VALUING IMPACTS FROM OBSERVED BEHAVIOR: INDIRECT MARKET METHODS

EE465/EE463 Project Evaluation

Semester 2/2015

Based on Chapter 14 of *Cost-Benefit Analysis: Concepts and Practice*, Boardman et al., 2011.

Intro

- In many applications of CBAs, the markets for certain "goods," such as human life or pollution, do not exist or are imperfect.
  - It's impossible to estimate to use the market demand (or supply) directly.
  - Instead, analysts try to obtain estimates of what the market price would be if the relevant good were traded in a market where the demand curve measures MSB and the supply curve measures MSC.
    - i.e. estimate the "shadow price"
- This lecture explains various methods for estimating shadow prices of non-marketed goods based on *observed behavior*.

Methods for estimating shadow prices

- Market analogy method
- The trade-off method
- Intermediate good method
- Asset valuation method
- Hedonic pricing method
- Travel cost method
- Defensive expenditures method

MARKET ANALOGY METHOD (1)

1. Using the market price of an analogous good as a shadow price

- The market price of a comparable good in the private sector provides a good estimate of the value of a publicly provided good if it equals the users' average willingness-to-pay for the publicly provided good.

  Example: Suppose comparable housing units in private sector charges $500/mo rent. The benefits of 50 publicly provided units would be $25,000. What if the govt charges $200 per unit?

- Where the government provides a good or service at a lower than market price, the price paid by consumers would generally *underestimate* the benefit of this good or service.

MARKET ANALOGY METHOD (2)

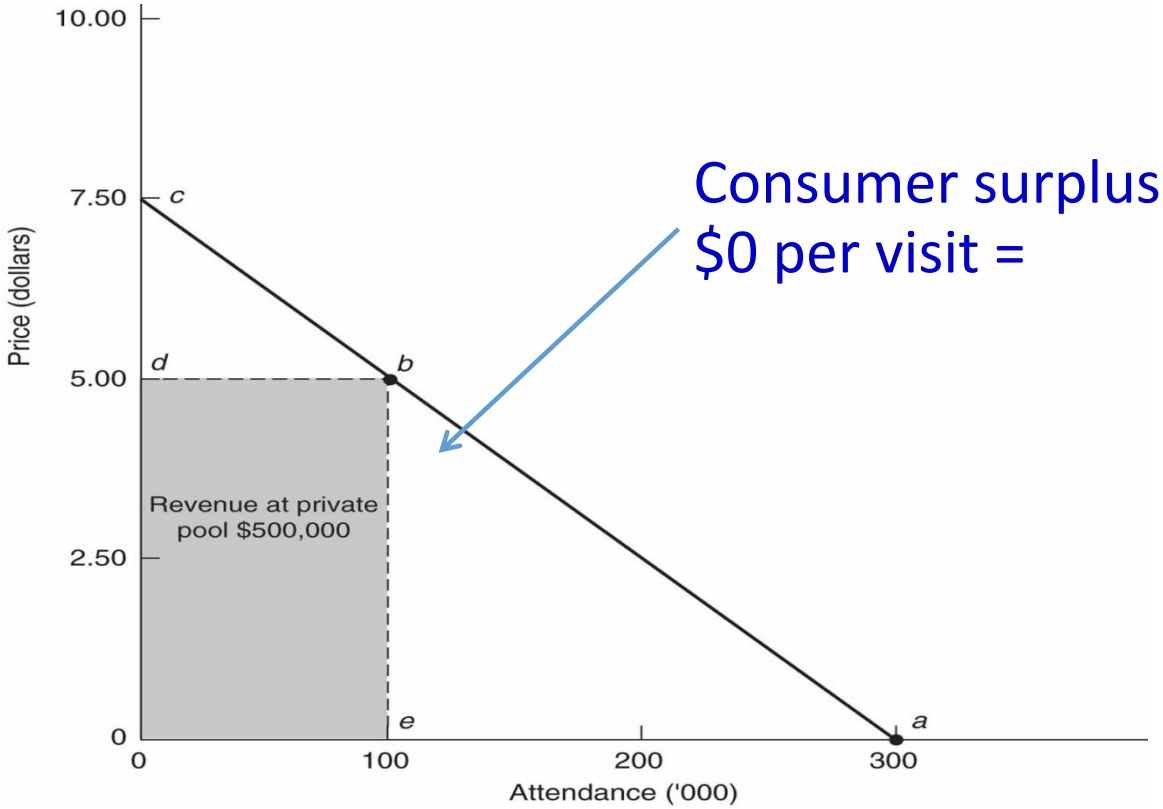
2. Using information about an analogous private-sector good to estimate the demand curve for a publicly provided good

- Rather than focusing on WTP, it is conceptually better and easier to think about the demand curve for the good
- We can use private-sector data to help map out the demand curve for a publicly-provide good if the goods and their markets are similar.
- Note that, using expenditures alone *underestimates* total benefits because it ignores consumer surplus.

Example: Suppose a local govt want to measure the gross benefits of a swimming pool that it owns and operates.

- No charge
- 300,000 visitors/year
- A private pool charges $5 and has 100,000 visitors/year.

