Software Engineering Economics (CS656)

Economic Analysis – II

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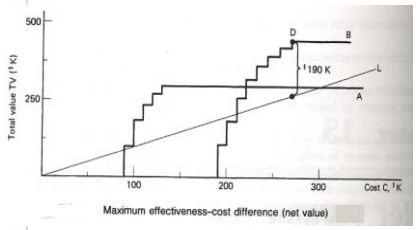
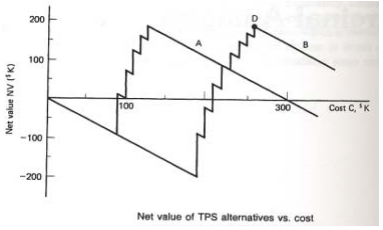
Net Value & Marginal Analysis

Net Value

- Measurement of effectiveness in terms of dollar ➔ Called *Total Value* (TV)
- *Net effectiveness-cost difference* as a useful decision criterion
  - Each transaction per second of processing capability: $2,500 worth
  - C = $260K, TV= $450K
- *Net Value (NV)* = TV –C = $450K – $260K = $190K



Maximum effectiveness–cost difference (net value)



Net value of TPS alternatives vs. cost

Marginal Analysis: Definitions

X – Activity level of an alternative

C(X) – Cost of alternative

TV(X) – Total value of alternative
(in same units as cost)

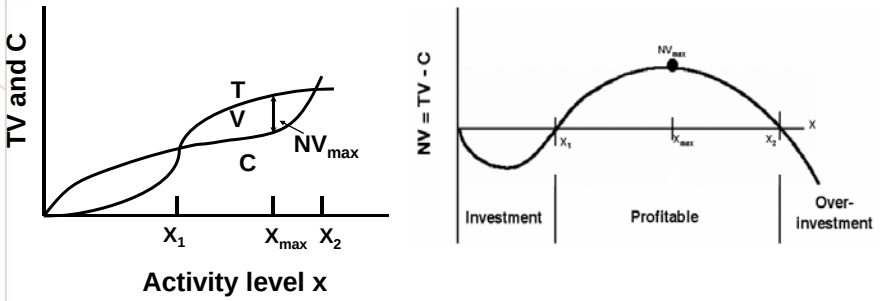
NV(X) – Net value of alternative
NV(X) = TV(X) – C(X)

MNV(X) – Marginal net value

$$MNV(X) = \frac{d(NV)}{dx}$$

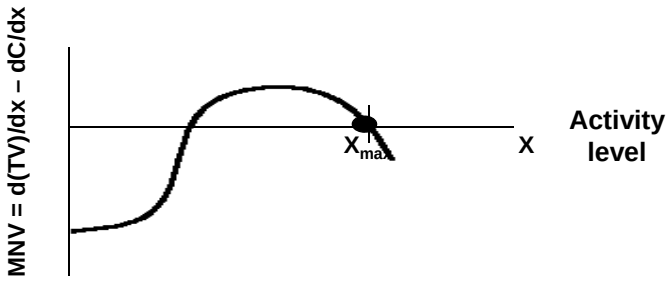
$$= \frac{d(TV)}{dx} - \frac{dC}{dx}$$

Marginal Analysis (Cost & Total Value)



- Cost often varies with the activity level of an alternative
  - here, the number of processors to be acquired
  - very useful to express cost, total value, and the net value as functions of the activity level

Marginal Net Value



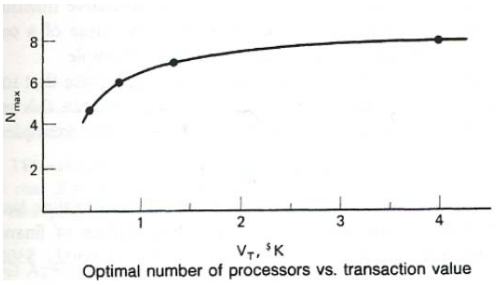
- *Marginal Net Value (MNV)*: the slope of the net value curve
- In the "profitable" segment: Decision Rule
  - If MNV > 0, Increase activity level
  - If MNV < 0, Decrease activity level
  - If MNV = 0, Activity level is optimal

MNV = d(NV) / dx = d(TV) / dx – dC/dx=0
d(TV) / dx = dC/dx

Example: TPS Option B

V_T = value of each TR/sec ($2,500)
C(N) = 180 + 10N
Marginal Cost: dC / dN = 10
TV(N) = $V_T(42.5N – 2.5N^2)$;
Marginal Value: d(TV) / dN = $V_T(880 – 80N)$
$10 = 42.5\ V_T – 5V_T\ N_{max}$

$N_{max} = (42.5\ V_T – 10) / 8.5\ V_T = 8.5 – 2/V_T$



Optimal number of processors vs. transaction value

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Present vs. Future Expenditure & Income

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Another Decision Problem: TPS

- Assuming use of composite option, we will acquire 5 processors/system and run option A for 2 years
- Which acquisition option should we choose:

-A1: Rent processors for 2 years at $1200/Mo.

