Stated Preference Methods in Environmental Valuation

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Economic Valuation for Environmental Goods

- Examples of environmental goods:
  - Air quality, water quality, noise, green space, etc
  - Existence-value: biodiversity, wildlife conservation, etc
- Environmental goods are often not priced in the market.
  - We can enjoy clean air for free, without having to pay a fee to the forest owners.
  - We do not need to pay a fine for not trying to save an extinguishing animal.
- Although such environmental goods have some "values", since they are not priced, the environmental goods tend to be underprovided in the marketplace.

Economic Valuation for Environmental Goods

- Cost-Benefit principle:
  - If the "value" of an environmental good is large relatively to the maintenance (or supply) cost of the good, that environmental good should be provided.
- In order to implement the cost-benefit based policy implementation, it is required to evaluate the environmental goods in "monetary terms".
- Environmental Valuation: The research field that aims for estimating the economic value of environmental goods.

Environmental Valuation
= methods for obtaining monetary values of unpriced environmental goods

Economic Valuation for Environmental Goods

Two types of environmental valuation techniques:
Revealed preference approach and Stated preference approach.

Revealed preference (RP) approach:

- RP methods are based on the data of actual decisions or behaviors made in the real market environment. The examples are as follows.
- Travel Cost method:
  - If an individual has bought a travel ticket to visit an environmental recreational site (e.g., Mt. Fuji, Yakushima (屋久島), etc) for 10,000 yen, her economic value for the site should be at least this amount.
- Hedonic method:
  - Suppose there are two very similar apartments except that one is located in a quiet neighborhood and the other is in front of a highway.
  - If the rental price of the former apartment is 10,000 yen/month higher than that of the latter, this amount can be interpreted as the economic value of the "quiet environment".

Stated preference (SP) approach:

- SP methods use questionnaire or survey to directly elicit the demand for an environmental good. The examples are as follows.
- Contingent valuation method (CVM):
  - The CVM involves directly asking people, in a questionnaire or survey, how much they would be willing to pay for specific environmental goods and services.
- Conjoint choice experiment:
  - The conjoint choice method asks the respondent to state a preference between several alternatives of goods that are distinguished by their level of environmental quality and price.

Remark:

- Because the responses are hypothetical, the SP method has sometimes been criticized as unrealistic, as mentioned below.
- However, the SP method has a great advantage in that it can be applied to valuation of almost "any" kind of environmental goods and services.

Contingent valuation method: CVM

Contingent valuation method: CVM

- Suppose that you would like to know the economic value of an environmental good, say, $\mathbf{A}$.
- A simplest way to estimate the value of $\mathbf{A}$ is to ask people

"How much are you willing to pay for $\mathbf{A}$?"

- This is the basic framework of CVM. The amount people are willing to pay for $\mathbf{A}$ is called Willingness-to-pay (WTP) for $\mathbf{A}$.
- CVM can be classified by the format of WTP question.

Open-ended CVM

- Open-ended CVM: the respondents are open to say any amount that they want as their WTP for the given good.

> "Suppose in two weeks a student representative will collect your donation to the New York State Department of Environmental Conservation for decreasing Acid Rain (to prevent deterioration from Condition A to Condition B).
>
> Keeping in mind the amount of money that you have available to spend, what is the most that you would be willing to donate?"

(From: Kealy and Turner (1993), American Journal of Agricultural Economics)

Dichotomous choice CVM

- Dichotomous choice CVM: the respondents are asked whether they are willing to pay the given bid amount for the good or not.

> Consider for a moment that to have access to the Cava Grande Nature Reserve you will be asked to purchase an admission ticket. If the price of this admission ticket were [*BID*] lire, would you purchase it and thus be able to make use of the Cava Grande? Yes [ ] No [ ]

(From: Cooper et al. (2002), Review of Economics and Statistics.

The Cava Grande Nature Reserve is a regional nature reserve in Sicily, Italy.)

Contingent valuation method: CVM

- For the open-ended CVM, if the respondents are randomly sampled from the population of interest, estimation of the mean WTP is very simple;
  we only need to calculate the sample average of the elicited WTP values.
  - Statistical analysis of open-ended CVM is easy and intuitive.
  - However, this format of CVM has been rarely used in practice, because respondents often find open-ended questions too difficult to answer.
- In order to estimate the mean WTP in the dichotomous choice CVM, we first estimate a binary choice model.
  - Although more statistically involved than the open-ended format, dichotomous choice questions are easier and more realistic to answer for the respondents.
  - In the following, we focus on dichotomous choice CVM.

