KU-UTC Joint Summer Training Course on
‘Road Infrastructure Asset Management’, 2007

Life Cycle Cost (1)

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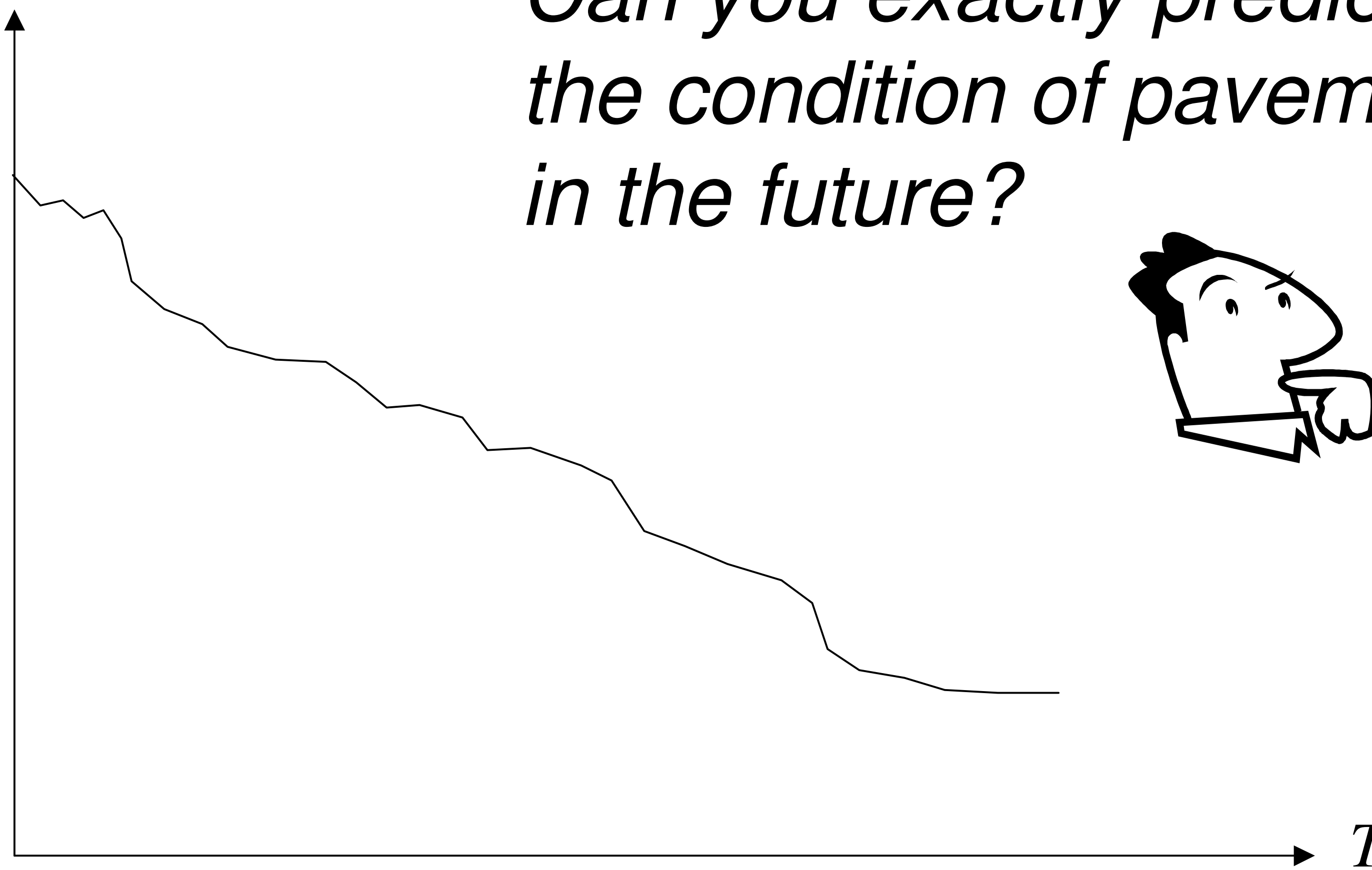
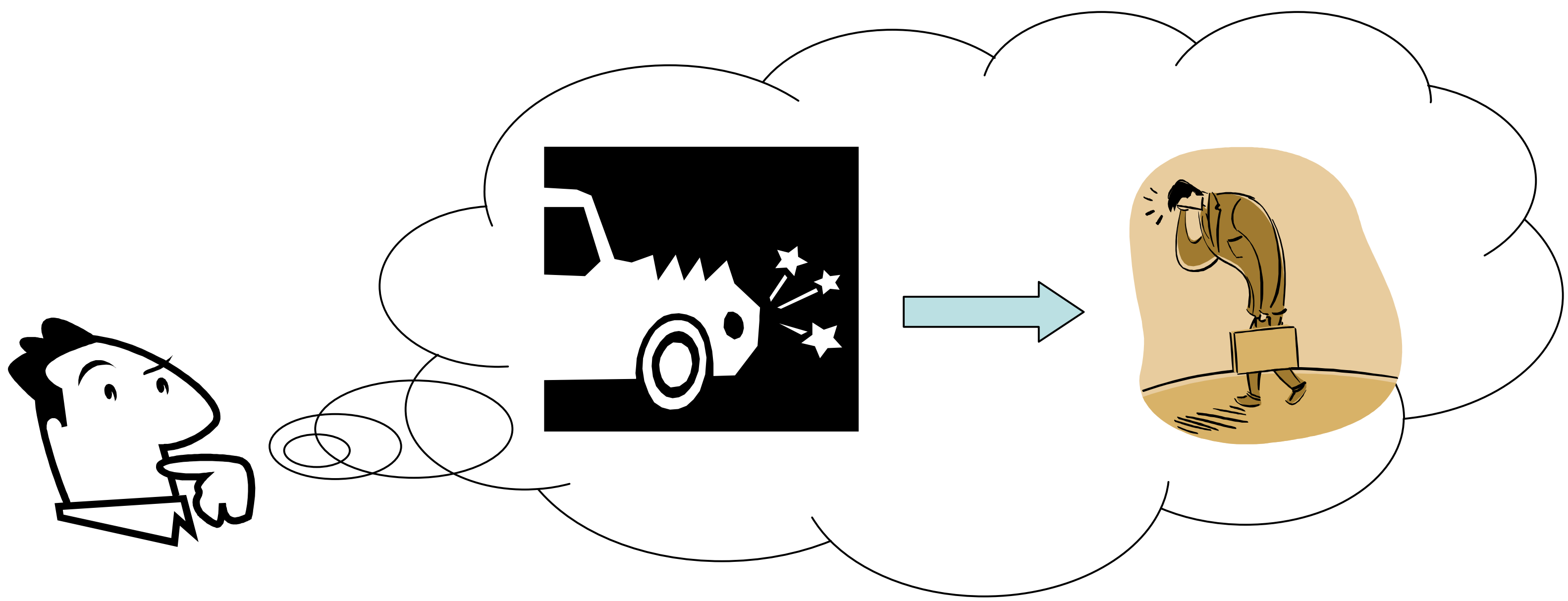
Forecasting of Performance Deterioration



