Risk Governance of Private Sector Infrastructure Management in Urban and Rural Areas

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Network Infrastructure:
Electronic power, Communication, Natural Gas,
Water supply and sewerage, Transportation, etc.

Public provision

↓ Non-exploiting price,
Non-discriminating location,
Universal service, etc.

Global movement of privatization after 1980s

Privatization of expressways in Japan

4 Public Roads Administrations (Japan Highway, JH)
→6 Expressway Company Limited.

Main purpose:
Repayment of a debt of JH in 45 years

Focus of the study

Toll systems of expressways:
Redemption system, Permanent toll system,
The toll revenue pooling system, etc.

In Japan,

1972 “Independent Redemption system of each line must bring about disparity among regions.”

➡ The toll revenue pooling system:
Uniform toll, Cross subsidy

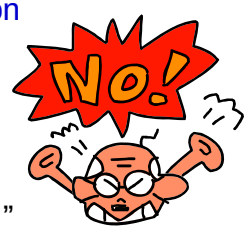
2005 Privatization

- Immediate aftermath: 10% discount
- Autonomous tolling in principle
- Introduction of price cap regulation is on table.

One of points in dispute as to privatization

“The level of service in rural areas must be deteriorated!”

“It must expand the disparity between urban areas and rural areas!”



➡ “Regulation either on toll or quality (the level of service) by government is demanded!!”

Is it true?

Purpose of the study

Taking expressway for example...

-Formulate the problem where private company determines the level of toll and quality of expressways in urban and rural areas.

-Illustrate the environments where regional disparity necessarily expands.

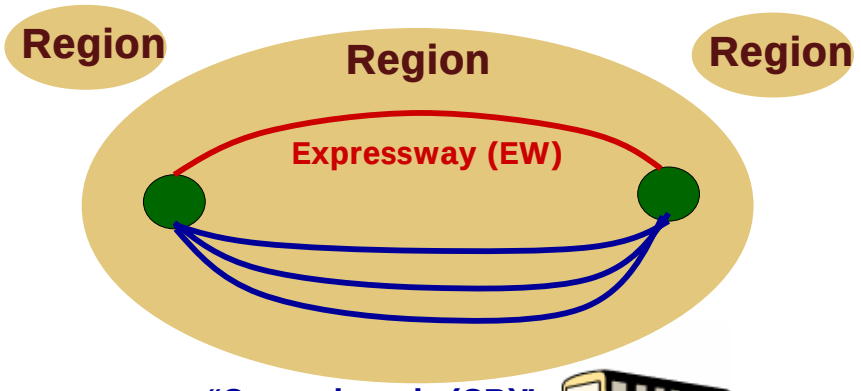
Model

private company :
Managing expressways in multiple regions for long period of time

-(in Basic model)
Total road length is given. Fixed costs are sunk.
(Roads were constructed by government in past.)

-Determine the level of toll, p, to draw its income.

-Determine the level of quality, q
(the level of service: state of pavement, PA/SA etc.)
and pay maintenance costs for it.



Users

- Heterogeneous users.

Type i : dependent on the marginal utility of quality of expressway, q.

- The number of periodical usage is constant and uniform among users.

Utility of expressway

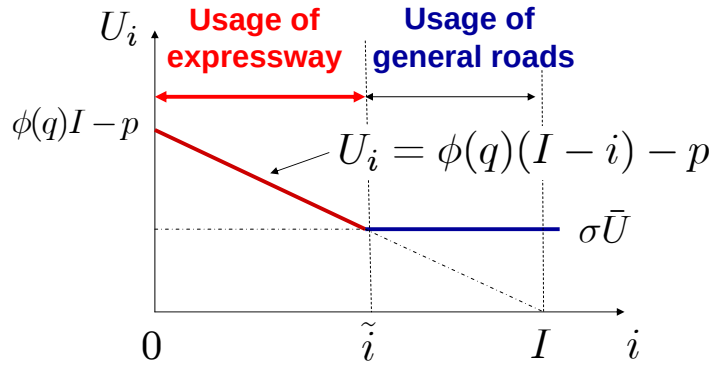
$$U_i = \phi(q)(I - i) - p, \quad 0 \le i \le I$$

$$\phi'(q) > 0, \ \phi''(q) \le 0$$

Difference between urban and rural region:
Utility of general roads $\sigma \bar{U}$

