

Cost Benefit Analysis

Background of Cost-Benefit Analysis

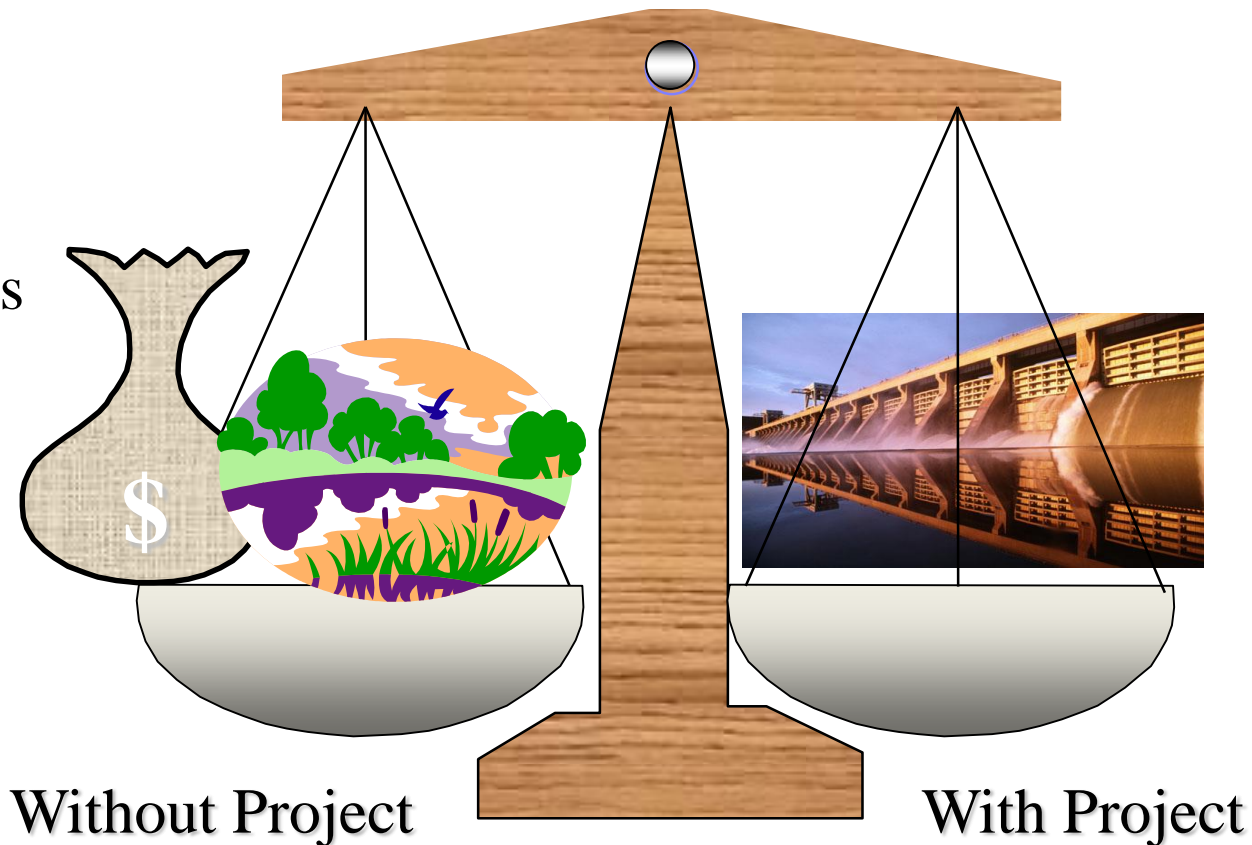
- The idea of this economic accounting originated with Jules Dupuit, a French civil engineer
 - The optimum toll for a bridge (1844)
- Cost–benefit analysis is often used by governments to evaluate the desirability of a given policy intervention.
 - Strict budget constraint of governments
 - To show necessity and effectiveness of public projects
 - To ensure the accountability to taxpayers

Cost-Benefit Analysis

- Financial Analysis
 - The private profit (a time-series cash flow) is only considered
- Cost-benefit analysis
 - includes tangible/intangible effects to the economy
 - takes into account of externalities such as pollutions to third persons/groups or environmental damages
 - considers