Can you exactly predict the condition of pavement in the future?

Why ‘Stochastic Model’?

- Without considering ‘Uncertainty’



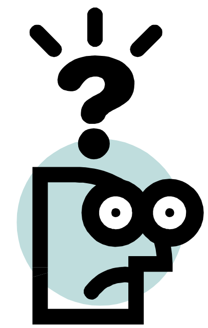
We always make decisions taking account of ‘uncertainty’ in our daily lives.

Uncertainty

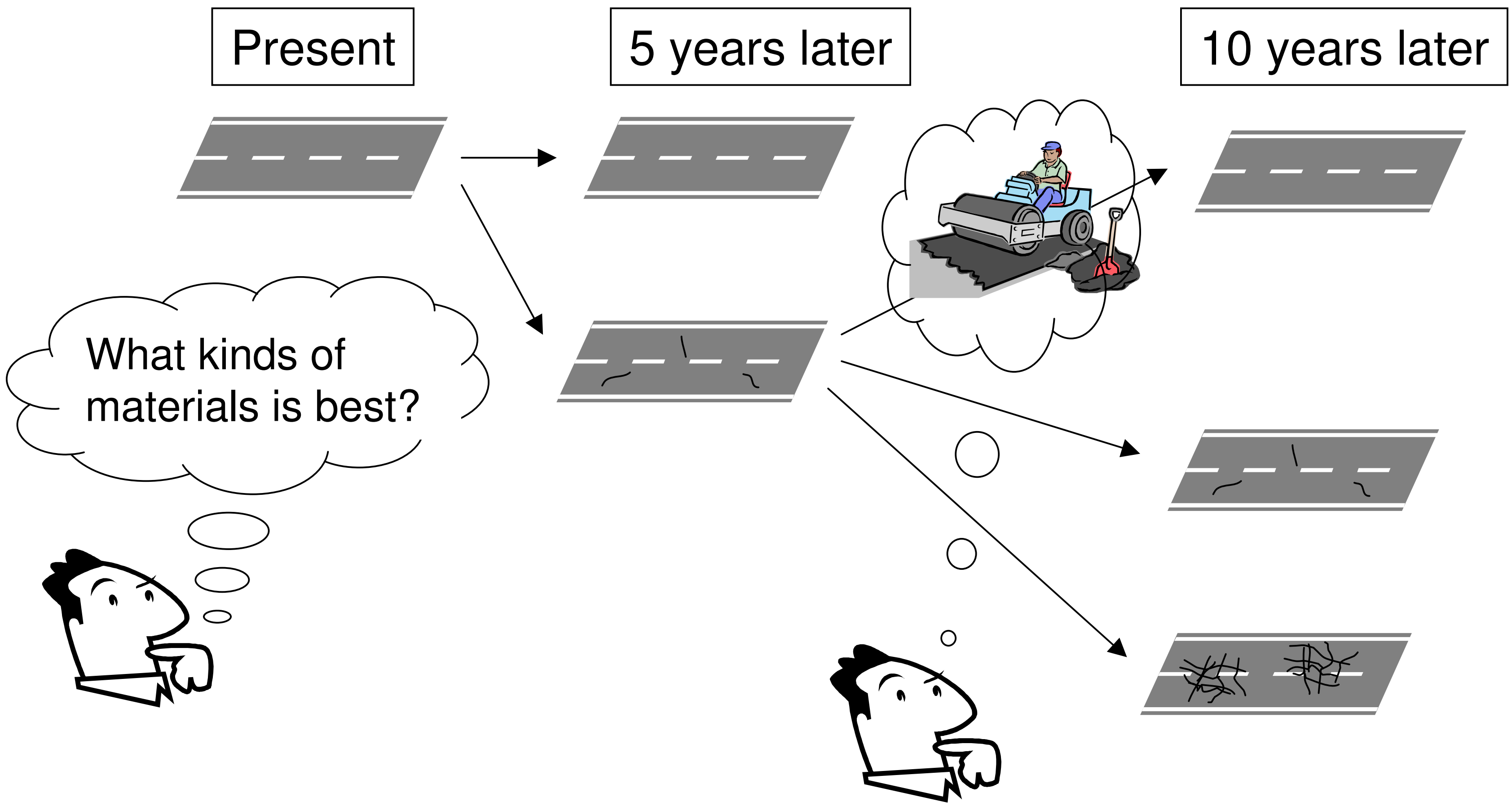
- Which is likely to occur 5 years later?

