Engineering Economics
ECO 1192
Topic 5: Capital Rationing (Budgeting)

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Content

- Methods for
  - Selecting
  - Ranking
  - the best independent projects with budget constraints.

References

- Blank, L., A. Tarquin and S. Iverson, Engineering Economy, Second Canadian Edition, McGraw-Hill Ryerson, Toronto, 2012, chapter 12, "*Selection from Independent Projects Under Capital Limitation*".
- Newnan, D.G., J.P. Lavelle and T. Eschenbach, Engineering Economic Analysis, Engineering Press, Inc., 2006, chapter 17, "*Rationing Capital Among Competing Alternatives*".
- White, J.A., K.E. Case and D.B. Pratt, Principles of Engineering Economics, 5th edition, John Wiley & Sons, 2010, chapter 15 "*Capital Budgeting*".

Capital budgeting characteristics

1. Several valid independent projects can be selected from.
2. Each project is selected entirely or not at all (no partial projects).
3. A known budgetary constraint limits the number of projects to be selected
   - the sum of the initial cost (P) of all valid projects exceeds available funds.
4. The objective is to maximize the return on the total investment in projects.

Capital Budgeting Methods

- Selection of Independent Projects
  - Linear programming
    - Maximize: $\Sigma_k PW_k x_k = Z$, k = 1 to N
    - Constraints: $\Sigma_k NCF_{k0} x_k \leq$ Budget ($)

    Where x_k = 0 or 1; N = number of projects;

    NCF = Net cash flow at time = 0 (initial cost)
  - Use Excel's "Solver" function.
  - Lorie-Savage method
    - Use a multiplier "p" to decrease the attractiveness of an alternative project in proportion to its use of scarce money.
      - NPW – p(PW of cost)
      - Trial and error method
  - Decision Criteria to use
    - NPW and IRR

Independent Projects With Capital Budgeting (i.e., limited funds)

- Capital budgeting or rationing applies to investment decisions with budget constraints (limited funds)
  - Probably impossible to fund all valid projects
- Methods used to ration capital;
  - Internal rate of return (IRR)
  - Net present worth (NPW)

Example

- An investor is considering three (3) investments (see next slide).
  - Determine each project's net present worth assuming that MARR=10%.
  - Assume that the **investor has $15,000** (limited finds) to spend on the projects
  - Determine the feasible investments
  - Determine the optimal investment (i.e., best combination of projects).

Independent Projects With Capital Budgeting (i.e., limited funds) cont'd

Possible Combinations	Individual or Project Combinations (A,B,C)	Funds Required ($)	Residual Budget ($)	Net Present Worth ($)
1*	0 0 0	0	15,000	0
2*	1 0 0	2,000	13,000	1,979
3*	0 1 0	9,000	6,000	948
4*	0 0 1	15,000	0	1,165
5,***	*1 1 0*	*11,000*	*4,000*	*2,927*
6**	1 0 1	17,000	-2,000	3,144
7**	0 1 1	24,000	-9,000	2,113
8**	1 1 1	26,000	-11,000	4,092

*** Combination 5 is optimal (maximum NPW of a feasible combination).
** Combinations 6, 7 and 8 are not feasible (insufficient funds).

Project Selection with Capital Rationing: IRR Method (Budget = $650,000)

Project	Cost ($ 000)	Annual Benefits ($ 000)	Life (years)	Computed IRR (%)	Σ First costs
1	100	23.85	10	20	$100
2	200	39.85	10	**14.5**	300
3	50	34.72	2	25	350
4	100	20.00	6	20	450
5	100	20.00	10	20	550
6	100	18.00	10	18	650
7	300	94.64	4	10	
8	300	47.40	10	12	
9	50	7.00	10	14	

With IRR method, select independent projects 1,2,3,4,5 and 6.
Total investment = $650,000
Source: Newnan Engineering Economic Analysis

Project Selection with Capital Rationing NPW Method (Budget = $650,000)