With-without Principle

Willingness
to pay



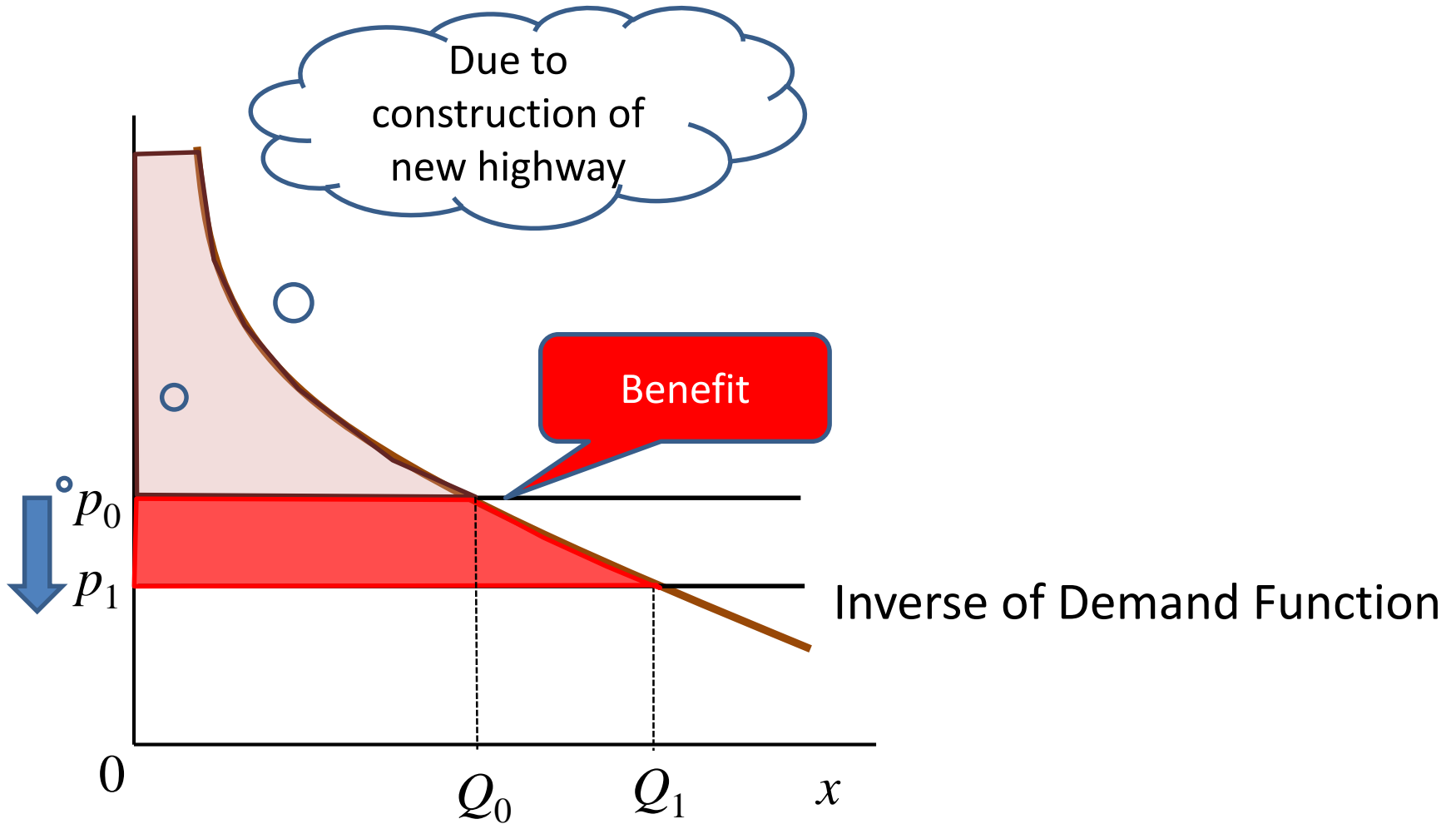
The main steps of Cost-Benefit Analysis

1. Listing items of cost/benefit for public projects?
2. Measurement and forecasting of time-series cost/benefit
3. Comparison in terms of cost/benefit between projects
4. Selection of a project

The procedure of Cost-Benefit Analysis

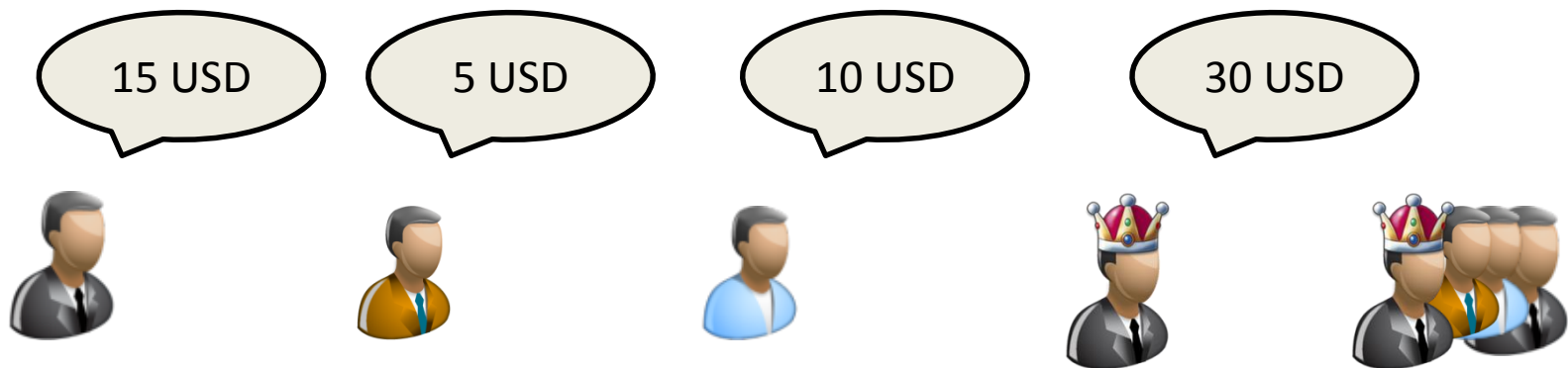
- The benefit of consumers from the project is evaluated as **consumer surplus**
- **Consumer surplus** is the difference between the maximum price a consumer is **willing to pay** and the actual price they do pay.