Present

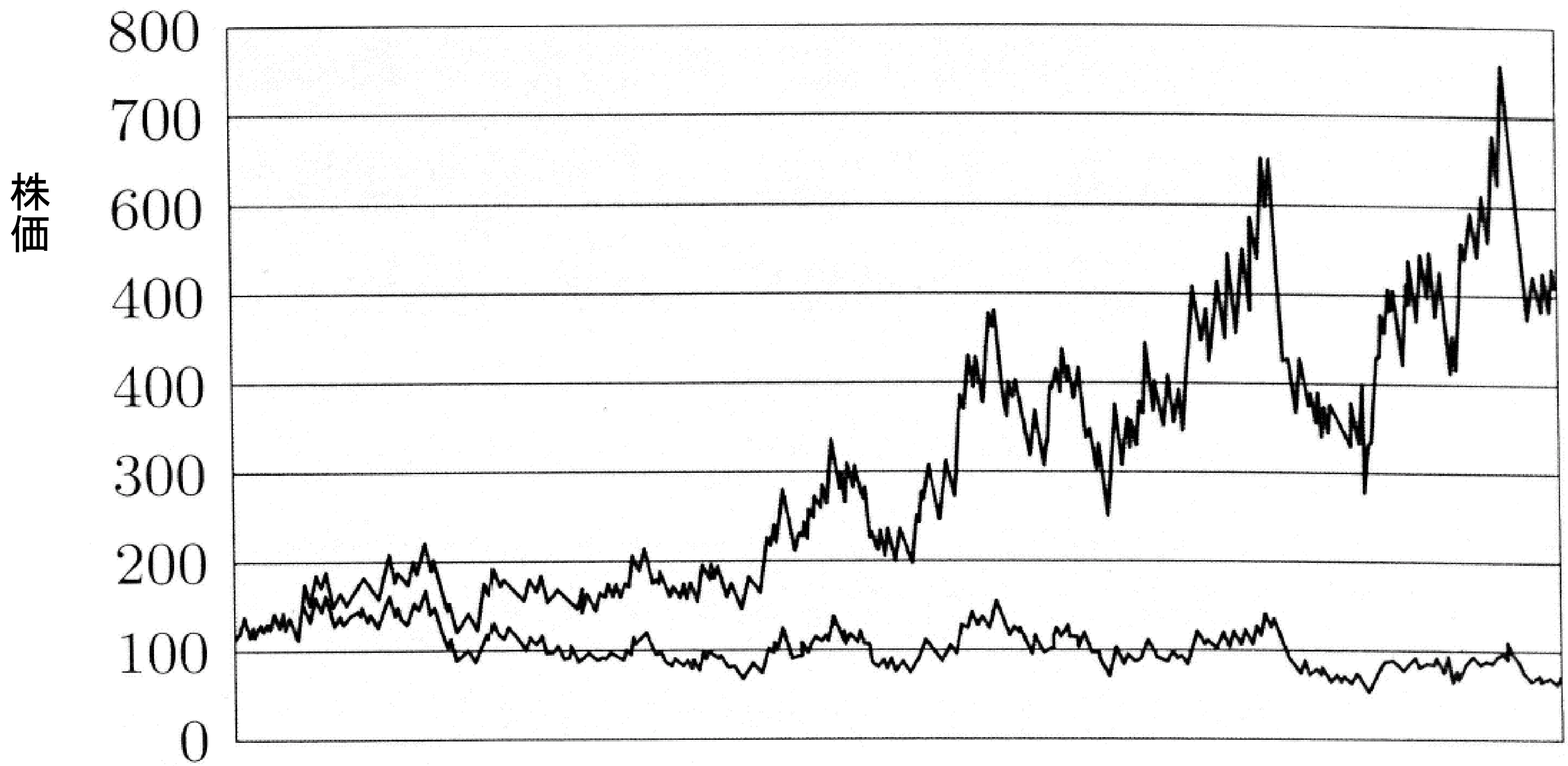
5 years later



Complexity of Decision Making under Uncertainty



Risk in stock price



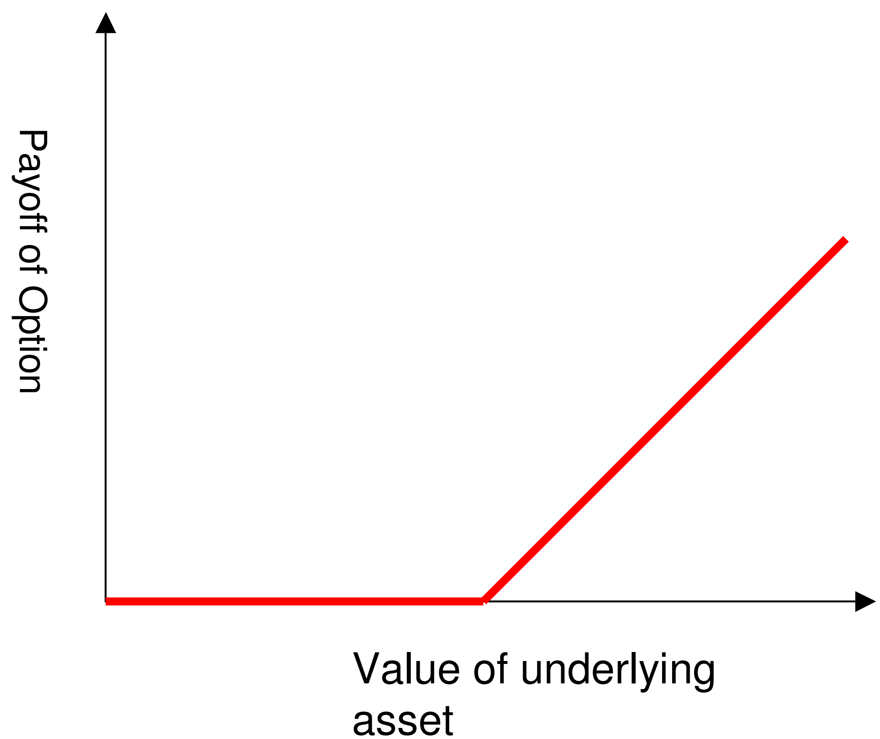
Irreversibility of investment

1. If the investment is reversible
