Benefits and Costs in Primary Markets

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BGVVW Chapters 3 & 4
Outline

- Questions
- Consumer surplus and producer surplus
- Social benefit (Gross consumer surplus)
- Social surplus
- Costs and producer surplus
Questions

- How to measure the benefits of a public project (for example a transportation investment)?
- How to measure the benefits of a price change?
- Can a money-losing project be justified?
- Should an increase in tax revenues of a local government be included in the benefits?
Consumer surplus and producer surplus: Review

- **Consumer surplus**: The area to the left of a demand curve
  - Height of a demand curve = Willingness to pay (WTP)
  - WTP: Maximum amount an individual is willing to pay to obtain something good
  - Net benefit for a consumer = WTP - Price

- **Producer (supplier) surplus**: The area to the left of a supply curve
  - Height of a supply curve: Opportunity cost = Marginal cost
  - Opportunity Cost: Value of an input in its best alternative use

- **Social Surplus**: Consumer surplus + Producer surplus
Benefits in the primary market

- Forecast quantities demanded, prices, and costs for Without and With cases (four points in a market).
- Estimate net benefits using the rule of a half if demand curves are linear.
Consumer surplus: The rule of a half (Trapezoid rule)

- The demand curve is often assumed to be a straight line.
- Rule of a half (Trapezoid rule) for a linear demand curve:
  Example: \( p^B \rightarrow p^A \)
  - B: Without
  - A: With
  \[
  B = \frac{1}{2} \left( p^B - p^A \right) \left( Q^A + Q^B \right)
  \]
Gross Consumer Surplus (Social Benefit) & Consumer Surplus

- Gross Consumer Surplus (Social Benefit) = Consumer Surplus + Expenditure
  - GCS is often called Social Benefit in Public Economics textbooks.
  - GCS is the total amount of WTP
  - GCS includes the price that consumers pay.
- Expressway case:
  - \( \Delta GCS (SB) = (3342 + 2592) \times (16 - 8)/2 \)
  - \( = 23,736 \) (thousand yen)

\[
\Delta GCS (= \Delta SB) = \frac{1}{2} \left( p^B + p^A \right) \left( Q^A - Q^B \right)
\]
Social Surplus with GCS and ASC

- **Social Surplus: GCS**
  - Social Cost (SC)
  - \( SC = ASC \times Q \)
- **\( \Delta GCS = \) Hatched Area**
- **\( \Delta SC = \) Thick Line Area**
- **\( \Delta SS = \Delta GCS - \Delta SC \)**
Two ways of measuring the social surplus

- SS = GCS – SC
- SS = CS + PS + GR – EC
  - GR: Government Revenue
  - EC: External Costs
- Relationship
  - GCS = CS + Expenditure
  - PS = Revenue for suppliers – Private (variable) cost $c(Q)$
  - SC = Private (variable) cost + EC
  - GR = Expenditure – Revenue for suppliers
Total Costs, Average Costs, and Marginal Cost

- Cost concepts: Total Cost, Total Variable Cost, Fixed Cost, Average Cost, Marginal Cost
- \( TC = TVC + F \)
- \( AC = \frac{TC}{Q} \)
- \( AVC = \frac{TVC}{Q} = \frac{(TC – F)}{Q} \)
- \( MC = \frac{\Delta TC}{\Delta Q} = \frac{\Delta TVC}{\Delta Q} = MVC \)
Average Costs and Marginal Cost

\[ TVC(Q) = \int_0^Q MC(q) dq \]
Total and Marginal Costs: Discrete Quantities

\[ TVC(Q) = \int_0^Q MC(q) dq \approx \sum_{i=1}^n MC(q_i) \Delta q \]

\[ q_1 = 0; q_{i+1} = q_i + \Delta q; q_n + \Delta q = Q \]
Producer Surplus

- Producer Surplus: Area to the left of the supply curve

Supply Curve = MC Curve
  - A supply curve assumes that suppliers are competitive.

Two equivalent estimation methods: MC or AC(AVC)

PS (Producer surplus) = Revenue – TVC
  - TVC = Area under MC curve (hatched area) = AVC x Q (rectangle)
Quick Questions #3_1

- Is it true that when MC > AC, AC is downward sloping?
- Should you add to the benefits an increase in employment caused by constructing a dam? How about in an area with serious unemployment problem?
- Should you add to the benefits an increase in tax revenue generated by a road investment?
Summary: Measuring the social surplus in the primary market

- \( SS = GCS - SC \)
- \( SS = CS + PS + GR - EC \)

Relationships

- \( GCS = CS + \text{Expenditure} \)
- \( PS = \text{Revenue for suppliers} - \text{Private (variable) cost} \)
- \( SC = \text{Private (variable) cost} + EC \)
- \( GR = \text{Expenditure} - \text{Revenue for suppliers} \)