Definition of Benefit



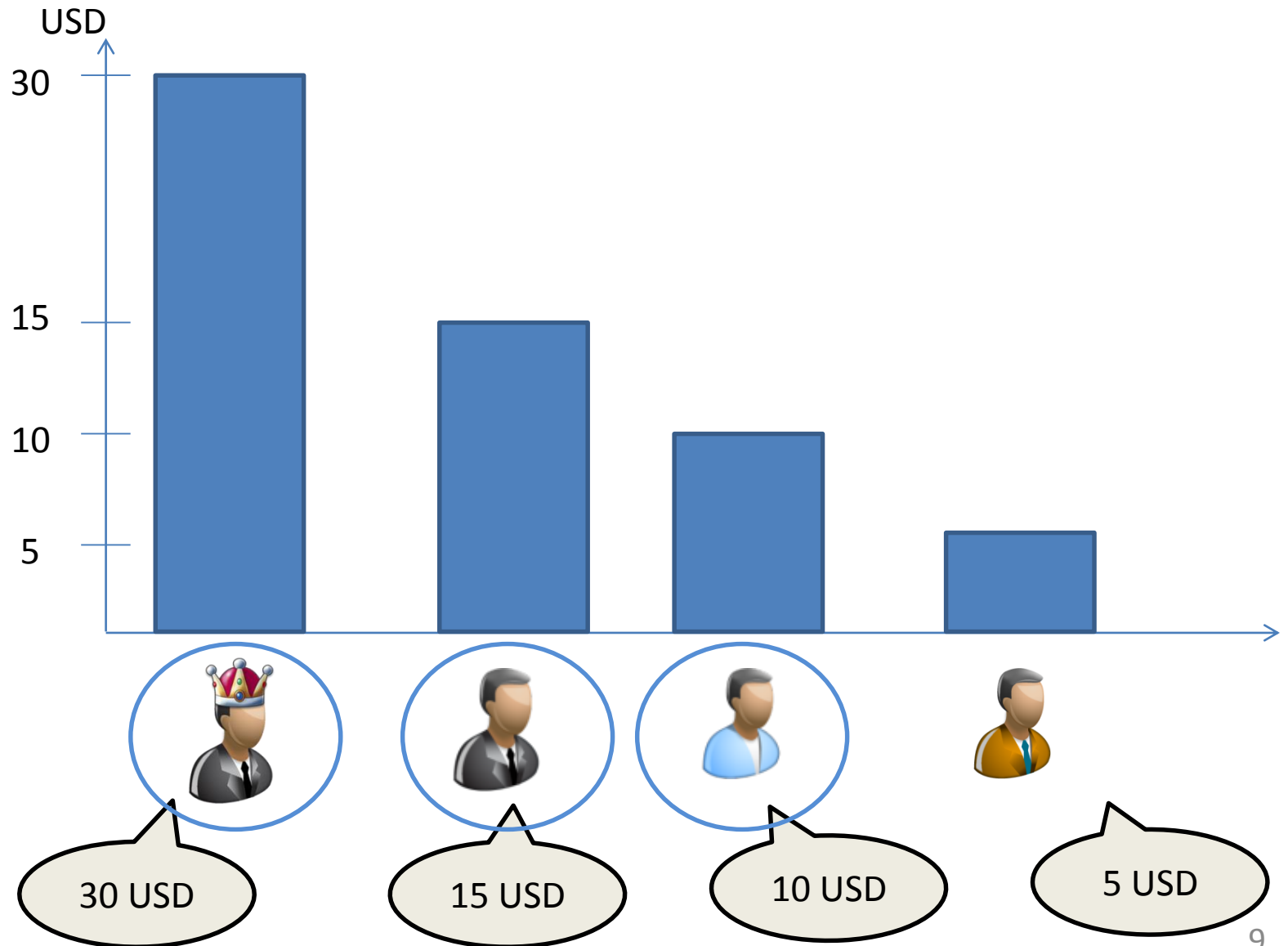
Willingness to Pay

- Ex. A new highway project
 - How much is the maximum amount of money you willing to pay when you use this highway ?