   - In case that market environment goes bad than expected, an investor salvage his/her investment after investing decision.

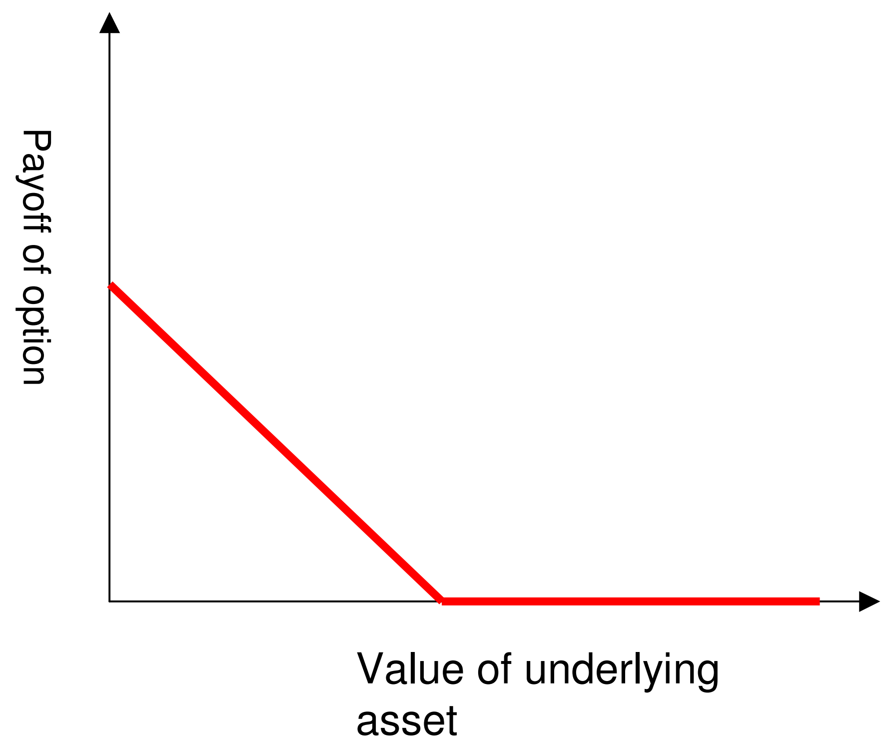
2. If the investment is irreversible
   - The investment cannot be salvaged once it is made.