WTP Estimation in Dichotomous Choice CVM

WTP Estimation in Dichotomous Choice CVM

- In the questionnaire, each individual i is asked if she is willing to pay a given bid amount for an environmental good or not.
- Also, the questionnaire asks the respondent's demographic and socio-economic characteristics (e.g., age, gender, income, etc) and her knowledge and attitude about the environmental good.
    - D_i: dummy dependent variable. (1 if the respondent i answered "yes" in the CVM question, 0 otherwise.)
    - p_i: bid amount[1]
    - X_i: vector of individual characteristics.

[1] The bid amounts proposed to the respondents must have some variations. Otherwise, we cannot distinguish p and a constant term, resulting in the unidentifiability of WTP.

WTP Estimation in Dichotomous Choice CVM

- Following the random utility theory, we assume that individual i's utility of choosing $D_i = 1$ (yes) is given by

$$U_i(D_i = 1) = p_i \cdot \alpha + X_i^\top \beta - \varepsilon_i$$

  where ε_i is the unobservable random utility component.
- The parameters of interest to be estimated are α and β.[2]
- The utility of choosing $D_i = 0$ (no), i.e., the utility of status quo, is normalized to zero:

$$U_i(D_i = 0) = 0$$

[2] Unless the good is a Giffen good, α is expected to have a negative value.

WTP Estimation in Dichotomous Choice CVM

- Then, if the individual i is willing to pay p_i for the good, this implies that

$$U_i(D_i = 1) \geq U_i(D_i = 0) \iff p_i \cdot \alpha + X_i^\top \beta \geq \varepsilon_i$$

- Therefore, the probability of saying "yes" is

$$\Pr(D_i = 1) = F(p_i \cdot \alpha + X_i^\top \beta),$$

  where $F(\cdot)$ is the distribution function of ε_i.

- In particular, in the case of a binary logit model,

$$\Pr(D_i = 1) = \frac{\exp(p_i \cdot \alpha + X_i^\top \beta)}{1 + \exp(p_i \cdot \alpha + X_i^\top \beta)}$$

WTP Estimation in Dichotomous Choice CVM

- Let (α_0, β_0) be the true value of (α, β).
- We can estimate (α_0, β_0) by the maximum likelihood method:

$$(\widehat{\alpha}_n, \widehat{\beta}_n) = \underset{(\alpha,\beta)}{\operatorname{argmax}} \, \ell_n(\alpha, \beta),$$

where

$$\ell_n(\alpha, \beta) = \sum_{i=1}^{n} \Big[D_i \ln F(p_i \cdot \alpha + X_i^\top \beta) + (1 - D_i) \ln(1 - F(p_i \cdot \alpha + X_i^\top \beta)) \Big]$$

and n is the number of respondents.

WTP Estimation in Dichotomous Choice CVM

- There are two WTP measures: **Mean WTP** and **Median WTP**.
- Both measures are individually specific (namely, specific to each value of X).
- We first consider the calculation of mean WTP.
- Note that for a given bid amount p, the probability a respondent with individual characteristics X_i is willing to pay p for the good is equal to $F(p \cdot \alpha_0 + X_i^\top \beta_0)$.
    - In other words,

$$\Pr(p \leq WTP_i) = F(p \cdot \alpha_0 + X_i^\top \beta_0)$$

    - When the above equality is given, how can we calculate the mean WTP $E[WTP_i]$?

Expectation of a non-negative random variable

- Suppose that a random variable X is non-negative.
- Note that for any non-negative number a, we can write

$$a = \int_0^a ds = \int_0 \mathbf{1}\{s \leq a\} ds.$$

- Therefore,

$$\begin{aligned} E[X] &= E\left[\int_0^X ds\right] \\ &= E\left[\int_0 \mathbf{1}\{s \leq X\} ds\right] \\ &= \int_0 E\mathbf{1}\{s \leq X\} ds = \int_0 \Pr(s \leq X) ds \end{aligned}$$

- From this fact, the mean WTP can be obtained by

$$
\begin{aligned}
E[WTP_i] &= \int_0 \Pr(p \leq WTP_i)dp \\
&= \int_0 F(p \cdot \alpha_0 + X_i^\top \beta_0)dp.
\end{aligned}
$$