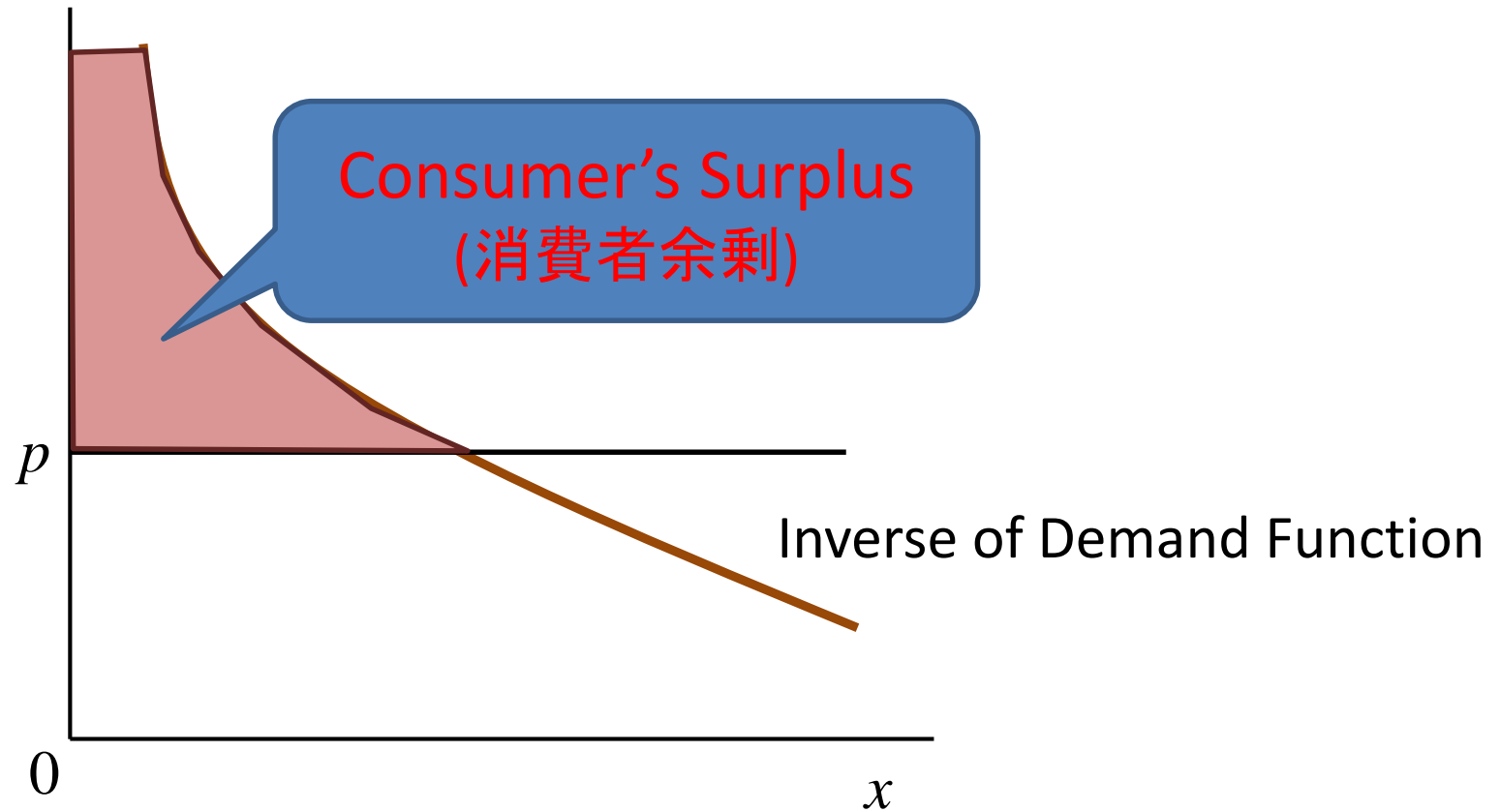


Each household has a different
willingness to pay to use the highway

