Chapter 6: Making Capital Investment Decisions (Highly Important)

Overview and Learning Objectives

Overview

To calculate the NPV of a project, we must estimate future cash flows (**size** and **timing**) and determine the appropriate discount rate corresponding to the risk level of future cash flows. This chapter discusses the guidelines for estimating future cash flows in details, and how to account for inflation in cash flow estimation. We also consider how we choose among mutually exclusive machines/projects that have different lives with an emphasis on the Equivalent Annual Cost (EAC) method.

Learning Objectives

After reading this chapter's materials, students should be able to:

- Correctly apply the guidelines of cash flow estimation numerically in the capital budgeting analysis on a project.
- Differentiate nominal versus real cash flows and discount rates, and explain the biases in investment decision resulted from inconsistent treatments of the inflation effect on cash flows and discount rates in capital budgeting analysis.
- Convert real cash flows into nominal cash flows for cash flow calculations.
- Use the Equivalent Annual Cost (EAC) method to choose among mutually exclusive machines/projects with unequal lives, and to decide on the timing of replacing a machine.
- Work through capital budgeting analysis independently.

Guidelines on Cash Flow Estimation (Ref: Sections 6.1 & 6.3) (Close Attention)

Let us first go over the concept of **incremental (or relevant) cash flows**. The easiest way to determine whether a cash flow is incremental (or relevant) is by asking two questions:

- What will be the amount of the cash flow component **with** the project?
- What will be the amount of the cash flow component without the project?

If the answers **differ** for the two questions, then the cash flow component is **incremental (or relevant) and should be included in the cash flow estimation**. Otherwise, the cash flow component is irrelevant and should not be included in the cash flow estimation.

A. Incremental (or Relevant) Cash Flows – not accounting earnings – That Should Be Included in Cash Flow Estimation

1. Incremental Cash Flows

- They are the changes in the **firm's** (not just the project's) future cash flows that are resulted from the acceptance of the project.
  - Remember that the goal of the capital budgeting decision is to allocate limited resources to projects that help achieve the firm's objective of long-term value maximization. In other words, the perspective of shareholders should be taken, instead of the interests of the department that submits the project, in order to mitigate agency conflict.
- Incremental, but NOT total, cash flows should be included in the cash flow estimation for the project under consideration.

2. Opportunity Costs

- They are the foregone cash flows due to the acceptance of the project. There is no free lunch for committing limited resources to the project under consideration. The foregone cash flows generated by the best alternate project represent the opportunity costs of accepting and hence investing in the project under consideration.
- If at all possible, use the market value of the most valuable foregone alternative to determine the opportunity costs for the project under consideration.

3. Side (or Spillover) Effects

- They are the changes in other parts of the firm due to the acceptance of the project under consideration. Both **positive** and **negative** impacts of the acceptance of the project on the changes in the future cash flows of other parts of the firm should be included.
- Remember again that the objective is to add value to the firm, not your department.

4. Net Working Capital (NWC) Investment

- They are cash flows that are associated with changes in the level of net working capital as a result of accepting the project.
- Recall from Chapter 1 that NWC investment is for supporting the production and sales activities resulted from the implementation of the project. Thus, it is assumed that NWC investment will be fully recaptured (recovered) at the termination of the project, unless otherwise specified. In other words, the level of NWC investment is set to zero at the termination of the project, implying that all cumulated investment in NWC will be fully recovered at that moment, unless otherwise specified!

B. Irrelevant Cash Flows That Should NOT be Included

1. Sunk (or Historical) Costs

- They should **NOT** be included in cash flow estimation for the project under consideration. They are cash flows that have already been incurred and cannot be removed, regardless of the decision on the project.
    - Reminder - Just because "we have come this far" does not mean that we should continue to throw good money after bad.

2. Financing Costs

- Should **not** include cash flows associated with the financing of the project because the financing effect is captured in the cost of capital (or discount rate) of the project, and the amount of debt financing is independent of the decision on the project. Examples of financing costs include dividends payments, principal repayments, etc.
- Note: Due to the fact that interest expenses are tax deductible, the impacts of using debt financing on cash flow estimation and the valuation analysis of a project will be discussed in a later text chapter that is covered in FIN 581 when the topic on interactions between financing and investment decisions is presented.

C. Other Considerations

1. Tax Effects

- Do the analysis on the **after-tax** basis!