Demand Curve for Visits to a Municipal Swimming Pool



Consumer surplus for charging $0 per visit =

Assume the local govt changes $0.

- The consumer surplus for the public pool is:
- Using revenues at the private pool would underestimate the benefits of the public pool by:

THE TRADE-OFF METHOD

Economists may use the opportunity cost as a measure of the value of what one gives up to get something.

- The value of time saved (including the value of travel time saved):
  - Time saved could be valued using the after-tax wage rate.
  - Example: foregone earning during time spent on traveling or waiting
- The value of statistical life:
  - A statistical life could be valued using the trade-off that people make between changes in fatality risk and wages.
  - Example: a monetary value of a life saved can be use to determine the benefits of projects.

THE TRADE-OFF METHOD:
The Value of Time Saved, VTS

- In the absence of market imperfections (i.e., people can choose the number of hours they work and there is no unemployment), the wage rate equals the marginal value of time.

  Example: The value of a govt project that saves an hour of a person who earns $20/hr is worth $20 to that person and to the society as a whole.

- Problems with using the wage rate to value time saved:
  - Wages ignore benefits.
  - People could be working while traveling or waiting.
  - People value different types of time differently.
  - The wage rate may not be appropriate.

THE TRADE-OFF METHOD:
The Value a Statistical Life, VSL (1)

1. Forgone earnings method

- This method is an inappropriate method.
- It suggests the value of a life saved equal the person's discounted future earnings.
- It generates higher values for young, high-income males than old, low-income females
- The fundamental problem with this method is that it ignores individuals' WTP to reduce the risk of their own deaths.
  - Distinction between the deaths of identifiable individuals and *statistical deaths*. Ex: Benefits of safety improvement programs

THE TRADE-OFF METHOD:

The Value a Statistical Life, VSL (2)

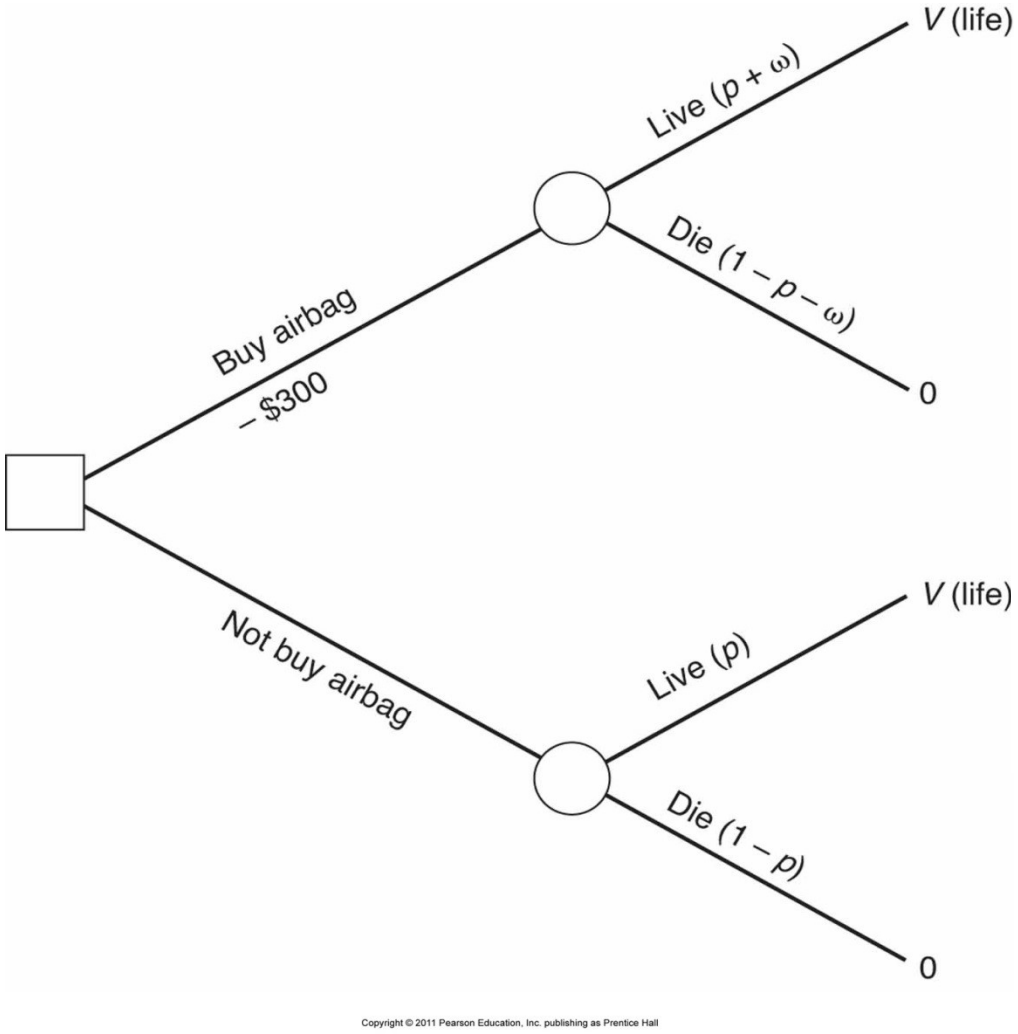
2. Simple Consumer Purchase Studies

- This method estimates the value of life by observing how much people pay for life-saving devices, such as safety belts.