-A2: Purchase processors for $50,000.
Resell them for $25,000 after 2 years

- Simple Calculation
  - Cost of A1 = $1200/mo * 24 mo = $28,800
  - Cost of A2 = $5,000 - $25,000 = $25,000
- Led to wrong conclusion by a faulty assumption
  - *"A dollar available to us 24 months from now is the same as a dollar available to us now"*

Interest Calculations

- Assumption: Interest Rate: 9%/yr (or 0.75%/mo)
- On Option A2, 25K tied up for 2 years
- How much would this be worth at an interest rate of .75%/month?

  V($25 K, 1) = $25 K (1.0075)
  V($25 K, 2) = $25 K (1.0075) (1.0075)
  …
  V($25 K, 24) = $25 K $(1.0075)^{24}$ = $29,910

- Lost the opportunity to earn almost $5K by having $25 K tied up

Present Value Calculation

- What is the present value X of the $25K we will receive in 24 months?

$$V(X, 24) = X(1.0075)^{24} = \$25K$$

$$X = \frac{\$25K}{(1.0075)^{24}} = \$20,896$$

$$PV(\$25K, .0075, 24) = \frac{\$25K}{(1.0075)^{24}}$$

$$PV(F, r, n) = \frac{F}{(1+r)^n}$$

F: cash flow
r: interest rate
n: number of time period
D: discount rate

$$PV(F, D, n) = FD^n$$

Present Value of A Series of Cash Flows

- Option A1, pay $1200 at the beginning of each month
- How much is this worth in present value?

PV_S ($1200, D, 1) = $1200
PV_S ($1200, D, 2) = $1200 + $1200 D
PV_S ($1200, D, 3) = $1200 (1 + D + D^2)

. . .

PV_S ($1200, D, 24) = $1200 (1 + D + … + D^{23})
= $1200 (1 - D^{24}) / (1 – D)

For D = 1/1.0075 = .9925558

PV_S ($1200, 1/1.0075, 24) = $26,464

Present Value of A Series of Cash Flows

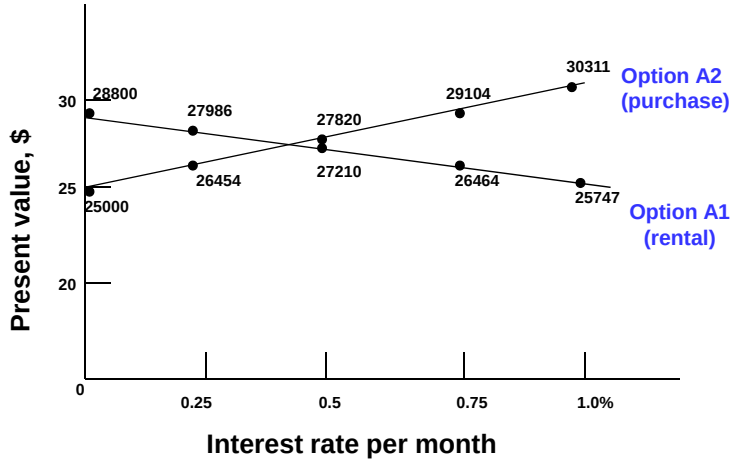
- *m* equal cash flows or payments *p*
  - **At the beginning of each time period**
- Constant discount rate: *D*

$$PV_S(p, D, m) = p\,[(1-D^m)/(1-D)]$$

Present Value Analysis Results

	Simple Analysis	Present Value Analysis
Cost of Option A1	$28,800	$26,464
Cost of Option A2	$25,000	$29,104

Sensitivity to Interest Rate or Discount Rate



Figures of Merits

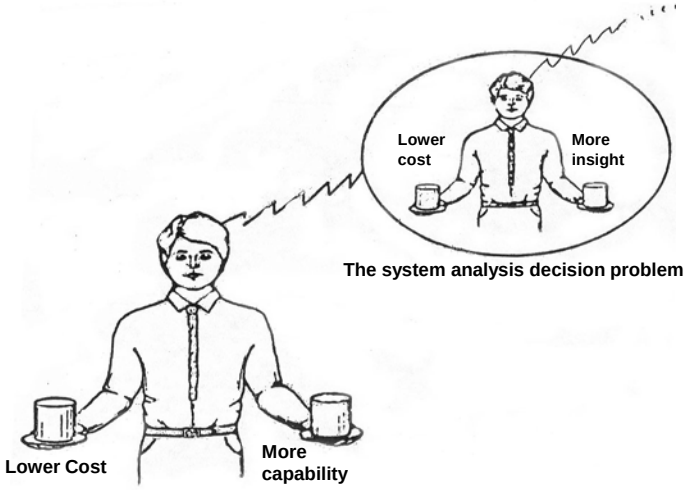
TPS: S/W Package Selection

- Choose best vendor operating system
  - System A – Standard OS
  - System A Plus
    - Better measurement, and diagnostic capabilities
    - Additional price $5 K