Larger in more urbanized region

Demand of expressway



Aggregate demand function

$$\tilde{i}=\frac{1}{\phi(q)}\{\phi(q)I-p-\sigma\bar{U}\}$$

Inverse demand function

$$P(\tilde{i},q)=\phi(q)(I-\tilde{i})-\sigma\bar{U}$$

Consumer surplus

$$S=\int_0^{\tilde{i}}\{\phi(I-i)-p\}d\tilde{i}+(I-\tilde{i})\sigma\bar{U}$$

Consumer surplus of general road users

Company's revenue and profits

$$R=\tilde{i}P(\tilde{i},q)=\tilde{i}(p,q)p$$

$$\pi=R-C(q)$$

Maintenance costs of quality, q

$$C'(q)>0,\quad C''(q)\geq 0$$

Social optimal solution

$$\max_{\tilde{i},q} W=S+\pi$$

Optimal conditions

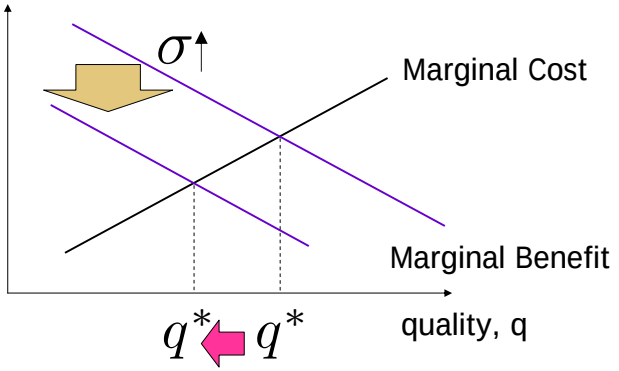
$$\tilde{i}^*=I-\frac{\sigma\bar{U}}{\phi(q^*)} \quad\Rightarrow\quad \frac{\partial\tilde{i}^*}{\partial\sigma}<0$$

$$\int_0^{\tilde{i}^*}\phi'(q^*)(I-i)di=C'(q^*)$$

Marginal Benefit (MB) Marginal Cost (MC)

Assuming MB is decreasing with respect to q,

$$\left(\frac{\partial MB}{\partial q}=\phi'(q^*)(I-\tilde{i}^*)\frac{\partial\tilde{i}^*}{\partial q}+\int_0^{\tilde{i}^*}\phi''(q^*)(I-i)di\right)$$



$$\frac{\partial q^*}{\partial\sigma}<0$$

Quality should be increased in rural region.

Market solution

$$\max_{p,q} \pi = p \cdot \tilde{i}(p,q) - C(q)$$

$$\text{s.t.} \quad \tilde{i} = \frac{1}{\phi(q)}\{\phi(q)I - p - \sigma\bar{U}\}$$

$$\frac{\partial \pi}{\partial p} = 0, \quad \frac{\partial \pi}{\partial q} = 0$$

Case of Quality Regulation ⇒ Optimal solution: p_1

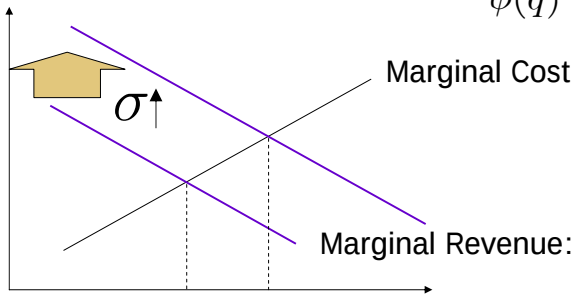
$$\frac{\partial p_1}{\partial \sigma} < 0$$

Urban region is accorded privileged treatment.

But monitoring quality is costly.

Case of Toll Regulation ⇒ Optimal solution: q_2

Marginal Revenue: $MR(\bar{p},q) = \frac{\bar{p}\phi'(q)}{\phi(q)^2}(\bar{p} + \sigma\bar{U})$



$q_2 \Rightarrow q_2$

$$\frac{\partial q_2}{\partial \sigma} > 0$$

Urban region is accorded privileged treatment.