- Total costs, average costs, marginal costs
  - \( TC = AC \times Q \)
  - \( TVC = \text{Area below the MC curve} \)
Surpluses with average costs

\[ Q = d(p) \]

\[ p \]

\[ p - t \]

\[ ASC \]

\[ AC \]

\[ EC \]

\[ TSC \]

\[ CS \]
Surpluses with marginal costs

\[ Q = d(p) \]

\[ p \]

\[ p - t \]

\[ MSC \]

\[ MC \]

\[ EC \]

\[ TSC \]

\[ Q \]
Complexity of applications

- **Highway**
  - Price: Generalized cost including time costs, operating costs, expressway tolls
  - Social costs: Include external costs, but exclude transfers (taxes and tolls)

- **Education and training program:**
  - Raises wage rates
  - Price: Wage rate
  - Social costs of labor supply: Can be measured by the supply curve
Expressway Case: NIHONKAI-TOHOKU EXPRESSWAY (Shibata - Niigata)

Toll reduction experiment

<table>
<thead>
<tr>
<th>Route Type</th>
<th>Local Road</th>
<th>Expressway</th>
<th>Local Road</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance (km)</td>
<td>24</td>
<td>26</td>
<td>4</td>
</tr>
<tr>
<td>Speed (km/hour)</td>
<td>28</td>
<td>80</td>
<td>30</td>
</tr>
</tbody>
</table>

Evaluate the benefits of a toll reduction from ¥750 to ¥0.
Expressway Case: Cost Structure

- User costs (Generalized cost): Costs paid by each user, corresponds to price in a demand-supply diagram
  - Time costs
  - **Expressway tolls:** transfer
  - Operating costs
    - **Fuel tax:** Transfer
    - Fuel costs, Depreciation costs, etc.

- Social costs: costs borne by society as a whole (users + non-users)
  - User costs excluding transfers
    - Time costs
    - Vehicle operating costs (excluding fuel tax)
  - **External costs**
    - Global warming
    - Air pollution
    - Accidents
    - (Congestion externality: already included in user costs)

References: World Bank Transport Notes No. TRN-5, 14, 15, 16
Many of the materials in the notes will be treated later in the course.
Expressway Case: Estimates of the generalized cost and traffic volume in the Without case

<table>
<thead>
<tr>
<th>Cost components</th>
<th>Expressway Route</th>
<th>Local Road Route</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time (minutes)</td>
<td>27.5</td>
<td>51.43</td>
</tr>
<tr>
<td>Time cost (yen/vehicle)</td>
<td>2,167</td>
<td>4,052</td>
</tr>
<tr>
<td>Toll (yen/vehicle)</td>
<td>750</td>
<td></td>
</tr>
<tr>
<td>Operating costs (yen/vehicle)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel tax (C1)</td>
<td>146</td>
<td>153</td>
</tr>
<tr>
<td>Operating cost - Fuel tax (C2)</td>
<td>280</td>
<td>515</td>
</tr>
<tr>
<td>Generalized cost (yen/vehicle) (A+B+C1+C2)</td>
<td>3,343</td>
<td>4,720</td>
</tr>
<tr>
<td>Traffic (vehicle/Day)</td>
<td>8,000</td>
<td>24,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cost components</th>
<th>Cost per unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel cost (yen/vehicle, km) 28km/h</td>
<td>6.37 (6.37)</td>
</tr>
<tr>
<td>30km/h</td>
<td>6.16 (6.15)</td>
</tr>
<tr>
<td>Expressway 80km/h</td>
<td>4.70 (4.66)</td>
</tr>
<tr>
<td>Time cost (yen/vehicle, minute)</td>
<td>78.8</td>
</tr>
<tr>
<td>Operating cost (yen/vehicle, km)</td>
<td>27.8</td>
</tr>
<tr>
<td></td>
<td>27.4</td>
</tr>
<tr>
<td>Expressway</td>
<td>12.1</td>
</tr>
</tbody>
</table>

Based on MLIT 2003 Manual

- Obtain unit cost estimates (e.g., fuel cost per vehicle kilometer) from a variety of sources such as manuals, guidelines, academic research, past experiences
## Expressway Case: Estimates of social costs

