

In the name of Allah



Amirkabir University of Technology
(Tehran Polytechnic)

Industrial Engineering Department

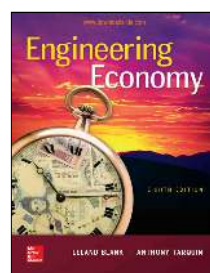
**Course Title:
Engineering Economics**

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**



Engineering Economics

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

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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

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

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

- Taxable income = gross revenue – operating expenses – depreciation

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

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

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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.

$$\begin{aligned}\text{ Taxes } &= \text{ tax rate } \times \text{ taxable income } \\ &= T \times (GI - OE - D)\end{aligned}$$



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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.

$$\begin{aligned}\text{NOPAT} &= \text{taxable income} - \text{taxes} = TI - T \times (TI) \\ &= TI \times (1 - T)\end{aligned}$$



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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



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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)
 - ▶ $T_e = \text{local rates} + (1 - \text{local rates}) \times \text{federal rate}$
 - ▶ Therefore, **Taxes = $T_e \times \text{TI}$**



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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%

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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**)
 - ▶ $CFBT = \text{gross income} - \text{expenses} - \text{initial investment} + \text{salvage value}$
 - ▶ $= GI - OE - P + S$
- ▶ Cash Flow After Taxes (**CFAT**)
 - ▶ $CFAT = CFBT - \text{taxes}$
 - ▶ $= GI - OE - P + S - (GI - OE - D)(T_e)$
- ▶ Once CFAT series is determined,
 - ▶ economic evaluation using any method is performed the same as before taxes, now using estimated **CFAT** values

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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) = $T_c(6)$	(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**

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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.
 - $d_1 = 20\%$, $d_2 = 32\%$, $d_3 = 19.2\%$, $d_4 = 11.52\%$, $d_5 = 11.52\%$, $d_6 = 5.76\%$.

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Example of CFAT

- Note: For your calculation, use **zero tax** for year 2.

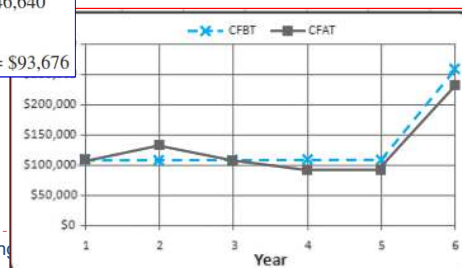
- As an example for year 4:

	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

$$TI_4 = GI - OE - D = 200,000 - 90,000 - 63,360 = \$46,640$$

$$Taxes_4 = (0.35) (TI) = (0.35) (46,640) = \$16,324$$

$$CFAT_4 = GI - OE - taxes = 200,000 - 90,000 - 16,324 = \$93,676$$



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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

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Engineering Economics

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, $d = 2/n = 2/5 = 0.4$

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Example 17.3 of the book

	A	B	C	D	E	F	G	H	I	J	K	L	M
			Straight Line			Double Declining Balance			MACRS				
2	Year	CFBT	CR	TI	Taxes	CR	TI	Taxes	CR	TI	Taxes		
3	1	20,000	10,000	10,000	3,500	20,000	0	0	10,000	10,000	3,500		
4	2	20,000	10,000	10,000	3,500	12,000	8,000	2,800	16,000	8,000	1,400		
5	3	20,000	10,000	10,000	3,500	7,200	12,800	4,480	9,800	10,400	3,640		
6	4	20,000	10,000	10,000	3,500	4,032	14,968	5,138	5,968	14,232	4,984		
7	5	20,000	10,000	10,000	3,500	2,218	14,782	5,118	5,782	14,240	4,984		
8	6	20,000	10,000	10,000	3,500	0	20,000	7,000	0	12,000	5,982		
9	Total		50,000		24,500	50,000		24,500	50,000		24,500		
10	Net of Taxes				15,500			17,000			18,518		
11													

*See Table 10.9 and 10.10 for rates.

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

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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