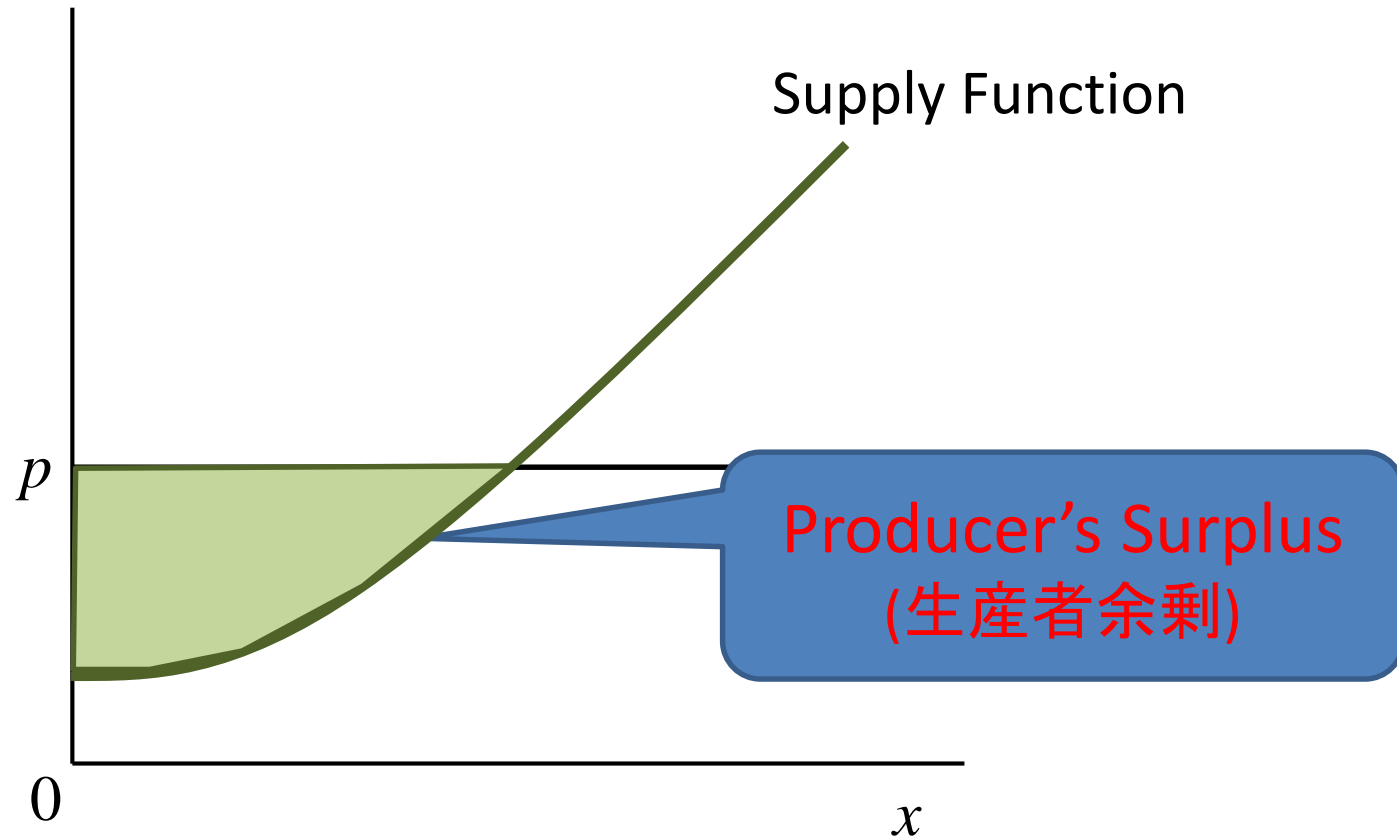
Consumer Surplus



Consumer's Surplus (消費者余剰)