Example: Suppose the airbag (costs $300) would increase your survival rate from use of the car from p to $p+\omega$. Would you buy the airbag?

- 2 alternatives:
  1. Buy airbag ➔ $EV = (p+\omega)V(life) - \$300$
  2. Not buy airbag ➔ $EV = pV(life)$
- If you are indifferent between the two alternatives, then:

Decision Tree for Airbag Purchase



- If people are indifferent between paying an extra $300 to reduce the probability that they will die by 0.0001 (ω = 1/10,000), then:

  V(life) =

THE TRADE-OFF METHOD:
The Value a Statistical Life, VSL (3)

3. Simple Labor Market Studies

- If a person is willing to give up an extra $3500/year to increase the probability that he will not have a fatal job-related accident by 1/1,000, then he values his life by $3,500,000.
- In general, if $\$a$ is the amount workers are willing to accept in order to compensate for greater risk, and ω is the change in fatality risk, then the VSL is given by:

$$VSL = \frac{\$a}{\omega}$$

Potential problems with simple consumer and wage-risk studies in estimating VSL

1. Workers may not fully understand the risks.
2. People in the studies may not be representative of the population.
3. They assume that researchers have accurate measures of the risks.
4. The WTP to reduce fatality risk (i.e., the estimated VSL) depends on both the risk level and the change in the risk level due to the policy. People probably have diminishing marginal utility for safety.
5. It is assumed that the relevant markets are efficient and all other variables are constant (no omitted variable problem).

Illustration: Omitted Variable Issue in VSL

EXHIBIT 14-1

Are estimates of the value of life that rely on wage premiums that workers receive for working in risky jobs systematically understated? Robert Frank and Cass Sunstein argue that they are understated by 18 to 75 percent *if* they are used to measure WTP for government safety regulations that improve the safety of *all* workers. According to Frank and Sunstein, the reason is that workers who decide to take relatively safe jobs pay for their additional safety by bearing two costs: they lose the wage premium they would receive if they took a more dangerous job and they are lower down in the wage distribution and thus lose status. Both factors affect their WTP for safety, although only the first is reflected in measures of the value of a statistical life that are based on wage premiums. However, a safety regulation that is universally applied reduces risk for everyone without affecting economic position. Thus, workers would be willing to pay more for such a regulation than the amount reflected by wage premiums alone.

Thomas Kniesner and Kip Viscusi take issue with this conclusion for several reasons. They point out that estimates of wage premiums for workplace risk differences are fairly small, on the order of a few hundred dollars a year, and thus are unlikely to have much of an effect on economic status. Kniesner and Viscusi further argue that, even if wage premiums do positively influence status, these gains may be offset because relatively risky jobs are likely to affect feelings of well-being adversely insofar as, by definition, health and safety are lower in such jobs.

Source: Adapted from Robert H. Frank and Cass R. Sunstein, "Cost-Benefit Analysis and Relative Position," *University of Chicago Law Review* 68(2) 2001, 323–374; and Thomas J. Kniesner and W. Kip Viscusi, "Cost-Benefit Analysis: Why Relative Economic Position Does Not Matter," *Yale Journal on Regulation* 20(1) 2003, 1–24.

INTERMEDIATE GOOD METHOD

- If a project produces an *intermediate good* that is not sold in a well functioning market, then its value can be imputed by determining the **value added** to the "downstream activity":

  Annual Benefit = NI(with project) – NI(without project)

  where NI = net income of downstream business.

- This method can be used to value improvements in human capital, such as training programs, by comparing the average incomes of those in the program to those who are not.

- Some problems with this method:
  1. It assumes the difference in income captures all of the benefits (there may be consumption benefits as well as investment benefits)
  2. It assumes all other variables are held constant (e.g., educational ability).

Illustration: Intermediate Good Method

EXHIBIT 14-2

Many studies have used the intermediate good method to value the social benefits from education. These studies usually measure the social benefits from a college education as the difference between the before-tax earnings of college graduates and those whose education stopped after graduating from high school. Some of these studies also estimate the cost of education—tuition fees, tax revenues, donations, and earnings that are forgone while in college. These estimates of benefits and costs can be used to compute the rate of return to different additional amounts of education. George Psacharopoulos, for example, found that the average rate of return to society from secondary schooling is 10 percent in developed countries, 18 percent in sub-Saharan countries, and 11 to 13 percent in other developing countries. The estimated average rate of return to society from investments in higher education is 9 percent in developed countries and 11 to 12 percent in developing countries. The rate of return to private individuals is higher than these estimates because they capture the benefits, whereas the cost is often subsidized by the government or donors.

Source: Adapted from George Psacharopoulos, "Returns to Investment in Education: A Global Update," *World Development* 22(9) 1994, 1325–1343.