$$\mathbf{DR = selling\ price - book\ value_t = SP - BV_t}$$

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

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

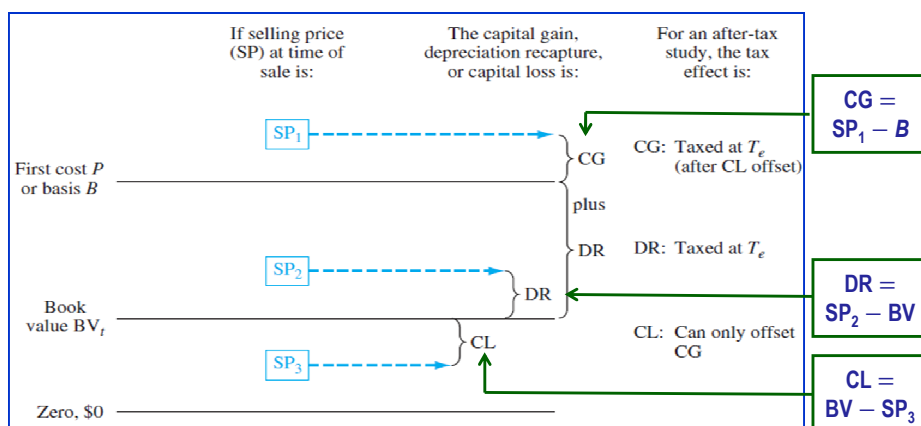
- ▶ **CL** occurs when an asset is sold for **less than** its **current BV_t**

$$\mathbf{CL = book\ value - selling\ price = BV_t - SP}$$

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Effects of DR, CG and CL on TI and Taxes



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

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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**)
 - ▶ $DR = 180,000 - 43,200 = \$136,800$
 - ▶ $CG = 180,000 - 150,000 = \$30,000$
 - ▶ $MACRS D_3 = 0.192(150,000) = \$28,800$
 - ▶ $TI = GI - OE - D + DR + CG$
 $= 800,000 - 50,000 - 28,800 + 136,800 + 30,000 = \$888,000$
 - ▶ $Taxes = TI \times T_e = 888,000 \times 0.34 = \$301,920$
 - ▶ Note: If not sold now,
 - ▶ $taxes = (800,000 - 50,000 - 28,800) \times (0.34) = \$245,208$

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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 $PW \geq 0$, 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 $i^* \geq \text{after-tax MARR}$, project is viable
 - ▶ **Two alternatives:** select ME alternative with $\Delta i^* \geq \text{after-tax MARR}$ for incremental CFAT series

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Engineering Economics

Approximating After-Tax ROR Value

- ▶ To adjust a before-tax ROR without details of after-tax analysis, an **approximating** relation is:
 - ▶ After-tax ROR \approx before - tax ROR $\times (1 - T_e)$
- ▶ Example: Estimate after-tax ROR from before-tax ROR analysis
 - ▶ $P = \$50,000$ $GI - OE = \$20,000/\text{year}$ $n = 5$ years
 - ▶ $D = \$10,000/\text{year}$ $T_e = 0.40$
 - ▶ **Solution:** Set up before-tax PW relation and solve for i^*

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

$$\text{After-tax ROR} \approx 28.65\% \times (1 - 0.40) = 17.19\%$$
 - ▶ Note: Actual after-tax analysis results in $i^* = 18.03\%$.
 - ▶ See Example 17.7 in the book for details

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Engineering Economics

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

1	A	B	C	D	E	F	G	H	I
2	Year	Revenue, R	Operating Expenses, OE	Basis, B and Salvage, S	CFBT	Depreciation, D	Taxable Income, TI	Taxes 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
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Solution: (a) Using IRR function, $i^* = 43\%$ (b) Using IRR function, $i^* = 36\%$
 (c) By approximation: after-tax ROR = $43\% \times (1 - 0.1840) = 35\%$

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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 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

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Example: Before- and After-Tax Replacement Study

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

Purchased 3 years ago
 Before-tax MARR = 10%
 After-tax MARR = 7%
 $T_e = 34\%$
 SL depreciation; $S = 0$

SOLUTION

Before Taxes					After Taxes			
Defender Age	Year	Expenses OE, \$	P and S, \$	CFBT, \$	Depreciation D, \$	Taxable Income TI, \$	Taxes* at 0.34TI, \$	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%:			
Challenger								
	0		-1,000,000	-1,000,000				-1,008,500
	1	-15,000		-15,000	200,000	+25,000 ¹	8,500	+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 ²	-73,100	+58,100
AW at 10%:				-278,800	AW at 7%:			

¹ Minus sign indicates a tax savings for the year.

² Depreciation recapture on defender trade in.

³ Assumes challenger's salvage value actually realized is $S = 0$; no tax.

¹ Minus sign indicates a tax savings for the year.

² Depreciation recapture on defender trade-in.

³ Assumes challenger's salvage actually realized is $S = 0$; no tax.

Select defender both ways

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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.

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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

- $\text{AW of EVA estimates} = \text{AW and CFAT estimates}$

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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 actual cash flows and noncash flows

▶ Procedure for EVA analysis

- ▶ Each year t determine the following for each alternative:

$$\begin{aligned} \text{EVA}_t &= \text{NOPAT}_t - \text{cost of invested capital} \\ &= \text{NOPAT}_t - (\text{after-tax MARR})(\text{BV}_{t-1}) \\ &= \text{TI}_t \times (1 - T_e) - i \times (\text{BV}_{t-1}) \end{aligned}$$

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

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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**

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