Call / Put Option

Call option
(Right to buy an underlying asset)



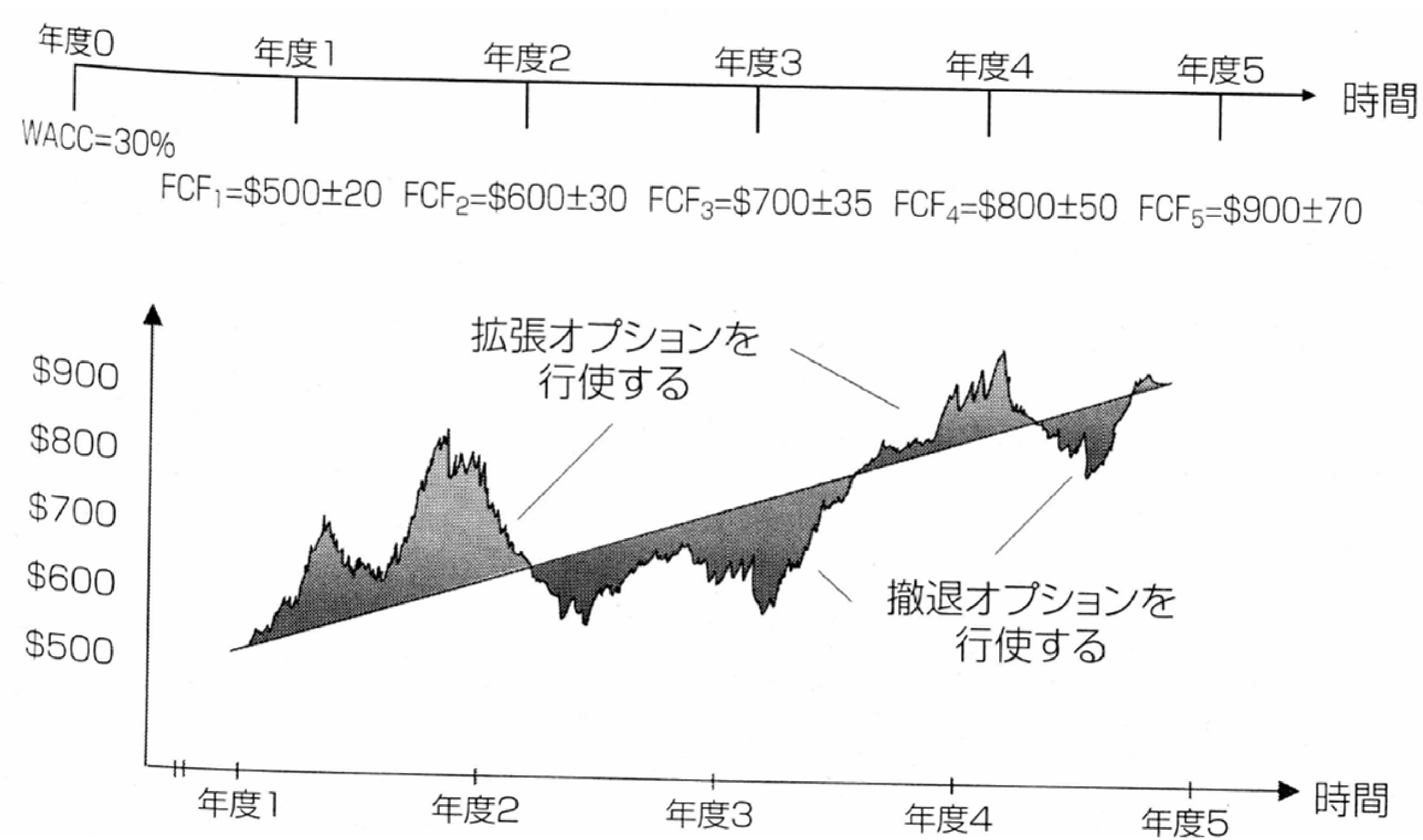
Put option
(Right to sell an underlying asset)



Real option

- Uncertainty and irreversibility in real business decision making
- Application of financial option to strategic decision makings in maintenance.
- Evaluating the value of flexibility in decision making

Intuitive concept of “Real Option”



Intuitive concept of “Real Option”

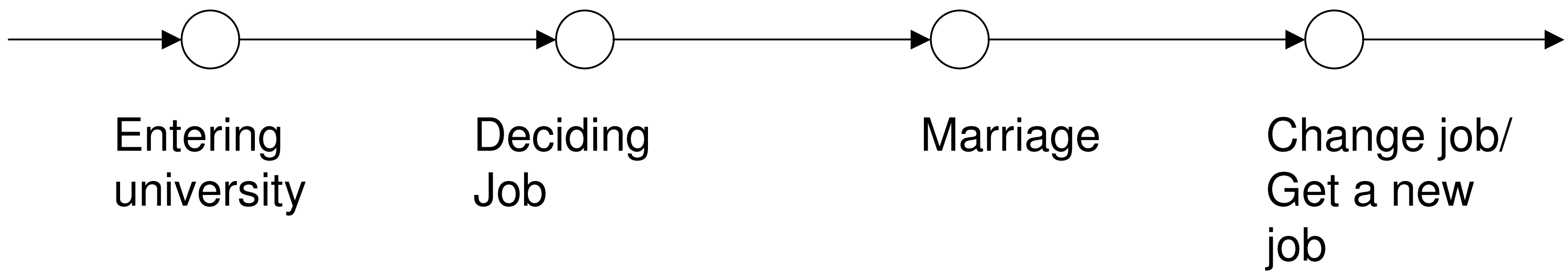
- Lottery in expecting winning team of the football league