- Use accelerated depreciation methods to capture tax savings on non-cash charges, e.g., depreciation, as soon as possible!
    - Note from Chapter 2 that even though depreciation is a non-cash charge, it is included in the cash flow estimation because it generates cash inflow in the form of depreciation tax shield (depreciation * marginal tax rate).
        - “A dollar saved is a dollar earned”!

- Remember to include the tax effect in asset transactions in the Capital Spending (CE) component of cash flow estimation,
  - Tax Effect = (market value − book value) * marginal tax rate
  - Hence, the after-tax salvage value of the asset transaction is the market value of the asset minus the associated tax effect.
    - After-tax salvage value = Market Value – Tax Effect
  - Symmetry tax treatment on capital gain and loss in asset transactions is assumed. Hence, a cash outflow that is associated with the tax payment on capital gains, and a cash inflow that is associated with the tax subsidy for losses, in cash flow estimation!

2. Consistent Treatment of Inflation Effect

- Discount nominal (or real) cash flows with the appropriate, i.e., risk-adjusted, nominal (or real) discount rate.
- Unless otherwise specified, we conduct capital budgeting analysis in nominal terms!!!
  - Note that there is no distinction between nominal and real terms at t=0!

Conceptual Check Exercises –

Which of the following should be treated as an incremental cash flow when computing the NPV of an investment? Explain why or why not!

1. A reduction in the sales of a company's other products caused by the investment.
2. An expenditure on plant and equipment that has not yet been made and will be made only if the project is accepted.
3. Costs of research and development undertaken in connection with the product during the past three years.
4. Annual depreciation expense from the investment.
5. Dividend payments by the firm.
6. The resale value of plant and equipment at the end of the project's life.
7. Salary and medical costs for production personnel who will be employed only if the project is accepted.

Though not required, you are encouraged to post your answer (with explanation that is supported by the Guidelines discussed in pages 2~4) for some or all of the above items on Canvas for the learning reference of the class!

D. Calculation of Cash Flows for Project Evaluation

Cash Flow = Operating Cash Flow (OCF) − Capital Spending (CE) – Change in Net Working Capital (ΔNWC)

- Recall from Chapter 2 that CF(A) = OCF − CE – ΔNWC

- **Operating Cash Flow, OCF**
  - We typically use income statement information to estimate operating cash flows, i.e., OCF = EBIT − Taxes + Depreciation

    When the related information is provided in a different format instead of an income statement, we can estimate cash flows from operations (OCF) as follows:
    - Operating Cash Flow = After-tax revenues − After-tax costs + Depreciation Tax Shield

      where Depreciation Tax Shield = Depreciation Expense * Tax Rate

      i.e., $OCF = [(1 - T) * R - (1 - T) * C] + T * Dep$

      or $OCF = [(1 - T) * (R - C)] + T * Dep$

- **Capital Spending, CE**
  - CE = Change in (gross) fixed assets, or

    CE = Change in net fixed assets + Change in accumulated depreciation, or

    CE = Change in net fixed assets + annual depreciation
  - Don't forget to include the after-tax salvage value, i.e., sale price of the asset – tax effect of the asset transaction!

- **Change in Net Working Capital, ΔNWC**
  - NWC = Current Assets − Current Liabilities
  - Recall that an increase (or a decrease) in NWC represents a cash outflow (or inflow).

When applying the cash flow from assets equation, CF(A), to estimate the incremental (or relevant) cash flow for the project, we should not include any variable related to financing in the estimation.

Note that the same framework for cash flow calculation, i.e., CF(A), applies to each period starting from the initial cash outlay at t=0 through the entire life of the project. This is illustrated in the Baldwin example in the following section.

The Baldwin Company: An Example (Ref: Section 6.2)

Data and Information:

- Costs of test marketing that were paid last year: $250,000.
- Current (after-tax) market value of proposed factory site (which we purchased at $120,000 five years ago): $150,000.
- Cost of bowling ball machine: $100,000 (depreciated according to ACRS five-year life).
- Estimated the market value of the machine at the end of Year 5: $30,000.
- Production (in units) by year during five-year life of the machine: 5,000, 8,000, 12,000, 10,000, and 6,000.
- Price during the <u>first year</u> is $20, P_1 = $20; price increases 2% per year thereafter.
- Production costs during the <u>first year</u> are $10 per unit, i.e., C_1 = $10, and increase 10% per year thereafter.
- Annual inflation rate: 5%.
- Net Working Capital: initially $10,000; then it varies with sales (set at 10% of annual sale revenues).
- Corporate tax rate: 21%.
- Discount rate: 10%.