- Note that the upper bound of the integration domain is ∞. Hence, the candidate WTP value p can take arbitrarily large value, and the resulting mean WTP can be unreasonably large.
- Assume that the WTP for i must be smaller than $\overline{p}_i$, where $\overline{p}_i$ is, for instance, annual income of i. Then, a more realistic mean WTP is

$$
\text{Mean WTP for } i = \int_0^{\overline{p}_i} F(p \cdot \alpha_0 + X_i^\top \beta_0)dp.
$$

WTP Estimation in Dichotomous Choice CVM

- Calculation of median WTP is simpler than the mean WTP.
- The median WTP for i is defined by the bid value such that the probability of saying "yes" in the CVM question is just equal to 0.5. That is,

$$\text{Median WTP for } i = p_{med,i} \quad \text{s.t.} \quad F(p_{med,i} \cdot \alpha_0 + X_i^\top \beta_0) = 0.5.$$

- When F is a logistic function (i.e., logit model), $F(0) = 0.5$ holds. Therefore, we have

$$F(p_{med,i} \cdot \alpha_0 + X_i^\top \beta_0) = 0.5 \iff p_{med,i} \cdot \alpha_0 + X_i^\top \beta_0 = 0,$$

and thus

$$\text{Median WTP for } i = -X_i^\top \beta_0 / \alpha_0.$$

Dichotomous Choice Contingent Valuation in **R**

- A practice data set: **cvmdata.csv**
  - Data on a contingent valuation survey.[3]
  - The survey was conducted aiming to assess the demand for preserving a scenic public forest.
- The data csv file is available on my website and **Course Navi**.
- Set your working directory appropriately, and import the csv file by `read.csv()`:

```
setwd("C:/Rdataset")
data <- read.csv("cvmdata.csv")
```

[3] This dataset is created from Balcombe and Fraser (2009), Dichotomous-Choice Contingent Valuation with 'Dont Know' Responses and Misreporting, **Journal of Applied Econometrics Data Archive**.

Dichotomous Choice Contingent Valuation in R

```
>  data <- read.csv("cvmdata.csv")
>  head(data)
  ID Ans Bid Urban Visits Age Gender Educ Inc1000
1  1   1   3     0     12  61      1   13      45
2  2   0  10     0      3  79      1   16      90
3  3   0   3     0     10  77      0   13      10
4  4   1   5     0      2  73      0   16      15
5  5   1  10     0      4  80      1   12      30
6  6   1   3     0      6  70      1   14      30
>  dim(data)
[1] 446   9
```

Definitions of variables

Dependent variable (2nd column)

Ans	response to the dichotomous question: yes = 1, no = 0

Explanatory variables (3rd - 9th columns)

Bid	Bid amount (USD)
Urban	1 = if the respondent lives in an urban area, 0 otherwise.
Visits	the number of recreational visits to natural areas in the past year.
Age	age in years
Gender	1 = male, 0 = female
Educ	education in years
Inc1000	annual income (1000 USD)

[CVM question]

Imagine an area with a scenic overlook in a nearby federal or state public forest. In the past, this area was free with only picnic tables and a dirt parking lot. This year the area is the same as always, but it is part of the Fee Demonstration Program (described in the cover letter), so you must buy a permit or face a fine of $100 if caught without a permit. Permits are sold at a visitor's center that you pass on the way to the site.

If a permit to use this area costs $______ per visitor per day, would you buy it, keeping in mind your household income and other financial commitments?

Dichotomous Choice Contingent Valuation in R

- We first estimate a logit model:

```
logit <- glm(Ans ~ Bid + Urban + Visits + Age + Gender + Educ +
      + Inc1000, data, family = binomial(link = "logit"))
summary(logit)
```

Dichotomous Choice Contingent Valuation in R

```
>  logit <- glm(Ans ~ Bid + Urban + Visits + Age + Gender + Educ
+  + Inc1000, data, family = binomial(link = "logit"))
>  summary(logit)

Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept) -0.263851   0.802448  -0.329  0.74230
Bid         -0.193056   0.041834  -4.615 3.93e-06 ***
Urban        0.336001   0.382306   0.879  0.37947
Visits      -0.024783   0.011492  -2.157  0.03104 *
Age          0.012696   0.008325   1.525  0.12724
Gender       0.007525   0.270279   0.028  0.97779
Educ        -0.054158   0.045105  -1.201  0.22986
Inc1000      0.013381   0.004463   2.998  0.00272 **
```

- As expected by economic theory, the bid amount is negatively and the respondent's income level is positively related to the "yes" answer.
- As the number of recreational visits increases, the probability of answering "yes" tends to decrease.