ASSET VALUATION METHOD

- The impacts of a project or policy can be imputed from changes in the price for certain capital goods.
  - Example: The "value" of noise can be inferred from comparing the price of a house in a noisy neighborhood to the price of a similar house in a quiet neighborhood.
- **Event study:** Changes in the market values of firms following a regulatory change can be used to estimate the change in producer surplus of the new regulations.
  - An advantage of using market prices is that information is quickly and efficiently capitalized into prices so that price changes or price differences provide a good estimate of the value of the policy change.
  - Appropriate data are often available in machine readable form.

Problems with Simple Valuation Methods (1)

- The omitted variable problem
  - The previous methods assume that all other explanatory variables are held constant.
  - However, if a relevant variable is omitted from the model, then the estimated value may be biased.

Example:

- Use of intermediate good method:
  - Valuation of irrigation by comparing the income of farmers if the irrigation project were built with the income of farmers if the project were not built
  - But, farmers' income may depend on factors other than the irrigation project.
- VSL in simple labor market studies
  - Differences in wages may depend on other factors (say, ability, intelligence, etc.)

Problems with Simple Valuation Methods (2)

- Self-selection bias
  - The self-selection problem arises when different people attach different values to particular attributes.

  Examples:

  - Rent-seeking people tend to self-select themselves to dangerous jobs.
    - An underestimation of the value of a statistical life.
  - People who are not bothered much noise naturally tend to move into noisy neighborhoods.
    - An underestimation of the shadow price of noise.

THE HEDONIC PRICE METHOD

- A.k.a. the hedonic regression method
- It can be used to value an attribute, or a change in an attribute, whenever its value is capitalized into the price of an asset, such as houses or salaries.
- It offers a way to overcome problems from *omitted variables* and *self-selection bias*.
- Example: Estimating the value of a scenic view

  1. Estimate the effect of a marginally better scenic view on the value of houses, while controlling for other variables that affect market prices of a house.

  2. Estimate the WTP for scenic views, after controlling for tastes.

Step 1: Estimate the effect of a marginally better scenic view on the value (price) of houses.

- We may hypothesize the following multiplicative model:

$$P = \beta_0 CBD^{\beta_1} SIZE^{\beta_2} VIEW^{\beta_3} NBHD^{\beta_4} e^{\varepsilon}$$

where CBD = the distance from the central business district

size = the lot size

view = the quality of its scenic view

NBHD = various characteristics of the neighborhood

- This equation is called a *hedonic price function* or *implicit price function*.
- The change in the price of a house that results from a unit change in a particular **attribute** (i.e., the slope) is called the *hedonic price*, *implicit price*, or *rent differential* of the attribute.

Step 1 (cont'd)

- The **hedonic price** can naturally be interpreted as the additional cost of purchasing a house that is marginally better in terms of a particular attribute.
  - Example: The hedonic price of scenic views (r_v) measures the additional cost of buying a house with a slightly better scenic view.
- From the above model, we can derive r_v as:

$$r_v = \beta_3 \frac{P}{VIEW} > 0$$

- Derivation of r_v:

Step 2: Estimate the WTP for scenic views

- The WTP function (inverse demand function) for scenic views:

$$r_v = W(VIEW, Y, Z)$$

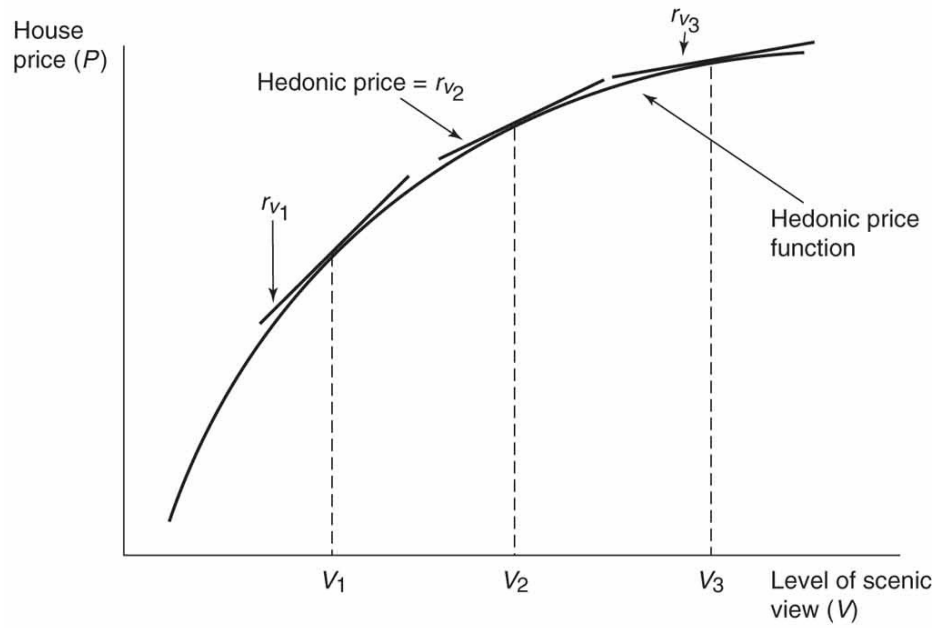
where r_v is the price of scenic view

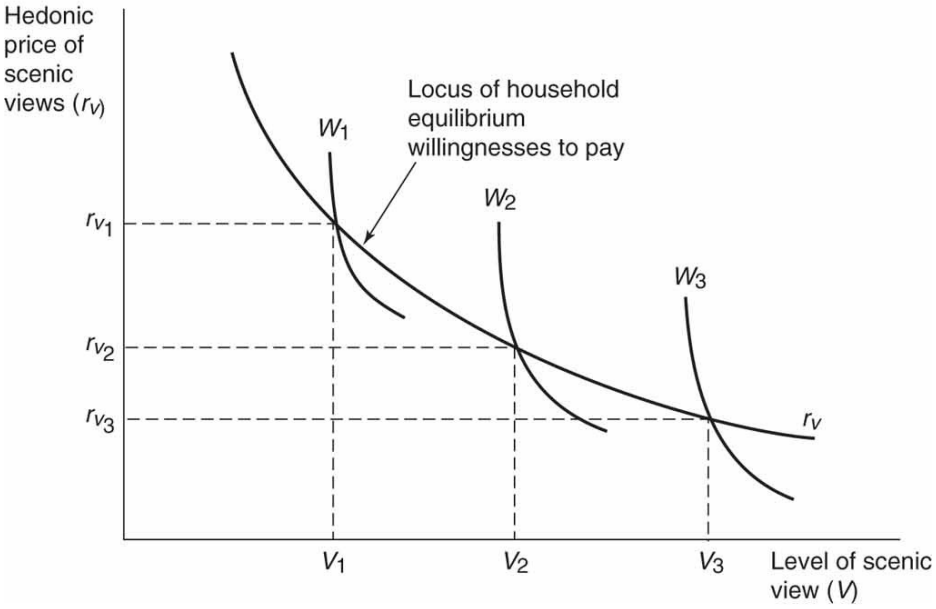
Y is household income

Z is a vector of household characteristics that reflects tastes (e.g., socioeconomic background, race, age, and family size).

- This method allows us to calculate the change in consumer surplus to a household due to a change in the level of scenic view.
- These changes in individual household consumer surplus can be aggregated across all households to obtain the total change in consumer surplus.

The Hedonic Price Method





Using Hedonic Models to Determine the VSL

Recall the labor market studies used to value a statistical life that may suffer from *omitted variable problem*

- e.g. studies that focus on *fatality risk* (the risk of death) often omit potentially relevant variables such as injury risk (the risk of nonfatal injury)

- Hedonic pricing method - estimate the following regression:

$$\ln(wage\ rate) = \beta_0 + \beta_1 \ln(\text{fatality risk}) + \beta_2 \ln(injury\ risk) + \beta_3 \ln(job\ tenure) + \beta_4 \ln(educ) + \beta_5 \ln(\text{age}) + \varepsilon$$

- $\hat{\beta}_1$ can be converted to a hedonic price of fatality risk, and to estimate the WTP to avoid fatality risks.
- By including injury risk, job tenure, educ, age, possible bias in $\hat{\beta}_1$ can be eliminated.

Problems with Hedonic Models

1. People must know and understand the implications of the attribute that is being valued.
2. Measurement error problem - Variables should be measured without error.
3. Specification error problem - The functional forms should be correct.
4. The market should have enough alternatives so that people can locate at their optimum point on the curve.
5. There may be multicollinearity problems.
6. Markets are assumed to adjust immediately to changes in the attributes of interest and to all other factors.

TRAVEL COST METHOD (TCM)

- This method is mostly applied to value recreational sites.
- Suppose that we want to estimate the value of a particular recreational site. An *individual* demand function for visiting the site can be written as:

$$q = f(p, p_s, Y, Z)$$

where q = the quantity of visits demanded *by an individual*

p = price, p_s = price of substitutes, p_s

Y = the person's income

Z = variables that reflect the person's tastes

- In TCM, the full price paid by persons for a visit to a recreational site is *more than* just the admission fee.
  - What should be included as the costs of traveling to and from the site?

Traveling Cost Method (Continued)

- The total cost includes the opportunity cost of time spent traveling, the operating cost of vehicles used to travel, the cost of accommodations for overnight stays while traveling, and parking fees at the site.
  - The sum of all of these costs gives the total cost of a visit to the site.
  - This **total cost** is used as an explanatory variable **in place of the admission price** in a model above.
- Insight of the TCM: the total cost faced by each person varies because of differences in the travel cost component.
  - ➢Usage also varies, thereby allowing researchers to make inferences about the demand curve for the site

Steps in estimating the demand schedule for a particular recreational site

- Select a random sample of households within the market area of the site.
- Survey these households to determine their numbers of visits to the site over some period of time, all of their costs involved in visiting the site, their costs of visiting substitute sites, their incomes, and other characteristics that may affect their demand.
- Specify a functional form for the demand schedule and estimate it using the survey data.