Depreciation for the Baldwin Company

	Recovery Period Class		
Year	3 Years	5 Years	7 Years
1	33.34%	20.00%	14.28%
2	44.44%	32.00%	24.49%
3	14.81%	19.20%	17.49%
4	7.41%	11.52%	12.50%
5		11.52%	8.92%
6		5.76%	8.92%
7			8.92%
8			4.48%

Initial Investment Cash Outlay (CF_0 or IO) at t=0:

- $OCF_0 = 0$
- CE_0 = $150,000* + $100,000 = $250,000
    - Note that we exclude the costs of test marketing ($250,000) because it is a sunk cost incurred last year. We use the current after-tax market value of the proposed factory site (i.e., $150,000, not $120,000) as an example of the opportunity costs.
- ΔNWC_0 = $10,000 - $0 = $10,000

➔ **CF_0 = 0 − $250,000 − $10,000 = -$260,000**

Annual Cash Flow during the life of the project, say, for Year 3 (CF_3):

- Revenues = 12,000 * $20 * $(1+2\%)^2$ = $249,696
    - Note that the initial price information is given for <u>Year 1</u>, not t=0! Hence, we apply the growth factor twice only to grow the unit price from Year 1 to Year 3.
- Costs = 12,000 * $10 * $(1+10\%)^2$ = $145,200
    - Note that the initial cost information is given for <u>Year 1</u>, not t=0! Hence, we apply the growth factor twice only to grow the cost from Year 1 to Year 3
- Depreciation on the machine = $100,000 * 19.20% = $19,200
    - Annual depreciation under ACRS = Asset Cost Basis * Depreciation Rate
    - Recall from the accounting prerequisite that there is no depreciation on the land site, which is assumed to have an infinite economic life.

Hence, EBIT = $(249,696 − 145,200 - 19,200) = $85,296; and
Taxes = 21% * $85,296 = $17,912.16

⇨ OCF_3 = $(85,296 − 17,912.16 + 19,200) = $86,583.84
- If needed, see page 5 for the formula!

- $CE_3 = 0$
    - There is no information that indicates capital spending in Year 3.

- ΔNWC_3 = 10% * $249,696 − 10% * $163,200 = $8,649.60
    - Note that ΔNWC_t is, by definition, the change in the level of NWC from one year to the next, i.e., $NWC_t - NWC_{t-1}$. Hence, ΔNWC_3 is calculated by subtracting NWC_2 from NWC_3.

➔ **CF_3 = $(86,583.84 − 0 − 8,649.60) = $77,934.24**

Cash Flow for the Terminal Year of the project (CF_5):

- Revenues = 6,000 * $20 * $(1+2\%)^4$ = $129,891.86
    - Note that the initial price information is given for Year 1, not t=0! Hence, we apply the growth factor four times to grow the unit price from Year 1 to Year 5.
- Costs = 6,000 * $10 * $(1+10\%)^4$ = $87,846
    - Note that the initial price information is given for Year 1, not t=0! Hence, we apply the growth factor four times to grow the cost from Year 1 to Year 5.
- Depreciation on the machine = $100,000 * 11.52% = $11,520

Hence, EBIT = $(129,891.86 − 87,846 − 11,520) = $30,525.86; and
Taxes = 21% * $30,525.86 = $6,410.43

⇨ OCF_5 = $(30,525.86 − 6,410.43 + 11,520) = $35,635.43

- Recapture of opportunity cost for factory site = \$150,000 – 21%*\$0 = \$150,000
    - Note: It is implicitly assumed that there is no capital gain/loss on the factory site.
- Sale price (salvage value) of the machine = \$30,000
- Book value of the machine = \$100,000*(1-20%-32%-19.2%-11.52%-11.52%) = \$5,760
- Tax effect of the machine's sale transaction = \$(30,000 − 5,760) * 21% = \$5,090.4
    - After-tax salvage value of the machine = \$(30,000 − 5,090.4) = \$24,909.6

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⇨ CE_5 = -\$(150,000 + 24,909.6) = -\$174,909.6

- Recapture of NWC, ΔNWC_5 = 0 − 10% * \$212,241.60 = -\$21,224.16
    - Note that at the termination of the project, the level of NWC is assumed to be zero, i.e., full recovery of NWC investment, unless otherwise specified in the application.