Project	Cost ($ 000)	Annual Benefits ($ 000)	Life (years)	Computed IRR (%)	Computed NPW (MARR=14.5%) ($ 000)
1	100	23.85	10	20	60.04
2	200	39.85	10	14.5	67.40
3	50	34.72	2	25	11.91
4	100	20.00	6	20	55.48
5	100	20.00	10	20	80.52
6	100	18.00	10	18	67.10
7	300	94.64	4	10	(13.46)
8	300	47.40	10	12	(64.38)
9	50	7.00	10	14	(20.13)

With PW method, select independent projects 1,2,3,4,5 and 6.
Total investment = $650,000
Source: Newnan Engineering Economic Analysis

“Lumpiness” Issue

- It doesn’t always follow that

  $$\Sigma \text{ Project First Cost (\$)} = \text{Budget (\$)}$$

  - known as the “lumpiness” issue
- If Σ Project First Cost $\neq$ Budget, other methods must be used to allocate available funds
  - This type of situation is NOT analyzed in this course
    - i.e., we will not have a “lumpiness” issue

Rationing capital by the NPW Method

- To be compatible with the ranking obtained with the IRR method, each project's NPW must be calculated with the cut-off rate of return
  - unless the MARR and the cut-off rate happen to be equal or close.
- MARR is used most frequently in real life capital budgeting situations.

Project NPWs based on the “cut-off” rate of return

“Cut-off rate of return” = rate of the last project accepted in the bundle (that is, project 2 with an IRR of 14.5%).

Project	Cost				
1	100				

Project	Project Se (Decreasi	
3	25%	
1	20	

Rank projects with the highest to the lowest IRR until the budget is exhausted.

Source: Newnan Engineering Economic Analysis

Project PWs based on the “cut-off” rate of return

Project	Cost ($ 000)	Annual Benefits ($ 000)	Life (years)	Salvage ($ 000)	Computed NPW ** ($ 000)
1	100	23.85	10	0	60.04
2	200	39.85	10	0	67.40
3	50	34.72	2	0	11.91
4	100	20.00	6	100	55.48
5	100	20.00	10	100	80.52
6	100	18.00	10	100	67.10
7	300	94.64	4	0	(13.46)
8	300	47.40	10	100	(64.38)
9	50	7.00	10	50	(20.13)

CAPITAL BUDGET = $650,000
**** Project NPWs are calculated with the cut-off IRR =14.5%**
Source: Newnan Engineering Economic Analysis

Ranking project proposals

- The NPW method is suitable for ranking projects
  - However, the NPW of a proposal must be divided by its initial (first) cost (P).
  - Use the “cut-off” rate of return to calculate the NPW of proposals.
- The individual IRR method is NOT suitable for ranking projects
  - However the incremental IRR method is valid (but not easy to apply).

Ranking Projects with the NPW method

RANKING PROPOSALS BY THE NET PRESENT WORTH (NPW) METHOD					
Project	**Cost (K$)**	**Annual Benefit (K$)**	**Life (years)**	**Computed NPW (14.5%)**	**Computed NPW (14.5%)÷First Cost**
1	100	23.85	10	22.01	0.2201: Project #2
2	200	39.85	10	3.87	0.0194: #6
3	50	34.72	2	6.81	0.1362: #5
4	100	20.00	6	21.10	0.2110: #3
5	100	20.00	10	28.14	0.2814 : #1 (Best)
6	100	18.00	10	17.91	0.1791: #4
7	300	94.64	4	(27.05)	(0.0902): Not acceptable
8	300	47.40	10	(31.69)	(0.1056): Not acceptable
9	50	7.00	10	(1.28)	(0.0256): Not acceptable