Case without Regulation

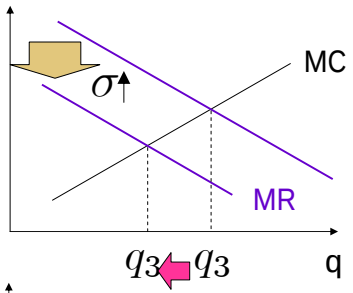
⇒ Optimal conditions

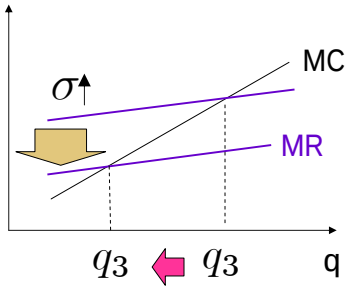
$$p_3 = \frac{1}{2}\{\phi(q_3)I - \sigma\bar{U}\}$$

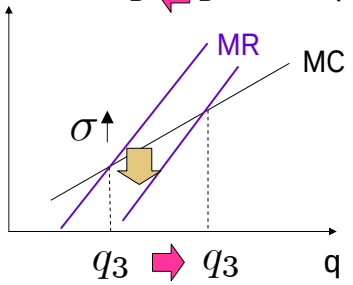
$$\frac{p_3\phi'(q_3)}{\phi(q_3)^2}(p_3 + \sigma\bar{U}) = C'(q_3)$$

Optimal solution: (p_3, q_3)

Results depend on gradient of Marginal Revenue curve.







Quality in Rural region is higher in upper two cases !!

Summery up to here

In some environments,
non-regulated market can decrease
regional disparity in quality of infrastructure.

Problem after disaster

"In case where expressways
both in urban and rural regions
are destroyed by disaster and
prompt reconstruction is required,
is private company motivated
to reset quality of rural express way
at high level?"

Problem after disaster

Assumptions

-Company manages two expressways:
Expressways in Urban region A and Rural region B.

-Two expressways are destroyed by disaster.

-Prompt reconstruction is required.

-Subsidy for reconstruction, Δ,
is provided by government.

Resource constraint of reconstruction

$$q_A + q_B = \Delta$$

- In Urban region A, some general roads are left to be passable. $\sigma\bar{U}$ is preserved.

Utility of general roads in Rural area

$\delta\bar{U}$ Case 1: $0 < \delta < 1$

Damaged, but still travelable.

Case 2: $\delta = 0$

Impassable.

Market solution

$$\max_{p_A, q_A, p_B, q_B} \quad \pi_A + \pi_B$$

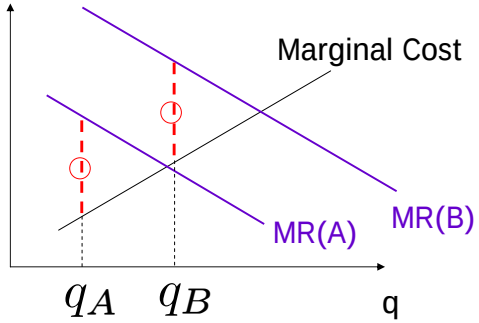
$$\text{s.t.} \quad q_A + q_B = \Delta$$

$$q_A, q_B \geq 0$$

Case 1: $0 < \delta < 1$

Rural general roads are still travelable.

$$p_A \frac{\partial \tilde{i}_A}{\partial q_A} - C'(q_A) = p_B \frac{\partial \tilde{i}_B}{\partial q_B} - C'(q_B)$$



Similar results
to those in the problem
of usual states

Case 2: $\delta = 0$

Rural general roads are impassable.

$$\tilde{i}_B(p_B, q_B) = I = \text{constant}$$

$$q_A = \Delta, \quad q_B = 0$$

All the resource is invested in expressway in
Urban region A !!

Implication and Conclusion

In case that disaster destroys Rural general roads completely to be impassable,

1. Regulation on quality of expressway may be required, although monitoring is costly .
2. Alternative transportation in Rural region should be restored.

Future tasks

-Evaluate social welfare.

-Investigate effects of other policies such as subsidy on toll.

Thank you.