➔ **CF_5 = \$[35,635.43 – (-174,909.6) – (-21,224.16)] = \$231,769.19**

After your close study of the above numerical illustrations, you are strongly advised to work through the cash flows for Years 1, 2 and 4, and check your work with the following slide!!!

Slide 20

Incremental Cash Flows for the Baldwin Company

	Year 0	*Year 1*	*Year 2*	*Year 3*	*Year 4*	*Year 5*
(1) Sales Revenue		\$100.00	\$163.20	\$249.70	\$212.24	\$129.89
(2) Operating costs		–50.00	–\$88.00	–145.20	–133.10	–87.85
(3) Taxes		–6.30	–9.07	–17.91	–14.20	–6.41
(4) OCF (1) + (2) + (3)		\$43.70	\$66.13	\$86.59	\$64.94	\$35.64
(5) Total CF of Investment	–\$260.00		–6.32	–8.65	3.75	196.13
(6) IATCF [(4) + (5)]	–\$260.00	\$43.70	\$59.81	\$77.93	\$68.69	231.77

$$NPV = -\$260 + \frac{\$43.70}{(1.10)} + \frac{\$59.81}{(1.10)^2} + \frac{\$77.93}{(1.10)^3} + \frac{\$68.69}{(1.10)^4} + \frac{\$231.77}{(1.10)^5}$$

NPV = \$78.53

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Note: The posted supplemental lecture slides #12~#21 provide further illustration of the estimation of cash flow for Baldwin Company.

Inflation and Capital Budgeting (Ref: Sections 6.5 & 6.3)

The relationship between nominal interest rates, real interest rates, and inflation, i.e., **the Fisher equation**, is:

(1 + nominal interest/growth/discount rate) =
(1 + real interest/growth/discount rate) * (1 + inflation rate)

Notes –

(i) **The Fisher Equation can be used to convert real discount (or interest or growth) rate into nominal discount (or interest or growth) rate.**

(ii) **The nominal rate has already accounted for the inflation rate according to the Fisher Equation. Hence, do NOT add or multiply the inflation rate to the nominal rate in the analysis!**

(iii) **The nominal growth rate, which accounts for both real growth rate and inflation rate, should be used to convert real cash flow into nominal cash flow,**
i.e., NOMINAL CF_t = REAL CF_{t-1} * (1 + NOMINAL growth rate).

The important lesson in choosing the appropriate discount rate is to be **CONSISTENT** --

Nominal cash flows must be discounted at the nominal interest rate, and real cash flows must be discounted at the real interest rate.

ADVICE: Follow the above information to convert both cash flow and growth and discount/interest rate information into nominal terms in the capital budgeting analysis!

Example of Capital Budgeting under Inflation – Sony International

Data and Information:

- The required investment on January 1 of this year (***i.e., t=0***) is $32 million.
- The firm will depreciate the investment to zero using the straight-line method.
- The firm is in the 21% tax bracket.
- The inflation rate is 5%.

- The price of the product on January 1 will be $400 per unit, i.e., P_0 = $400 at t=0. The price will stay constant in real terms, implying a nominal growth rate of 5% according to the Fisher Equation.
  Nominal growth rate, g_P = (1+0%)*(1+5%)-1 = 5%!

- Labor costs will be $15 per hour on January 1, i.e., LC_0 = $15 at t=0. And they increase at 2% per year in real terms, implying an annual nominal growth rate of 7.1%.
  Nominal growth rate, g_{LC} = (1+2%)*(1+5%)-1 = 7.1%!

- Energy costs will be $5 per TV on January 1, i.e., EC_0 = $5 at t=0; they increase 3% per year in real terms, implying an annual nominal growth rate of 8.15%.
  Nominal growth rate, g_{EC} = (1+3%)*(1+5%)-1 = 8.15%!

- The real discount rate for costs and revenues is 8%, implying a nominal discount rate of 13.4% according to the Fisher Equation.
  Nominal discount rate, r = (1+8%)*(1+5%)-1 = 13.4%!