Team A: 0 win, 0 lose
Team B: 0 win, 0 lose
Team C: 0 win, 0 lose

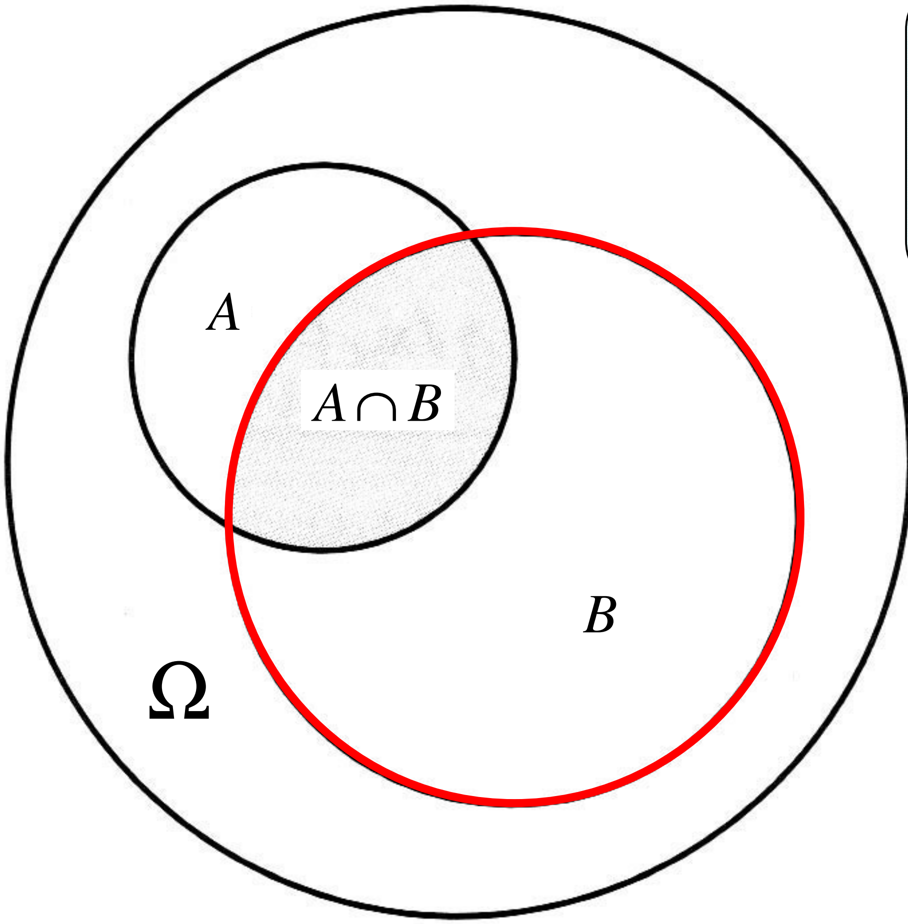
Team A: 30 win, 20 lose
Team B: 25 win, 25 lose
Team C: 20 win, 30 lose

