Chapter 12
Dealing with Uncertainty

MSCI 261
SECTION 1 (CHE/GEOE) AND SECTION 2 (SOFTWARE)

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Dealing with Uncertainty

Data for PW, AW, IRR calculations are uncertain

Is the <u>decision</u> (accept or reject) sensitive to the uncertainty ?

Two types of sensitivity analysis are covered:

- **Breakeven Analysis:** what uncertain parameter value achieves a "threshold" or "breakeven" value of PW, AW or IRR ?
  - levelized cost is a breakeven selling price
  - IRR itself is the breakeven interest rate that makes PW=0
- **Scenario Analysis:** optimistic, expected and pessimistic "scenarios" (sets of data estimates)

Breakeven Analysis for Choice Between Projects

(Calculate the value of a parameter that makes them equally desirable.)

Example 12-1: Lighting Contractor's Problem

- determine ranges of hours per year that Incandescent, Fluorescent-I, or Fluorescent-II are the least costly;
- for a particular job, determine how many fixtures of each type, e.g.
  - 400 square metres of lobby and hallways to be lighted at all times, i.e. 8760 hours per year
  - 2000 square metres of factory space to be lighted for 5000 hours per year
  - 600 square metres of office space to be lighted for 1500 hours per year
  - 200 square metres of storage space to be lighted for 300 hours per year

Let x = # of hrs/yr that lights are on.

EAC(incandescent) = EAC(fixtures) + EAC(bulbs) + EAC(electric energy)

100 sqm, in $/yr $= 175(A/P, 25\%, 15) + \dfrac{25x(1)(2.95)}{1000} + 0.082\left(\dfrac{500}{1000}\right)25x$

hrs fixtures bulbs/fixture cost/bulb hrs

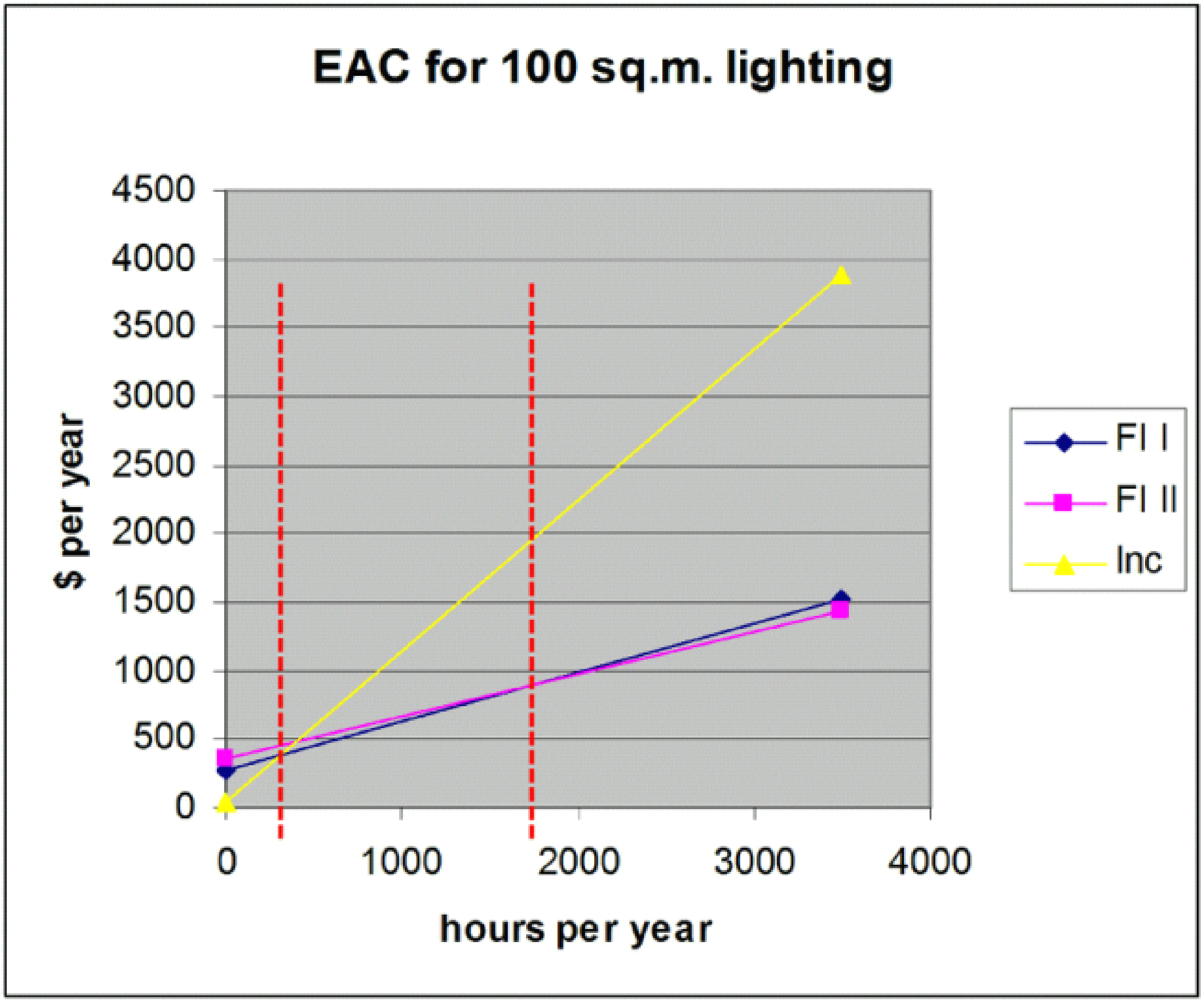
$= 45.35 + 1.09875x$

Example 12-1 (continued)