Illustration: TCM

EXHIBIT 14-4

Kerry Smith and William Desvousges used the travel cost method to estimate the average household value of a trip to recreational sites along the Monongahela River and the average household value of improving water quality. Their estimates of travel costs assumed the marginal cost of operating an automobile was $0.08 per mile in 1976. For the time cost component of travel cost, they set the value of time equal to the wage rate in a person's particular occupation, which ranged from $2.75 per hour for female farmers to $7.89 per hour for male professional, technical, and kindred workers in 1977 dollars. Smith and Desvousges estimated many models including the following relatively simple travel cost model (*t*-statistics in parentheses):

$$\ln V = \underset{}{-3.928} - \underset{(-3.075)}{0.051TC} + \underset{(-2.846)}{0.00001Y} + \underset{(1.109)}{0.058DO} \qquad \underset{(3.917)}{(R^2 = 0.225)}$$

where V is the number of site visits, Y denotes income, and DO is the percent saturation of dissolved oxygen in the water. Based on this model, the authors estimated that the average annual value of improving the water quality from boatable to game fishing would be $7.16 in 1981 dollars (about $15 in 2004 dollars), and the average annual value of improving the water quality from boatable to swimming would be $28.86 in 1981 dollars (about $60 in 2004 dollars).

Source: Adapted from V. Kerry Smith and William H. Desvousges, *Measuring Water Quality Benefits* (Boston: Kluwer Nijhoff Publishing, 1986), especially pp. 270–271.

Zonal Travel Cost Method

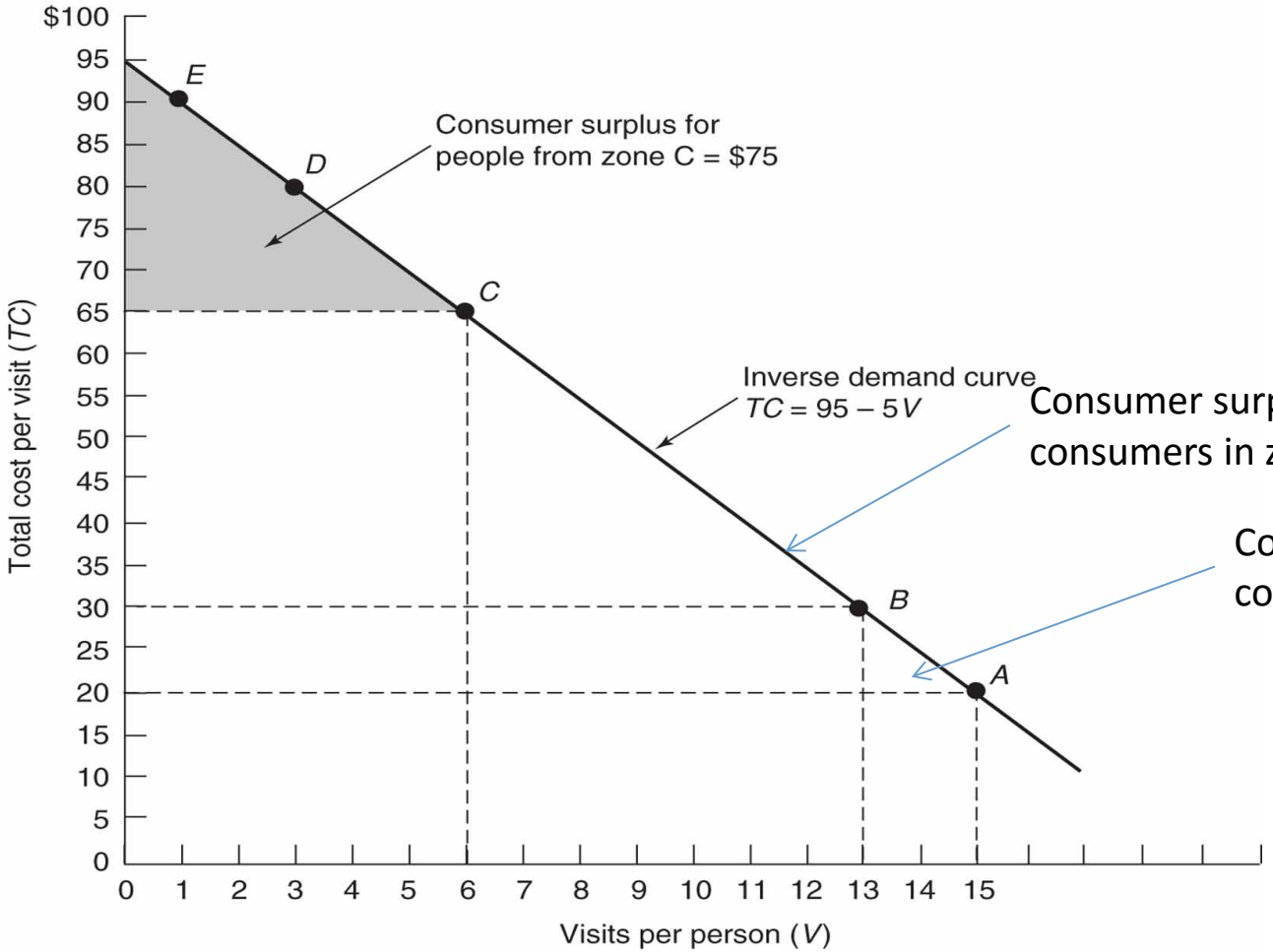
- Using this method, researchers survey **actual visitors** rather than *potential ones*.
- Visitors are allocated to a particular zone, depending on their "travel costs" (usually distance).
- For each zone, the analyst computes the average number of visits per year and the average total travel cost.
  - Estimate the relationship between cost/trip and the number of trips per person.
  - The consumer surplus for a visitor from a particular zone is given by the area below this curve and above the cost of a visit from that zone