Team C: 30 win, 20 lose
Team A: 25 win, 25 lose
Team B: 20 win, 30 lose

Human life as Real Option



Conditional Probability

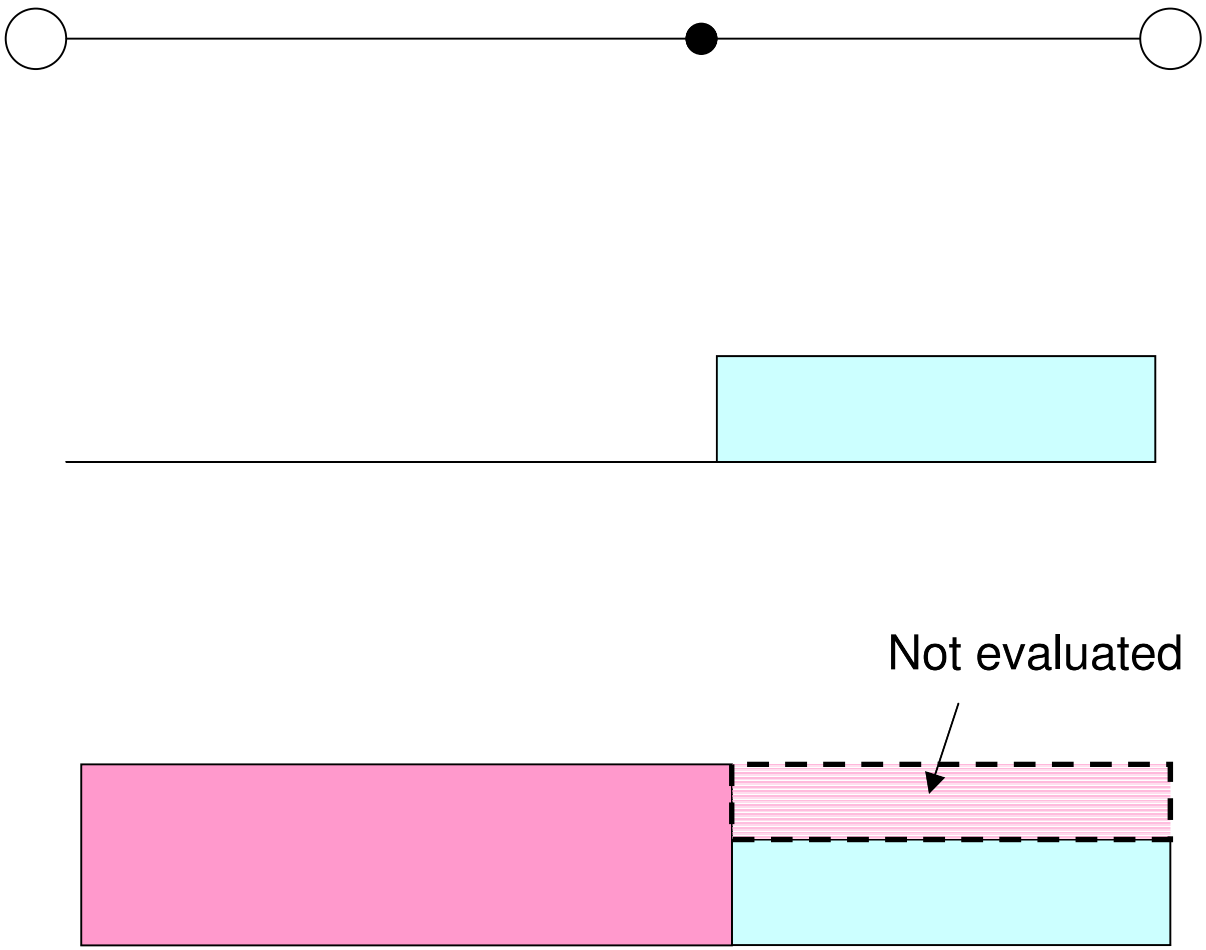


$$\mathbf{P}(A \mid B) = \frac{\mathbf{P}(A \cap B)}{\mathbf{P}(B)}$$

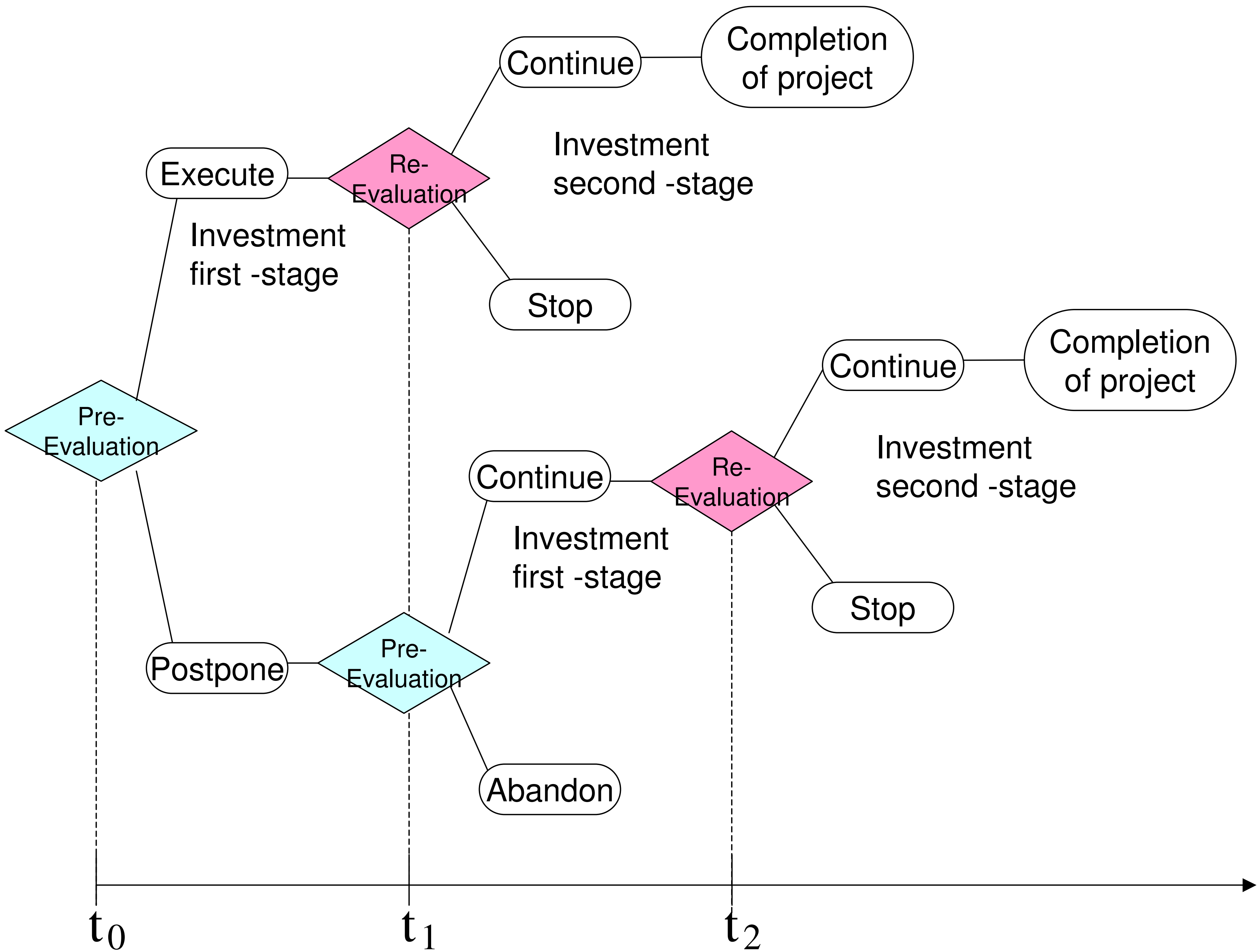
Sample space is limited to the space B from space Ω