Source: Newnan Engineering Economic Analysis

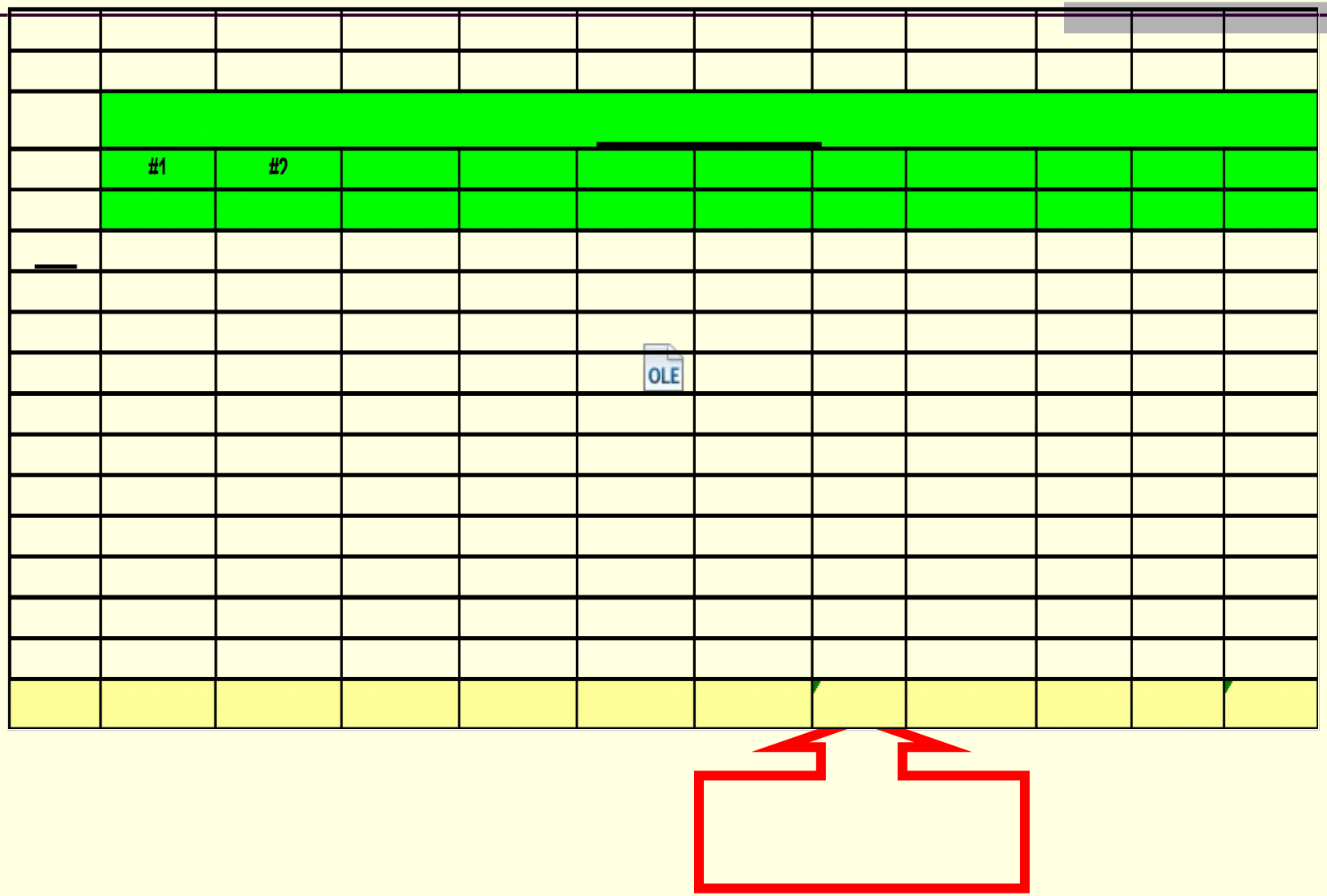
Ranking Independent Projects (NPW ÷ P method)

Project	Cost ($1000)	Computed NPW (14.5%) ÷ Cost	Rank
1	100	0.2201	2
2	200	0.0194	6
3	50	0.1362	5
4	100	0.2110	3
5	100	0.2814	1
6	100	0.1791	4
7	300	(0.0902)	
8	300	(0.1056)	
9	50	(0.0256)	

Source: Newnan Engineering Economic Analysis

Ranking Projects ... e individual IRR

Project	Cost ($1000)	Annual Benefits ($1000)	Life (years)	Computed IRR (%)	Computed NPW (MARR=8%) ($1000)
1	100	23.85	10	20	60.04
2	200				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