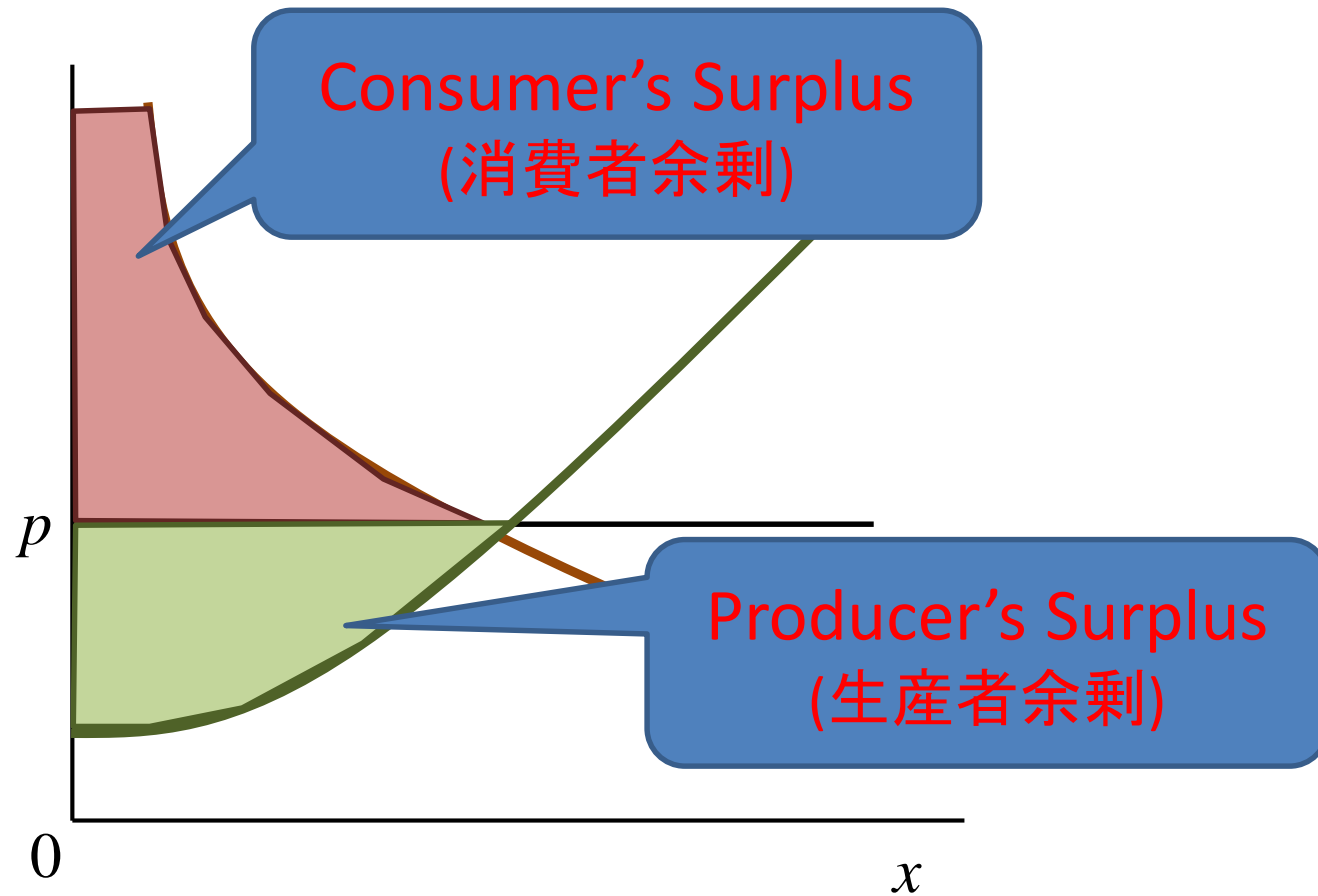


Producer's Surplus (生産者余剰)