Alternative TPS Operating System Characteristics

Criterion	Alternative	
	System A	**System A Plus**
1. Added Cost	0	$5 K
2. Processor overhead	200	200
3. Multiprocessor overhead	80	80
4. Measurement capability	Poor	Good
5. Trace capability	None	Adequate
6. Diagnostics, error messages	Adequate	Good
7. Maintenance support	Marginal	Good
8. Accounting system	Adequate	Very Good
9. Usage summaries	None	Good
10. Documentation	Good	Adequate

Meta-Decision Problems



Weighted Sum Figure of Merit

- Assign weight W_i to criterion i

  $\Sigma_i \; W_i = 1$

- For each option j and criterion i, assign rating r_{ij} $(0 \le r_{ij} \le 10)$

- Compute figure of merit for each option j

  $F_j = \Sigma \; w_i r_{ij}$

TPS Figure of Merit Analysis

Criterion	Weight	System A			System A Plus		
		Characteristic	Rating	Weighted Rating	Characteristic	Rating	Weighted Rating
1. Added Cost	30	$0	10	300	$40K	4	120
2. Processor overhead	10	200	3	30	200	3	30
3. Multiprocessor overhead	15	80	3	45	80	3	45
4. Measurement capability	7	Poor	2	14	Good	8	56
5. Trace Capability	8	None	0	0	Adequate	6	48
6. Diagnostics, error msgs	10	Adequate	6	60	Good	8	80
7. Maintenance Support	10	Marginal	4	40	Good	8	80
8. Accounting system	2	Adequate	6	12	Very good	10	20
9. Usage summaries	3	None	0	0	Good	8	24
10. Documentation	5	Good	8	40	Adequate	6	30
Total	100			541			533

What if we assign a rating of 5 rather than 4 to the cost of System A Plus?
–Hard to get a secure feeling about choosing one system over another on the basis of this analysis

Delivered System Capability (DSC) Figure of Merit

DSC = (SC) (DC) (AV)

- SC: System Capability = $\Sigma W_i r_i$
  - Defined as a hierarchical weighted sum of individual criterion ratings
    - W_i: Weight assigned to i th criterion (add up to 1.0)
    - r_i: Ratings assigned on a scale of 0.0 to 1.0
- DC: Delivered Capacity
  - Defined as the actual computer capacity
- AV: Availability
  - Defined as the fraction of time that the computer system is available
  - Exclude time spent on preventive maintenance and system down time

The DSC Figure of Merit

- Dimensionless
- Covers effectiveness only
- SC component handles many criteria
- DC, AV components apply multiplicatively

Gains from System A Plus - I

- Reduction of $30 K maintenance cost
  - **Basic cost:** **($135K)**
  - **Maintenance Support:** **10%** **(-$3K)**
  - **Diagnostics, Error Msgs.:** **5%** **(-1.5K)**
  - **Documentation (worse):** **-5%** **(1.5K)**

  $132K

- Delivered capacity increase via measurement: 3%

  180.0 tr/sec (1.03) ==➔ 185.4 tr/sec

- Availability increase via diagnostics, error messages, trace capability: 50% less downtime

  0.95 ==➔ 0.975

Gains from System A Plus – II

- **System Capability**

Criteria	Weight	System A		System A Plus	
		Rating	Score	Rating	Score
Basic TPS Functions	0.95	1.0	0.950	1.0	0.950
Accounting Systems	0.01	0.6	0.006	1.0	0.010
Usage Summaries	0.01	0.0	0.000	0.8	0.008
OS Documentation	0.03	0.8	0.024	0.4	0.012
Total			0.980		0.980

TPS Comparison: DSC

Criterion	System A	System A Plus
System capability (SC)	0.980	0.980
Delivered capability (DC)	180	185.4
Availability (AV)	0.95	0.975
Delivered system capability (DSC)=(SC)(DC)(AV)	167.6	177.1
Cost	$130K	$132K
Capability/Cost ratio	1.29	1.34

Revised TPS Weighted Sum Analysis

Criterion	Weight	System A			System A Plus		
		Characteristic	Rating	Weighted Rating	Characteristic	Rating	Weighted Rating
1. System capability (SC)	40	0.980	9	360	0.980	9	360
2. Delivered capacity (DC)	30	180	8	240	185.4	9	270
3. Availability (AV)	30	0.950	7	210	0.975	9	270
Total	100			810			900

Comparison of Weighted Sum & DSC Figures of Merit

	Weighted Sum	Delivered System Capability
Relative advantages	Simpler	More representative of many computer systems
	Better for assessing side effects of DC, AV factors	Better for assessing wide variations in DC, AV factors
Recommendation	Use where DC, AV factors will not vary widely	Use where DC, AV factors may vary widely

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