Input and Output Unit Data

	Year 1	Year 2	Year 3	Year 4
Physical Production (units)	100,000	200,000	200,000	150,000
Labor Input (hours)	2,000,000	2,000,000	2,000,000	2,000,000
Energy Input (physical units)	200,000	200,000	200,000	200,000

In the following numerical illustration, I first present the preferred approach that converts all information into nominal terms and conduct the NPV analysis in nominal terms accordingly. Then, the text chapter approach, which separates real data from nominal data in the NPV analysis, will also be presented for your learning reference**.**

- ## The Preferred (Recommended) Approach

The core message of this approach is to conduct the NPV analysis in nominal terms. We first convert all real cash flow components into nominal cash flow components, i.e., using the respective annual nominal growth rates to convert real costs (and revenues) into nominal costs (and revenues), and then discount them with the nominal discount rate.

Nominal Cash Flow Components for Year 1:

- Nominal Revenues = 100,000 * $400 * $(1+5\%)^1$ = $42,000,000
- Nominal Labor Costs = 2,000,000 * $15 * $(1+7.1\%)^1$ = $32,130,000
- Nominal Energy Costs = 200,000 * $5 * $(1+8.15\%)^1$ = $1,081,500
    - Note that, unlike the Baldwin example (see page 6), the initial unit value for each of the above variables is given at t=0 ("January 1 …"), i.e., the beginning of the year. Hence, we need to grow the initial unit value with the respective growth factor for each variable every year (including Year 1) over the life of the project!
- Depreciation Expense = $8,000,000, which is calculated as $32M/4!

Hence, $EBIT_1$ = $(42,000,000 - 32,130,000 - 1,081,500 – 8,000,000) = $788,500;
$Taxes_1$ = 21% * $788,500 = $165,585

➔ OCF_1 = $(788,500 – 165,585 + 8,000,000) = $8,622,915

Nominal Cash Flow Components for Year 3:

- Nominal Revenues = 200,000 * $400 * $(1+5\%)^3$ = $92,610,000
- Nominal Labor Costs = 2,000,000 * $15 * $(1+7.1\%)^3$ = $36,854,427
- Nominal Energy Costs = 200,000 * $5 * $(1+8.15\%)^3$ = $1,264,968\
- Depreciation Expense = $8,000,000

Hence, $EBIT_3$ = $(92,610,000 - 36,854,427 - 1,264,968 – 8,000,000) = $46,490,605;
$Taxes_3$ = 21% * $46,490,605 = $9,763,027

➔ OCF_3 = $(46,490,605 – 9,763,027 + 8,000,000) = $44,727,578

Note: In this Sony International example, there is no NWC requirement, i.e., NWC=0, and hence ΔNWC=0. Besides, at the termination of the project, there is no salvage value, i.e., market value is zero, and the equipment is fully depreciated such that its book value is zero, implying that the tax effect of the asset transaction is also zero.
Due to these simplifying conditions pertaining to ΔNWC and CE,
⇨ $CF_t = OCF_t + 0 + 0$ for Years 1~4!

By applying the nominal discount rate of 13.4% to the estimated annual nominal cash flows over the project's 4-year life, we get **NPV = $56,254,024**!!!

Check: CF_0 = -32,000,000; C01 = 8,622,915; C02 = 43,249,111;
C03 = 44,727,578; C04 = 27,032,064; I = 13.4
⇨ NPV = 56,254,024

After your close study of the above numerical illustration, you are strongly advised/ recommended to work through the cash flows for Years 2 and 4, and check your work with the above table!!!

• Text Chapter Approach

Nominal Cash Flow Component

Under the straight line depreciation method, the annual depreciation expense is $32M/4 = $8M generates a tax shield of $1,680,000 (= $8M * 21%), which is by nature in nominal term, is discounted at the nominal discount rate of 13.4%. This gives us the PV of depreciation tax shield = $4,955,863.50 over the entire life of the project.

Real Cash Flow Components

The other cash flow components of this project are stated in real term. As such, the cash flows associated with costs and revenues are discounted at the real discount rate of 8%.

- Real Cash Flows
  - Price: $400 per unit with zero real price increase
  - Labor: $15 per hour with 2% real wage increase
  - Energy: $5 per unit with 3% real energy cost increase

- Year 1 After-tax Real Cash Flows (Slide 28):
  After-tax revenues =
  $\$400 \times 100{,}000 \times (1 - .21) = \$31{,}600{,}000$
  After-tax labor costs =
  $\$15 \times 2{,}000{,}000 \times 1.02 \times (1 - .21) = \$24{,}174{,}000$
  After-tax energy costs =
  $\$5 \times 200{,}000 \times 1.03 \times (1 - .21) = \$813{,}700$
  After-tax Real (R - C) =
  $\$31{,}600{,}000 - \$24{,}174{,}000 - \$813{,}700 = \$6{,}612{,}300$