Classifications of Real option

- Option value related to project alternatives
  - alternative option / switching option
- Option related to Timing
  - postpone option
  - abandon option / withdraw option
- Option related to Investment scale
  - Extension option / reduction option



Development Option


Completion of project
Continue
Investment second -stage
Execute
Re-Evaluation
Investment first -stage
Stop
Continue
Completion of project
Pre-Evaluation
Investment second -stage
Continue
Re-Evaluation
Investment first -stage
Stop
Postpone
Pre-Evaluation
Abandon
t_0
t_1
t_2

NPV

$\downarrow$

VaR

$\downarrow$

Option Value

Net Present Value（NPV）

1. Present value (PV) of expected profit of a project

$$PB = \frac{\sum_{i=0}^{N} B_i}{(1+r)^i}$$

2. Present value of expected cost of the project

$$PC = \frac{\sum_{i=0}^{N} C_i}{(1+r)^i}$$

3. NPV＝PB－PC $\gtreqless 0$

4. Internal Rate of Return (IRR)
   r which gives NPV＝0

Project

$$t_0 \xrightarrow[\text{C1}]{} t_1 \xrightarrow[\text{C2}]{} t_2$$

Cost

$$\left.\begin{array}{l}\text{C1=30 million \$}\\ \text{C2=70 million \$}\end{array}\right\}\ \text{Total: 100 million \$}$$

Benefit (3 scenarios)

$\frac{1}{3}$	180 million $
$\frac{1}{3}$	90 million $
$\frac{1}{3}$	0 $

Net Present Value (NPV)

$$B = \frac{1}{3} \text{Ç } 180 + \frac{1}{3} \text{Ç } 90 + \frac{1}{3} \text{Ç } 0 = \quad 90$$

$$C = 100$$

$$B \text{ Ä } C = \quad 90 \text{ Ä } 100$$

$$= \quad \text{Ä}10 \longrightarrow \text{abandon}$$

“Now or Never” discipline

Real option

t_1 : Additional cost 70 million $

$$B - C = 180 - 70 = 110 > 0 \quad \cdots \text{scenario 1}$$

$$= 90 - 70 = 20 > 0 \quad \cdots \text{scenario 2}$$

$$= 0 - 70 = -70 < 0 \quad \cdots \text{scenario 3} \longrightarrow \text{abandon}$$

t_0 : Initial cost 30 million $

$$B = \frac{1}{3} \times 110 + \frac{1}{3} \times 20 + \frac{1}{3} \times 0 = 43.3$$

$$B - C = 43.3 - 30 = 13.3 > 0 \longrightarrow \text{Investment}$$

Policy selection and future management costs

Ex) ▪Life span: 2 periods

▪Discount rate is 0.5

▪Two management policies

	1	2	
Do nothing option	0	10	$0.5 \times 10 = 5$
Maintenance option	4	4	$4 + 0.5 \times 4 = 6$

‘Do nothing option’ is selected by LCC evaluation for individual facility

Multiple infrastructure

(Case1) Staggered regime

Generation		1	2	3	4	・・・
Do Nothing Option	A	10	0	10	0	・・・
	B	0	10	0	10	・・・
	Total	10	10	10	10	・・・
Maintenance option	A	4	4	4	4	・・・
	B	4	4	4	4	・・・
	Total	8	8	8	8	・・・

Maintenance option is desirable irrelevant to discount rate.

Average Cost minimization principle

Evaluating LCC as a flow of average costs equivalent, and minimizing the average cost

(Case 2) Synchronous regime

Generation		1	2	3	4	…
Do nothing option	A	0	10	0	10	…
	B	0	10	0	10	…
	Total	0	20	0	20	…
Maintenance option	A	4	4	4	4	…
	B	4	4	4	4	…
	Total	8	8	8	8	…

Do nothing option is desirable

Desirable Evaluation Method

Staggered regime

By calculating optimal M&R policy based on **average cost minimization principle**, optimal M&R policy in the total system can be obtained.

Synchronized regime

By calculating optimal M&R policy based on **discounted present value principle**, optimal M&R policy in the total system can be obtained.

Staggered regime or Synchronized regime?

Advantage of staggered regime

- Preventing moral hazard in M&R decision
- Preventing the abuse in using reserved money
- Avoiding raising fund issues