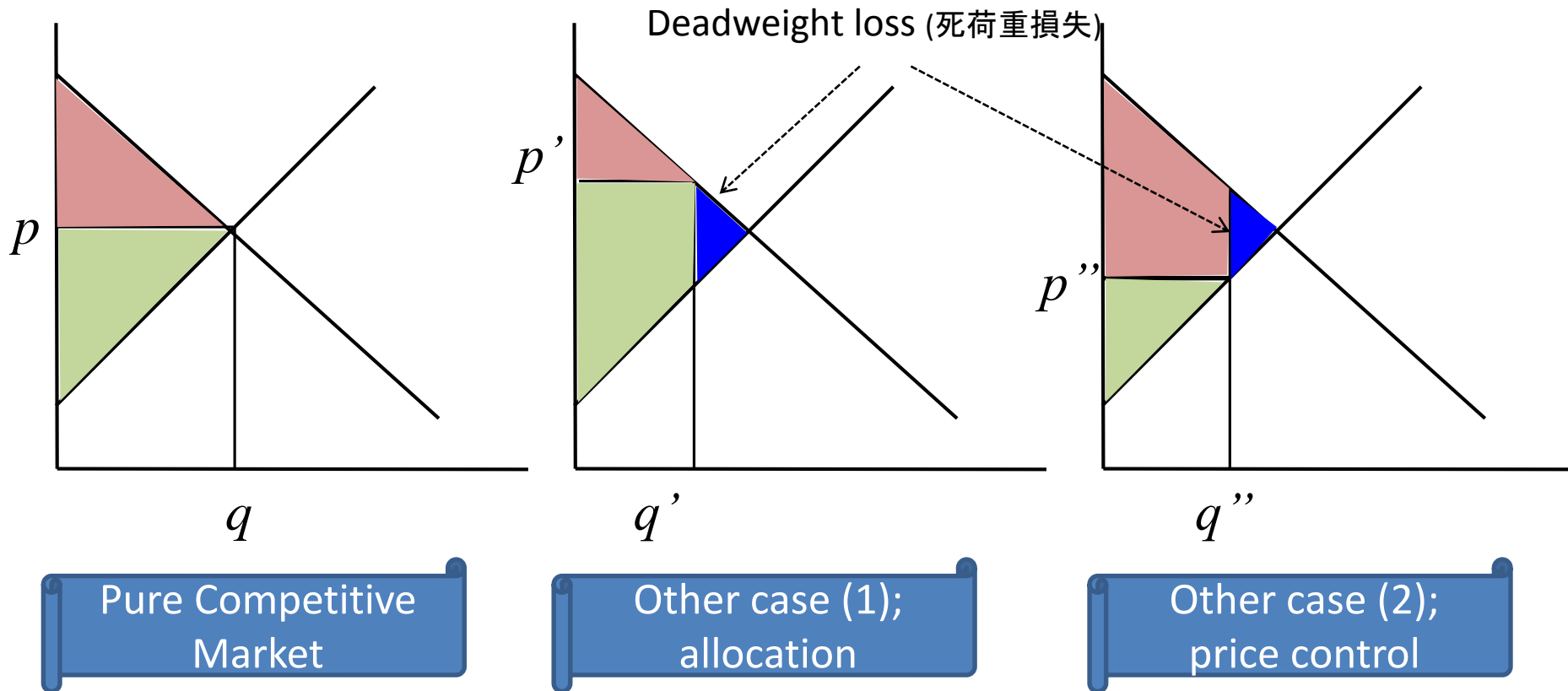


Social Surplus

(社会的余剩)



Efficiency at Pure Competitive Market



- Efficiency is measured by Social Surplus

Cost and Benefit (1)

- In general, the duration of construction project is long . Therefore, let us consider n th year project
 - Cost : c_1, c_2, \dots, c_n
 - Benefit : b_1, b_2, \dots, b_n
- The future's value is converted into the present value using **discount rate** r
 - It is assumed that the value of 10,000 yen one year's later is lower than that of now
- The present value of c_t and b_t
 - Present value of $c_t = c_t / (1+r)^{t-1}$
 - Present value of $b_t = b_t / (1+r)^{t-1}$

Cost and Benefit (2)

- The summation of present value of cost or benefit is respectively defined as;

$$C = \sum_{t=1}^n \frac{c_t}{(1+r)^{t-1}}$$

$$B = \sum_{t=1}^n \frac{b_t}{(1+r)^{t-1}}$$

Criteria for CBA

1. Net Present Value (NPV; 純現在価値)

$$NPV = B - C = \sum_{t=1}^n \frac{b_t - c_t}{(1+r)^{t-1}}$$

2. Cost Benefit Ratio (CBR; 費用便益比)

$$CBR = \frac{B}{C} = \frac{\sum_{t=1}^n \frac{b_t}{(1+r)^{t-1}}}{\sum_{t=1}^n \frac{c_t}{(1+r)^{t-1}}}$$