<table>
<thead>
<tr>
<th>Cost components</th>
<th>Expressway Route</th>
<th>Local Road Route</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>User costs (Exc. taxes &amp; tolls)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subtotal (A)</td>
<td>2,447</td>
<td>4,567</td>
</tr>
<tr>
<td>Time cost</td>
<td>2,167</td>
<td>4,052</td>
</tr>
<tr>
<td>Operating cost (Excl. taxes &amp; tolls)</td>
<td>280</td>
<td>515</td>
</tr>
<tr>
<td><strong>Taxes &amp; Tolls</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subtotal (B)</td>
<td>896</td>
<td>153</td>
</tr>
<tr>
<td>Expressway toll</td>
<td>750</td>
<td></td>
</tr>
<tr>
<td>Fuel tax</td>
<td>146</td>
<td>153</td>
</tr>
<tr>
<td><strong>Generalized cost</strong></td>
<td>(A+B)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3,343</td>
<td>4,720</td>
</tr>
<tr>
<td><strong>External costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subtotal (C)</td>
<td>120</td>
<td>232</td>
</tr>
<tr>
<td>Global warming</td>
<td>50</td>
<td>53</td>
</tr>
<tr>
<td>Air pollution</td>
<td>26</td>
<td>27</td>
</tr>
<tr>
<td>Accident costs</td>
<td>44</td>
<td>152</td>
</tr>
<tr>
<td><strong>Social cost</strong></td>
<td>(A+C)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2,567</td>
<td>4,800</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cost components</th>
<th>Cost per unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accident costs (yen/vehicle, km, day)</td>
<td>6.36</td>
</tr>
<tr>
<td>Local</td>
<td>0.74</td>
</tr>
<tr>
<td>Global warming (yen/liter)</td>
<td>19.3</td>
</tr>
<tr>
<td>Air pollution (yen/liter)</td>
<td>9.9</td>
</tr>
</tbody>
</table>
The Benefit of Expressway Toll Reduction

- Estimate the benefit of the Expressway toll reduction: 750 to 0

- Impacts of the toll reduction:
  - Expressway route: From 8,000 to 16,000 vehicles per day
  - Local road route: From 24,000 to 18,000

- Changes in GCS and SC

- Complications
  - External costs and benefits
  - Taxes and toll revenues
  - Secondary markets
    - If no price distortion, benefits and costs measured in monetary unit cancel out each other.
    - With price distortions, net benefits or costs in secondary markets: Congestion reduction in another route
The expressway case: The primary market

- External costs, taxes and tolls (per vehicle, average costs)
  - Expressway toll = 750 yen/vehicle, Fuel tax = 146 yen/vehicle, External costs: 120 yen/vehicle
  - Without: Generalized cost = 3,343 yen/vehicle; Social cost = 2,567; Traffic = 8,000 vehicles/day
  - With: Generalized cost = 2,592 yen/vehicle; Social cost = 2,567, Traffic = 16,000 vehicles/day

\[ SS = GCS \ (SB) - SC \]

\[ \Delta GCS \ (SB) = (3,343 + 2,593) \times (16 - 8) / 2 = 23,744 \]
\[ \Delta SC = 2,567 \times (16 - 8) = 20,536 \]
\[ \Delta SS = \Delta GCS - \Delta SC = 3,208 \]

\[ SS = CS + PS + Gov. Revenue - External Costs \]

\[ \Delta CS = (3,343 - 2,593) \times (16 + 8) / 2 = 9,000 \]
\[ \Delta PS = (3,343 - (750+146)-2447) \times 8 - ((2,593-146)-2447) \times 16 = 0 \]
  - Drivers/users are the suppliers of transportation services.
\[ \Delta Gov. Revenue = 146 \times 16 - (750+146) \times 8 = -4,832 \]
  - The highway company is included in the government sector.
\[ \Delta External Costs = 120 \times 8 = 960 \]
\[ \Delta SS = \Delta CS + \Delta PS + \Delta Gov. Revenue - \Delta External Costs = 3,208 \]
Expressway example: Social Surplus

\[ Q = D(p) \]

\[ p^A = 2,593 \]

\[ p^B = 3,343 \]

\[ ASC^b = ASC^A = 2,567 \]

\[ ∆CS \]

\[ ∆SS \]

\[ ∆GCS \]

\[ ∆SC \]

\[ Q^B = 8,000 \]

\[ Q^A = 16,000 \]
Applications:
Deficit does not mean a negative net social benefit

- $SS = SB - TVC$
  $= CS + PS$

- $PS = pQ - TVC$

- Deficits do not mean negative net social benefits

- Net Social Benefit
  $= SS - F$
  $= CS - Deficit$
Applications: Traffic congestion

- **AVC**: Private cost borne by each user = Average cost per person

- Congestion: Upward sloping AVC
  - MC > AC ↔ Marginal Social Cost > Private Cost

- Social surplus when congestion tolls are not levied?
  - With AC, the triangle
  - With MC, the hatched area minus the shaded area (called the deadweight loss)