- Year 3 After-tax Real Cash Flows (Slide 30):
  After-tax revenues =
  $\$400 \times 200{,}000 \times (1 - .21) = \$63{,}200{,}000$
  After-tax labor costs =
  $\$15 \times 2{,}000{,}000 \times 1.02^3 \times (1 - .21) = \$25{,}150{,}629.60$
  After-tax energy costs =
  $\$5 \times 200{,}000 \times 1.03^3 \times (1 - .21) = \$863{,}254.33$
  After-tax Real (R - C) =
  $63,200,000 – $25,150,629.60 – $863,254.33 = $37,186,116

You are recommended to reference posted Lecture Slides #28 through #32 for details on the calculations of the yearly real cash flows, i.e., Years 1~4, and their valuation of this Sony International project!

Note that we use the alternative OCF equation (see page 5),

i.e., $OCF = [(1 - T) * (R - C)] + T * Dep$**,**

that separates the (nominal) depreciation tax shield from the other (real) operating cash flow components in our analysis. Similarly, we separate the calculation of PV of the depreciation tax shield from the calculation of PV of after-tax real (R - C)'s in determining the NPV of the project.

The project NPV can now be computed as the sum of the initial cash outlay, the PV of real cash flows, i.e., after-tax real (R - C)'s, discounted at the real discount rate, and the PV of nominal cash flows, i.e., depreciation tax shield, discounted at the nominal discount rate. At t=0, we can add up these three components because they are all vertically aligned at the same time point, and there is no distinction between nominal and real terms at t=0.

Hence, NPV = -$32,000,000 + $83,298,160 + $4,955,864 = $56,254,024

Again, it is critical to be consistent in treating the inflation effect in capital budgeting analysis - discount nominal cash flows (depreciation tax shield) with the nominal discount rate, and discount real cash flows with the real discount rate!!!

Last but not least before leaving this important topic of cash flow estimation, you are strongly encouraged to work through the details on the Dorm Beds example that can be found in the posted Lecture Slides #50 through #55.

Investments of Unequal Lives (Ref: Section 6.4)

There are times when the NPV method can lead to the wrong investment decision. One of such instances is when we need to choose among mutually exclusive alternatives that have different horizons.

Example

Consider a factory that must have an air cleaner. The equipment is mandated by law, so there is no "doing without." Here are the two choices of air cleaner:

- The "Cadillac cleaner" costs $4,000 today, has annual operating costs of $100 and lasts for 10 years.
- The "cheap cleaner" costs $1,000 today, has annual operating costs of $500 and lasts for 5 years.

Which one should we choose?

- The NPV method will lead us to choose the "cheap cleaner" because it has a higher NPV (less negative) than the "Cadillac cleaner."

  At first glance, the cheap cleaner has the lower NPV (r = 10%):

$$NPV_{\text{Cadillac}} = -\$4{,}000 - \sum_{t=1}^{10} \frac{\$100}{(1.10)^t} = -4{,}614.46$$

$$NPV_{\text{cheap}} = -\$1{,}000 - \sum_{t=1}^{5} \frac{\$500}{(1.10)^t} = -2{,}895.39$$

This overlooks the fact that the Cadillac cleaner lasts twice as long. When we incorporate the difference in the life span of the two air cleaners, the Cadillac cleaner is actually cheaper. However, the NPV analysis does not consider the difference in lives of these two cleaners. As such, the comparison is invalid.

Nature of the Problem

- ***Choose among mutually exclusive machines that have UNEQUAL lives.***

Solutions for the Problem

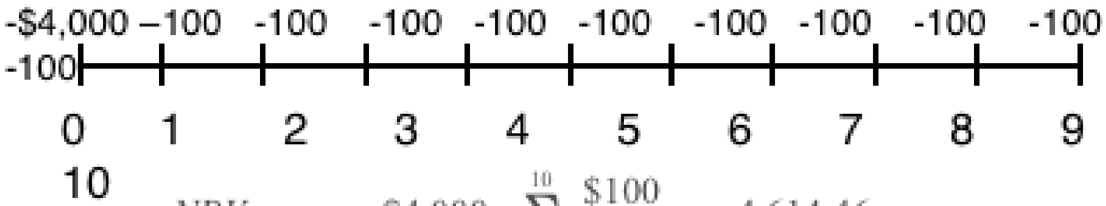
Investments of unequal lives must be put on a comparable basis, either through matching cycles or through the Equivalent Annual Cost (EAC) method.