3. Internal Ratio of Return (IRR; 内部収益率)

$$IRR = r^* \text{ where } \sum_{t=1}^n \frac{b_t - c_t}{(1+r^*)^{t-1}} = 0$$

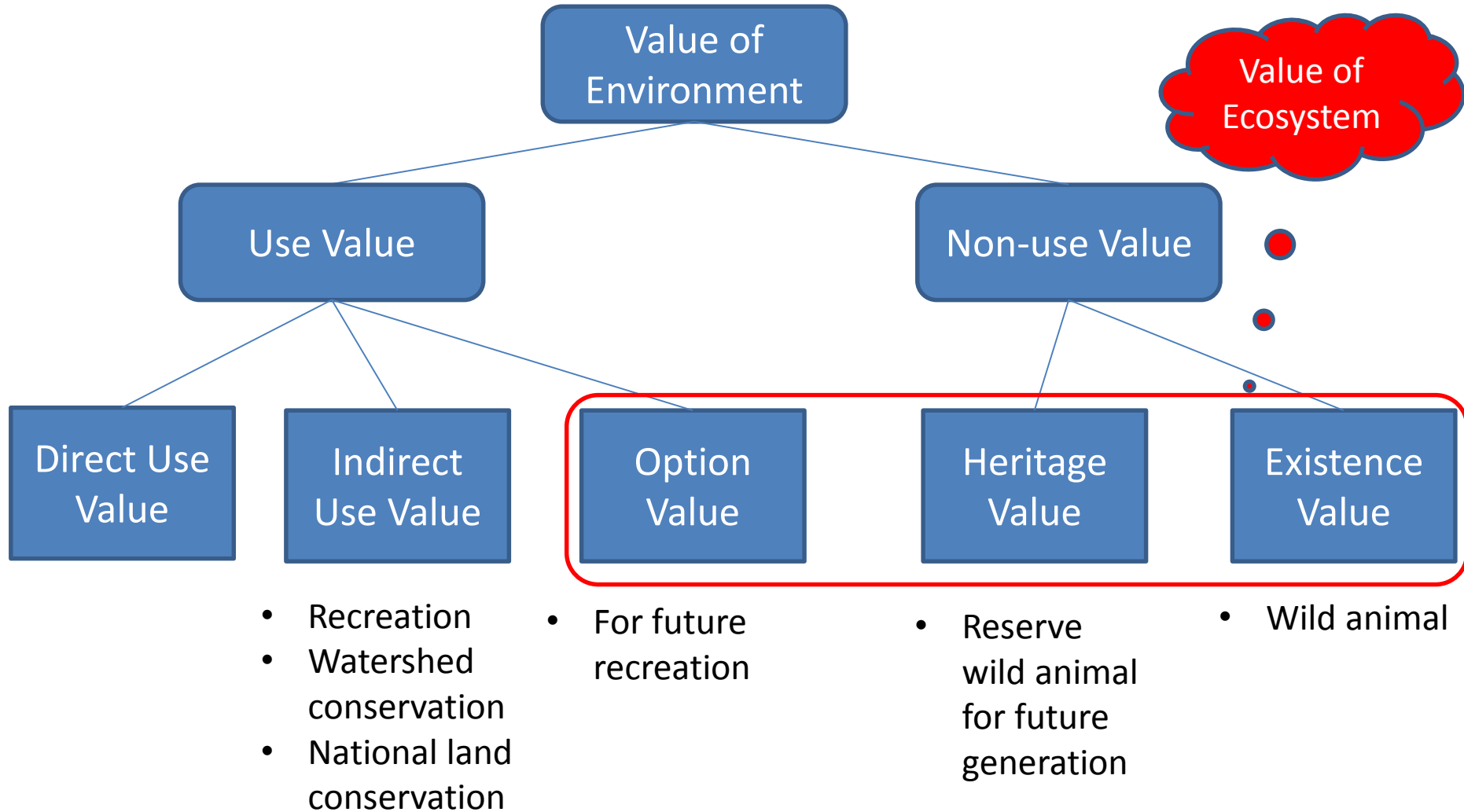
Comparison of three criteria

Criteria	Condition that a project is adopted	Feature
NPV	$NPV \geq 0$	NPV is applied when a decision maker, without considering a budget constraints, wants to adopt a project with bigger effect
CBR	$CBR \geq 1$	CBR is applied when a decision maker, with considering a budget constraints, wants to adopt an effective project
IRR	IRR is greater than a certain threshold	IRR is applied when a decision maker highly consider the profitability

Evaluation of the benefit of **Ecosystem**

- So far, it is assumed that the benefit is evaluated with the **monetary value**
- It is impossible to evaluate the benefit of ecosystem with the monetary value
 - Value of park, wild animal, ...
- **However**, if we cannot evaluate the value of them, it is difficult to preserve them.

Function of Ecosystem from the viewpoint of Utility Forms



How to evaluate the value of Ecosystem ?

- **Based on Revealed Preference (RP)**

- The value is evaluated based on the statistical data

- **Travel Cost method**

- The value of recreation is evaluated based on travel cost

- **Hedonic approach**

- The value of environmental resource is evaluated based on it's effect to the land price and the wages

- **Based on Stated Preference (SP)**

- The value is evaluated by directly asking to people

- **Contingent Value Method (CVM)**

CVM (Contingent Value Method)

- The **c**ontingent **v**aluation **m**ethod (CVM) is the methodology to ask households' willingness to pay by asking them contingent situation where the environment becomes better (or worse)
- It is widely used to evaluate non-market value

Outline of CVM

- The value of ecosystem is evaluated based on questionnaire

Example of questionnaire

- How much will you pay if you preserve the scenery against constructing a tall building?
- LRT can contribute to eco-friendly city and to create good scenery. How much will you pay to introduce LRT system?

Random Utility Model by Hanemann(1984)

“Suppose that the tax will increase
¥T/year in order to change the quality
level of the environment from Q' to
 Q'' . Do you agree with the policy?

$$V(Q'', C, M - T)$$

$$V(Q', C, M)$$

C:households' attribute

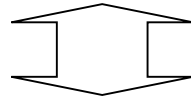
$$\begin{aligned}
& \Pr(\text{Yes}) \\
&= \Pr[V(Q'', C, M - T) + \varepsilon'' \geq V(Q', C, M) + \varepsilon'] \\
&= \Pr[\Delta V + \eta \geq 0] \\
&1 - G_n(-\Delta V)
\end{aligned}$$

If G_n follows the logistic distribution,

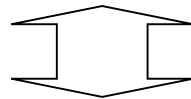
$$\Pr(\text{Yes}) = \frac{1}{1 + e^{-\Delta V}}$$

Median

$$\Pr(\text{Yes}) = 0.5$$



$$\Delta V = 0$$



$$V(Q'', C, M - CS) = V(Q', C, M)$$

Mean value $E[CS] = \int_0^{\infty} [1 - G_n(t)] dt$

The probability
where households
answer 'Yes'

