.66GI −40,500
AW at 10%				GI −205,520	AW at 7%			.66GI−138,056
Challenger								
	0		−1,000,000	−1,000,000		+25,000†	8,500	−1,008,500
	1	−15,000		GI −15,000	200,000	GI−215,000	.34GI−73,100	.66GI +58,100
	2	−15,000		GI −15,000	200,000	GI−215,000	.34GI−73,100	.66GI +58,100
	3	−15,000		GI −15,000	200,000	GI−215,000	.34GI−73,100	.66GI +58,100
	4	−15,000		GI −15,000	200,000	GI−215,000	.34GI−73,100	.66GI +58,100
	5	−15,000	0	GI −15,000	200,000	GI−215,000‡	.34GI−73,100	.66GI +58,100
AW at 10%				GI−278,800	AW at 7%			.66GI−187,863

* Minus sign indicates a tax savings for the year.
† Depreciation recapture on defender trade-in.
‡ Assumes challenger's salvage actually realized is $S = 0$; no tax.

Now, assume same GI for both alternatives, then calculate ΔAW or ΔPW, get the same result

Economic Value Added (EVA) Analysis

- Definition:
  - The economic worth added by a product or service from the perspective of the consumer, owner or investor
- In other words,
  - it is the contribution of a capital investment to the net worth of a corporation after taxes
- Example:
  - The average consumer is willing to pay significantly more for potatoes processed and served at a fast-food restaurant as fries (chips) than as raw potatoes in the skin from a supermarket.

Economic Value Added (EVA) Analysis

- Value-added analysis is performed in a different way than CFAT analysis, however
  - Selection of the better economic alternative is the same for EVA and CFAT analysis, because
  - It is always correct that
    - AW of EVA estimates = AW and CFAT estimates

EVA Analysis: Procedure

- Difference between CFAT and EVA approaches
  - CFAT estimates (describes) how actual cash will flow
  - EVA estimates extra worth that an alternative adds
  - EVA is a measure of worth that mingles/mixes actual cash flows and noncash flows

- Procedure for EVA analysis
  - Each year t determine the following for each alternative:

$$\begin{aligned} EVA_t &= NOPAT_t - \text{cost of invested capital} \\ &= NOPAT_t - (\text{after-tax MARR})(BV_{t-1}) \\ &= TI_t \times (1 - T_e) - i \times (BV_{t-1}) \end{aligned}$$

Selection: Choose alternative with better AW of EVA series

Remember: Since AW of EVA series will always = AW of CFAT series, the same alternative is selected by either method

Summary of Important Points

- For a corporation's taxable income (TI), operating expenses and asset depreciation are deductible items
- Income tax rates for corporations and individuals are graduated by increasing TI levels
- CFAT indirectly includes (noncash) depreciation through the TI computation
- Depreciation recapture (DR) occurs when an asset is sold for more than the book value; DR is taxed as regular income in all after-tax evaluations
- After-tax analysis uses CFAT values and the same guidelines for alternative selection as before-tax analysis
- EVA estimates extra worth that an alternative adds to net worth after taxes; it mingles actual cash flows and noncash flows