Data: To illuminate 100 square metres of floor area (dollar values are real):

	Incandescent	Fluorescent Type I	Fluorescent Type II
number of fixtures	25	40	15
first cost of all fixtures, including first bulbs	$175	$1050	$1390
number of bulbs per fixture	1	2	4
cost per bulb, including labour	$2.95	$3.20	$4.95
rated life of bulb in hours	1000	4000	5000
watts per fixture	500	90	200

Cost of electricity = $0.082 per kilowatt-hour
Lifetime of all fixtures = 15 years (with zero salvage value)
Before-tax, real MARR = 25%


EAC for 100 sq.m. lighting
4500
4000
3500
3000
2500
2000
1500
1000
500
0
$ per year
0
1000
2000
3000
4000
hours per year
Fl I
Fl II
Inc

$EAC_{oil} = 1500000(A/P, 10\%, 30) - 200000(A/F, 10\%, 30) + 4000$
$+ [x \cdot 100(1.01)(P/A, g=1\%, 10\%, 30)](A/P, 10\%, 30)$
$= 197903 + 110x$

$EAC_{wind} = 3800000(A/P, 10\%, 15) - 120000(A/F, 10\%, 15) + 12000 + 3x$
$= 507824 + 3x$

Set $EAC_{wind} = EAC_{oil}$
solve for x
$x = 2900.5$ hrs

if $x > 2900.5$ hrs, wind is preffered

Example 12-2: Diesel versus Wind+Battery for electricity in remote place.

Diesel versus Wind+Battery for electricity in remote place

Real Costs of Generation, Before-tax, and other information, for 1 MW

Generation Type	First Cost (2009\$)	Fixed Operating Costs (2009\$/yr.)	Fuel & Maintenance Costs (2009 prices) (2009\$/MWh)	rate of increase of real fuel & maintenance cost (%/yr.)	Service Life (Years)	Salvage Value at Service Life (2009\$)
Oil-diesel	1,500,000	40,000	100	1%	30	200,000
Wind	3,800,000	12,000	3	0%	15	120,000

Find x = hours of operation per year that makes them equal in cost.
Use EAC, with MARR = 10% (before-tax, real).
Which is better for x larger than breakeven?

Let x be # units/yr : PW = 0 or AW = 0 or IRR = MARR

$PW(x) = -3000000 + 400000\,(P/F, 10\%, 12) - 150000\,(P/A, 10\%, 12)$
$+ (9-3.5)x(P/A, 10\%, 12) = 0$

$0 = -3894603 + 37.4735x$

$x = 103924.48$ units / yr.

Example 12-3

Breakeven Sales Rate for New Product

- First Cost = $ 3 million
- Salvage Value = $400,000 in 12 years
- Annual Fixed Operating Expenses = $150,000 per year
- Variable Production Cost, per unit of product = $3.50 per unit
- Selling Price = $9.00 per unit
- Sales Rate = Output Rate = X units per year
- MARR = 10% per year (before-tax)
- Find the breakeven value of output. What use can this number be?

$$PW(x) = -3M + 400000\,(P/F, 10\%, 12) - 150000\,(P/A, 10\%, 12) + (x - 3.5)(100000)(P/A, 10\%, 12) = 0$$

$$\underset{\text{per unit}}{\$9.22} = x = \frac{\left[3M - 400000\,(P/F, 10\%, 12) + 150000\,(P/A, 10\%, 12) + 3.5(100000)(P/A, 10\%, 12)\right]}{100000\,(P/A, 10\%, 12)}$$

Example 12-4

Breakeven Selling Price for a New Product (= levelized cost !)

- First Cost = \$ 3 million
- Salvage Value = \$400,000 in 12 years
- Annual Fixed Operating Expenses = \$150,000 per year
- Variable Production Cost, per unit of product = \$3.50 per unit
- Selling Price = \$X per unit
- Sales Rate = Output Rate = 100,000 units per year
- MARR = 10% per year (before-tax)

Scenario Analysis

Scenario analysis shows the impact of changes to more than one parameter at a time.

Engineers typically look at:

- Optimistic Scenario
  - high revenues, low costs
- Expected Scenario
  - most likely values of parameters
- Pessimistic Scenario
  - low revenues, high costs

Expected $PW = -3M + 400000(P/F, 10\%, 12) - 150000(P/A, 10\%, 12)$
$+ (9-3.5)(100000)(P/A, 10\%, 12)$
$= -147071$

Pessimistic $PW = -3.2M + 350000(P/F, 10.2\%, 12) - 160000(P/A, 10.2\%, 12)$
↳ Higher MARR $+ (7-4.1)(80000)(P/A, 10.2\%, 12)$
$= -2605068$

Example 12-5

Scenario Analysis of New Product Proposal

- First Cost = $ 3 million (+/- $0.2 million)
- Salvage Value = $400,000 in 12 years (+/- $50,000)
- Annual Fixed Operating Expenses = $150,000 per year (+/- $10,000)
- Variable Production Cost, per unit of product = $3.50 per unit (+/- $0.60)
- Selling Price = $9.00 per unit (+/- $2.00)
- Sales Rate = Output Rate = 100,000 units per year (+/- 20,000)
- MARR = 10% per year (before-tax) (+/- 0.2%)

Create pessimistic, expected, and optimistic scenarios and calculate the present worth for each scenario.

[Hint: "optimistic" means "makes PW larger."]

Optimistic $PW = -2.8M + 450000(P/F, 9.8\%, 12) - 140000(P/A, 9.8\%, 12)$
$+ (11-2.9)(120000)(P/A, 9.8\%, 12)$
$= 3071511$