- We next calculate the mean WTP.
- Recall that the WTP can vary with the value of X. Thus, we fix X at its sample mean.
- Define

```
alpha <- logit$coef[2]
beta  <- logit$coef[-2]
Xmean <- colMeans(data[,4:9])
```

The third line calculates the mean of each of [Urban, ... , Inc1000] all at once.

- We can estimate the mean WTP following the equation shown in p.19.
- We define the integrand as follows:

```
Prob <- function(p){
    plogis(p*alpha + c(1, Xmean)%*%beta)
    }
```

To compute a vector-vector multiplication (inner product), use "%*%" instead of "*".

- Integrating this function `Prob` from 0 to $\overline{p}$ yields the WTP.
- According to the questionnaire (p.25), one has to pay a fine of 100 USD if caught without the permit. Thus, it would be reasonable to set $\overline{p} = 100$.

- WTP calculation:

```
MeanWTP <- integrate(Prob, 0, 100)
```

- The mean WTP for the permit is about 3.7 USD (per visitor per day).

```
> ## Mean WTP Calculation ##
>
> Prob <- function(p){
+ plogis(p*alpha + c(1, Xmean)%*%beta)
+ }
> MeanWTP <- integrate(Prob, 0, 100)
> MeanWTP
3.722585 with absolute error < 2.1e-06
```

- We next calculate the median WTP. Again, let X be fixed at the sample mean.
- Following the equation in p.20, we can estimate the median WTP simply by

```
MedWTP <- -c(1, Xmean)%*%beta/alpha
```

```
> ## Median WTP Calculation ##
>
> MedWTP <- -c(1, Xmean)%*%beta/alpha
> MedWTP
          [,1]
[1,] 0.2610942
```

- Thus, for an average person, the median WTP for the permit is only 26 cents.
- This is not surprising, because, for an average person, the probability of visiting a forest for recreation is only slightly larger than 50% even when the permit is for free (`Prob(0)` ≈ 0.513).

Limitations of Stated Choice Methods

- Stated choice methods, such as the CVM, are quite useful in that they can measure the economic value of a fairly wide rage of environmental goods and services
- However, there are a number of criticisms for using them.

> **Contingent Valuation: From Dubious to Hopeless**
>
> Jerry Hausman
>
> Approximately 20 years ago, Peter Diamond and I wrote an article for this journal analyzing contingent valuation methods (Diamond and Hausman 1994). At that time Peter's view was that contingent valuation was hopeless, while I was dubious but somewhat more optimistic. But 20 years later, after millions of dollars of largely government-funded research, I have concluded that Peter's earlier position was correct and that contingent valuation is hopeless.

[4]

[4] Hausman (2012), Journal of Economic Perspectives. Peter Diamond is an American economist and winner of the 2010 Nobel Prize in Economics.

Limitations of Stated Choice Methods

Hypothetical Bias

- Hypothetical bias is the bias that arises in answering a hypothetical question with which the respondent has no market experience; namely, **what people say would be different from what they behave in a real market situation.**
- The estimated WTP values often tend to be overstatements.

Limitations of Stated Choice Methods

Strategic Bias

- Strategic bias arises when the respondent provides a biased answer in order to influence a particular policy outcome.
- When a policy decision to preserve a stretch of river for fishing depends on whether or not the survey produces a sufficiently large value for fishing, the respondents who enjoy fishing may have incentives to overstate their WTP values.

Limitations of Stated Choice Methods

Non-response Bias

- In many questionnaire surveys, the problem of non-reponse is common and often unavoidable.
- Individuals who are less concerned about the environmental good may be more likely to skip answering the CVM question than more environmentally friendly people, yielding upward-biased WTP estimates.

Limitations of Stated Choice Methods

Payment Vehicle Bias

- Respondents may give different WTP amounts, depending on the specific payment vehicle chosen.
- For example, some payment vehicles, such as taxes, may lead to protest responses from people who do not want increased taxes.
- Others, such as a contribution or donation, may lead people to answer in terms of how much they think their "fair share" contribution is, rather than expressing their actual economic value for the good.

Behavioral economics plays an important role in recent researches in this area to understand how to mitigate or eliminate these biases.