Illustration of the Zonal TCM

Zone	Travel Time (hours)	Travel Distance (km)	Average Total Cost per Person ($)	Average Number of Visits per Person	Consumer Surplus per Person	Consumer Surplus per Zone ($ thousands)	Trips per Zone (thousands)
A	0.5	2	20	15	525	5,250	150
B	1.0	30	30	13	390	3,900	130
C	2.0	90	65	6	75	1,500	120
D	3.0	140	80	3	15	150	30
E	3.5	150	90	1	0	0	10
Total						10,800	440

Assume zones A, B, D, and E have 10,000 people, and zone C have 20,000 people.

"Representative" Individual's Inverse Demand Curve for Visits to a Recreational Area as a Function of Total Cost per Visit



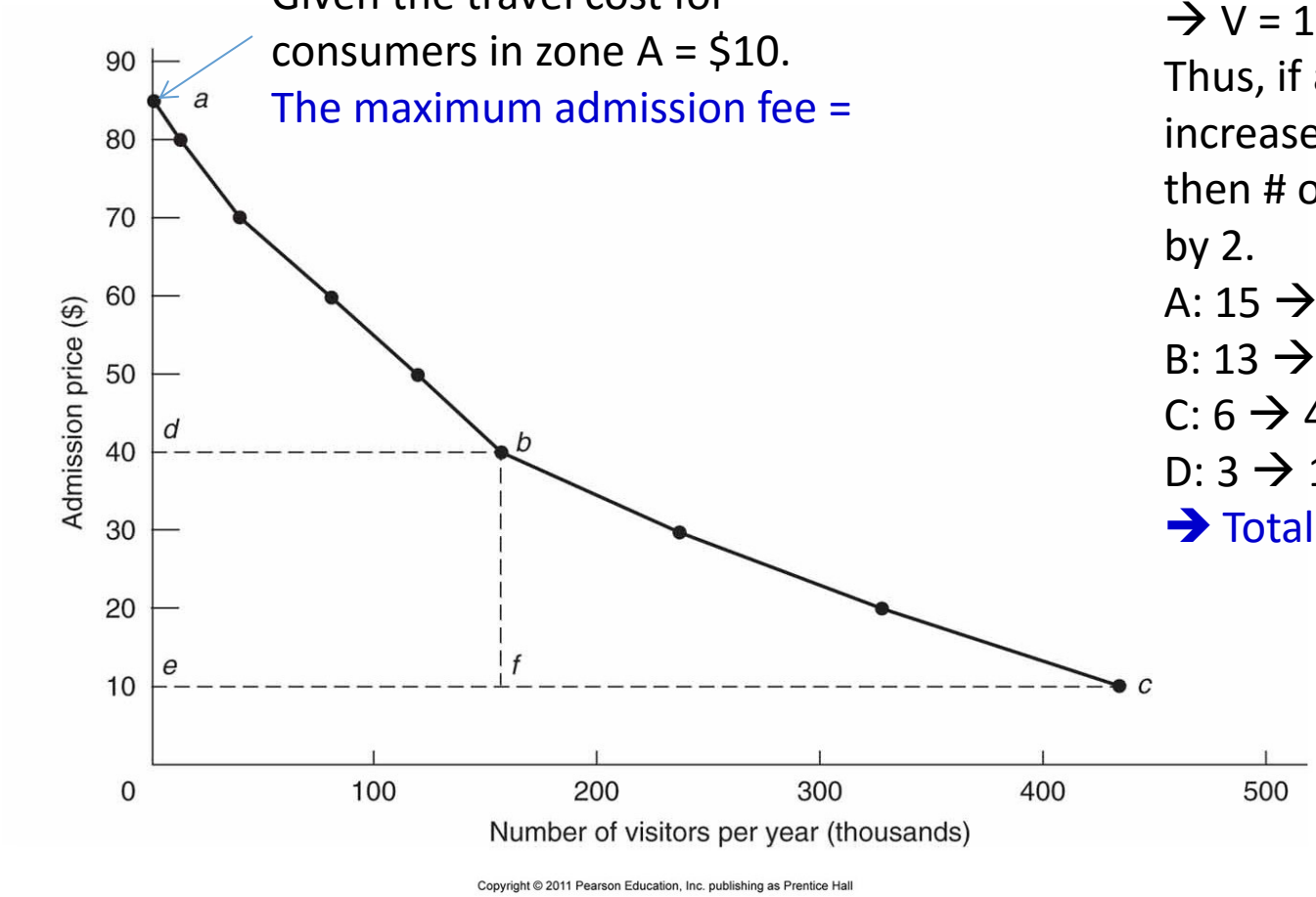
Consumer surplus for consumers in zone B =

Consumer surplus for consumers in zone A =

The Market Demand Curve for a Recreational Site Derived Using the Zonal Travel Cost Method

Given the travel cost for consumers in zone A = $10.