A. The Matching Cycle Method

- Repeat the projects until they begin and end at the same time.
  - Find the least common multiple (LCM) of the respective lives of the projects.

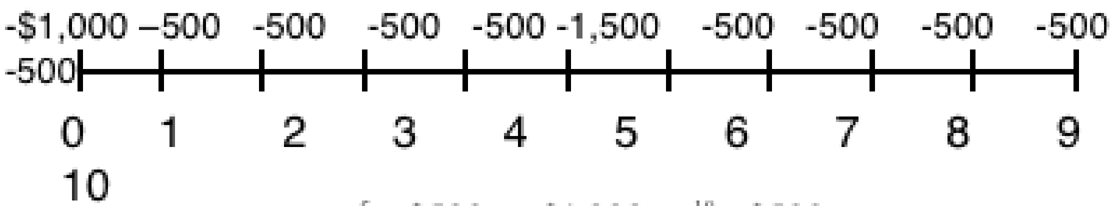
- Calculate the NPV for each "repeated project".

  The Cadillac cleaner time line of cash flows:



$$NPV_{\text{Cadillac}} = -\$4{,}000 - \sum_{t=1}^{10} \frac{\$100}{(1.10)^t} = -4{,}614.46$$

  The "cheap cleaner" time line of cash flows *over the same ten-year horizon:*



$$NPV_{\text{cheap}} = -\$1{,}000 - \sum_{t=1}^{5} \frac{\$500}{(1.10)^t} - \frac{\$1{,}000}{(1.10)^5} - \sum_{t=6}^{10} \frac{\$500}{(1.10)^t} = -\$4{,}693.20$$

As shown in the above illustrations, it costs more to use the Cheapskate cleaner than the Cadillac cleaner over the same ten-year horizon. Hence, the Cadillac cleaner should be selected!

B. The Equivalent Annual Cost (EAC) Method (Important)

- **The EAC is the level payment in the "equivalent" annuity that has the same *PV* as the original set of cash flows.**
  - For example, the EAC for the Cadillac air cleaner is $750.98.
  - The EAC for the Cheapskate air cleaner is $763.80, which confirms our earlier decision to reject it.

The 2-Step Computation Procedures for EAC:

- **Step 1: Calculate the NPV of each alternative.**
  - This step calculates the PV of the total cost, which includes both the purchase cost and annual operating costs, of using the machine over its lifespan.

- **Step 2: Calculate the equivalent annual cost (EAC) of each alternative such that the present value of EAC's over the life of the alternative will equal the NPV of the alternative calculated in Step 1.**
  - This step calculates the cost of using the machine for only one year. This annual cost (EAC) accounts for both the purchase cost and operating costs, as well as the time value of money!

Note: The NPV corresponds to the PV of an annuity while the EAC corresponds to the PMT in an annuity!

Criterion:

- **Select the alternative with the lowest EAC!**

Example:

- For "Cheapskate Cleaner,"
  Step 1: Input: CF_0 = -1,000; C01 = … = C05 = -500; I = 10
  ➔ NPV = -2,895.39
  i.e., it costs a total of $2,895.39 to use "Cheapskate" for its entire life of 5 years!
  Step 2: Input: N = 5; I/Y = 10; PV = 2,895.39; FV = 0
  ➔ PMT = -763.80 → EAC = **$763.80**
  i.e., it costs $763.80 for using the "Cheapskate" cleaner <u>for one year</u>!

- For "Cadillac Cleaner,"
  Step 1: Input: CF_0 = -4,000; C01 = ……… = C10 = -100; I = 10
  ➔ NPV = -4,614.46
  i.e., it costs a total of $4,614.46 to use "Cadillac" for its entire life of 10 years!
- Step 2: Input: N = 10; I/Y = 10; PV = 4,614.46; FV = 0
  ➔ PMT = -750.98 → EAC = **$750.98**
  i.e., it costs $750.98 for using the "Cadillac" cleaner <u>for one year</u>!

As shown in the above illustrations, the annual costs (that include both the purchase cost and annual operating costs) of using the Cheapskate cleaner is $763.80, compared to only $750.98 for the Cadillac cleaner. Hence, the Cadillac cleaner should be selected because of its lower annual costs!

Reference the posted supplemental lecture slides #46~#48 for another numerical illustration on the application of EAC!