The maximum admission fee =



From TC = 95-5V,

→ V = 19 – 0.2TC

Thus, if admission fee (TC) increases from $10 to $20, then # of visits is reduced by 2.

A: 15 → 13

B: 13 → 11

C: 6 → 4

D: 3 → 1

➔ Total # of visits =

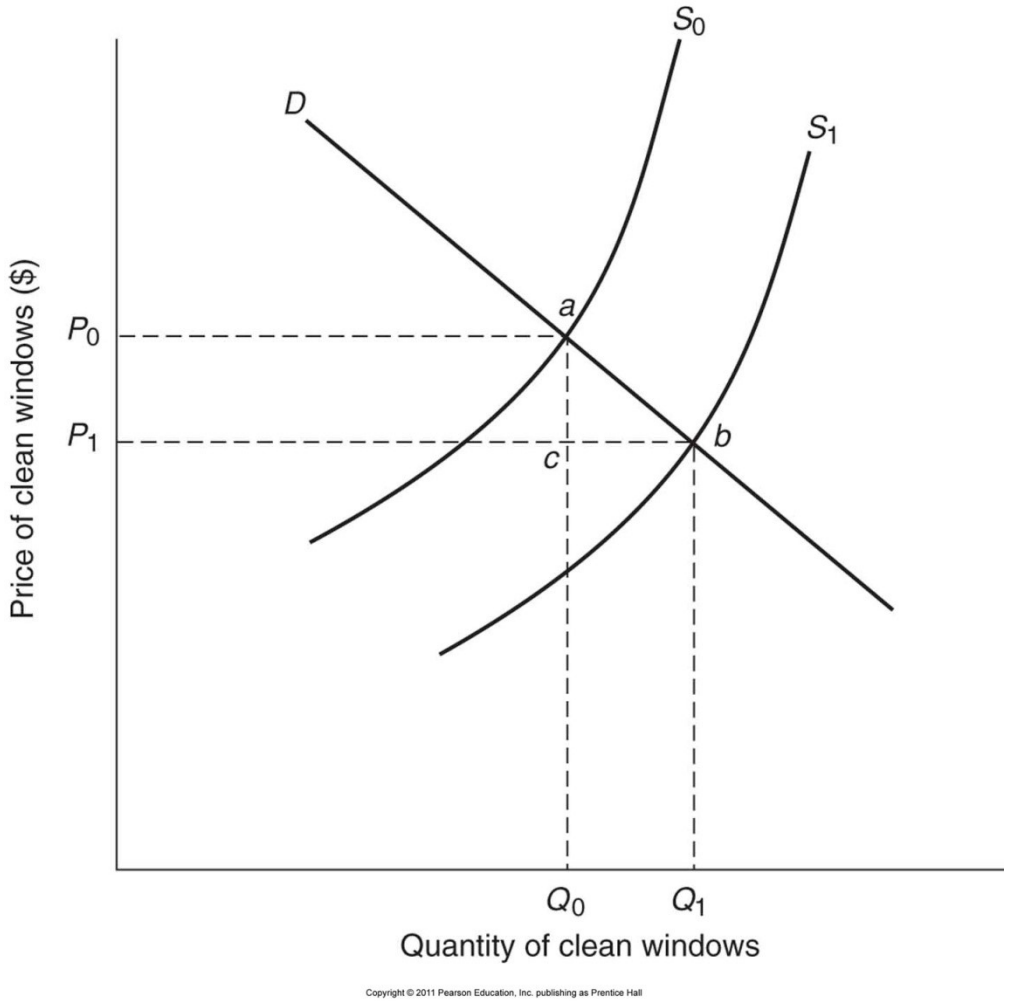
Limitations of the TCM

1. It is restricted to sites where people (in the zones) have different travel costs.
2. There may be analytical problems in measuring the total cost of a visit. For instance, how does one measure opportunity cost of travel time?
3. Travel cost may be endogenous not exogenous.
4. There may be other econometric problems, such as truncation (drawing sample from only visitors rather than the population at large – resulting in biased results).
5. The method estimates the WTP for the entire site rather than features of the site.

DEFENSIVE EXPENDITURES METHOD

- A defensive expenditure is an expenditure spent to mitigate or even eliminate the effect of something undesirable (or negative externality), such as pollution.
  - Example: If smoke and haze in northern provinces in Thailand worsens, the government may need to spend more on treating local people with respiratory conditions (e.g. asthma).
  - The change in expenditures can be used as a measure of the cost of the change in pollution.
- Suppose the government passes on an law that reduces the level of haze. Then, people will spend less on health care expenditure.
  - The reduction in defensive expenditures can be viewed as a measure of the benefits of the law prohibiting haze.

The Effect of an Ordinance Reducing Smog on Expenditures for Window Cleaning



Problems with Defensive Expenditure Method

1. Reduced spending on a defensive expenditure underestimates the benefits of cleaner air.
2. It assumes people adjust quickly to the new equilibrium, such as new smog levels.
3. Defensive expenditure may not remedy entire the damage.
4. Defensive expenditures may have benefits other than remedying damage, which should be included.
5. Not all defensive expenditures are purchased in markets, for example, some people clean their own windows; changes in these “expenditures” should also be included.