Ⅳ-33 A BENEFIT MEASUREMENT MODEL OF THE NEWLY INTRODUCED TRANSPORT FACILITY

LE Dam Hanh, Gifu University
MORISUGI Hisa, Gifu University
OHNO Eiji, Gifu University

1. INTRODUCTION

This study focuses on two problems first, there is not any concrete measurement method for measuring the benefit of the newly introduced transport facility. Also, the conventional benefit measurement method is well developed only in the context, that measures the benefit of the improvement facility under two price levels; the "before change" price, p^0 and the "after change" price, p^1. Since the newly introduced facility has not yet realized, there is a problem of estimating the cost of the new mode of the "before" situation, p_n^0. Secondly, referring to the application of the Logit model in the transport demand behavior, there is a problem of dealing with generated traffic due to the fixed demand assumption. The objective of this study is based on the consumer behavior theory to construct a new benefit measurement model of the newly introduced transport facility and provides a transport demand model which either have some merits of the the Logit model and also can be used to deal with the generated transport demand.

2. A TRANSPORT DEMAND MODEL

The basic technique used in this study is different from the conventional technique. It starts with a specified system of demand function and then derive the unobserved indirect utility function by using the Roy's identity property and inverse it to obtain the expenditure function. These two functions permit exact calculation of the compensating variation CV and the equivalent variation, EV without using any approximation technique. The basic tool used here is the Roy's identity property that is the link between the indirect utility function and the demand function:

$$(1) \qquad x_i = -\frac{\partial V(p,y)/\partial p_i}{\partial V(p,y)/\partial y} .$$

The Logit model is well-known probabilistic choice model which is derived from the random utility theory by assuming the random component (ε) varies according to the Gumbel distribution. In this study a different derivation of the Logit model will be provided within the framework of the consumer behavior theory. The basic idea is to start from the specific functional form of the indirect utility function, by using the Roy's identity to derive the corresponding demand function. Suppose, the specified indirect utility function as

$$(2) \qquad V(p,y) = \Sigma_i \; a_i \exp[b_i y - c_i p_i],$$

where
- p_i is the price of service j,
- y is income level of individual,
- a_i, b_i, c_i are unknown parameters.

The demand function which corresponds to equation (2) can be found by differentiation:

$$(3) \qquad x_i = \frac{a_i c_i \exp[b_i y - c_i p_i]}{\Sigma_j \; a_j b_j \exp[b_j y - c_j p_j]} .$$

As a result, this demand function is not the Logit model exactly, but the function itself is the Logit type of demand function, with the linear form of the deterministic component of the utility function, called the Logit type of demand function. By using this demand function we can easily and explicitly deal with generated demand since it is obtained directly from the specified indirect utility function without fixed demand assumption. In figure (1) this derivation are shown. One of the typical and important implication of this model is that it can be used for obtaining and explaining the demand model for the newly introduced transport facility.

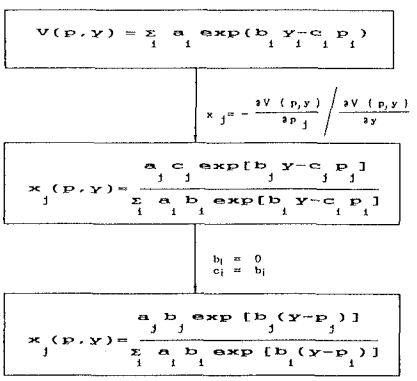

Fig.(1) A Derivation of Logit Model

3. A BENEFIT MEASUREMENT MODEL

To fully express both the "non-existing" and the "existing" situation of the new transport mode that corresponding to two states; the "before-introduction" where the demand of the new mode is considered as equal to zero, and the "after-introduction" of the new transport mode, respectively. The so-called "availability" index, r, is introduced into the model.

The model is developed for three goods case. Denotes z is composite goods, x_2 and x_3

are the demand of existing and newly introduced transport mode, respectively. The consumer's maximizing problem can be formulated for this situation:

$$(4)\quad \max_{z,x_2,x_3} u(z,x_2,\theta x_3),$$

$$\text{s.t. } z+x_2 p_2 = y, \ (\text{when } \theta=0),$$

$$z+x_2 p_2+x_3 p_3 = y, \ (\text{when } \theta=1),$$

where

- $\theta=0$: the "non-availability" of the new mode or when $x_3=0$,
- $\theta=1$: the "availability" of the new mode or when $x_3=x_3$.

The Roy's identity also ensures that the derived demand model, called the Logit type of demand function (3), can be used to derive the corresponding indirect utility function. Recalling equation (3):

$$(5)\quad x_i = \frac{a_i c_i \exp[b_i y-c_i p_i]}{\sum_j a_j b_j \exp[b_j y-c_j p_j]}, \ (j=1,2,3),$$

$$= -\frac{\partial V(p,y)/\partial p_i}{\partial V(p,y)/\partial y}.$$

The associated indirect utility function is derived as

$$(6)\quad V(p,y) = f(\Sigma_j a_j \exp[b_j y-c_j p_j]).$$

As a result, it shows that, from the maximization problem in equation (4) the derived indirect utility function yields when $\theta=0$ and when $\theta=1$, respectively, as following:

$$(7)\quad V(\theta=0,y)= a_1 \exp[b_1 y-c_1 p_1]+a_2 \exp[b_2 y-c_2 p_2],$$

$$(8)\quad V(\theta=1,y)= a_1 \exp[b_1 y-c_1 p_1]+a_2 \exp[b_2 y-c_2 p_2] +a_3 \exp[b_3 y-c_3 p_3].$$

Using the concept of equivalent variation EV, that can be defined formally as

$$(9)\quad V(\theta=0,y+EV) = V(\theta=1,y), \text{ or}$$

$$(10)\quad a_1 \exp[b_1 (y+EV)-c_1 p_1]+a_2 \exp[b_2 (y+EV)-c_2 p_2] = a_1 \exp[b_1 y-c_1 p_1]+a_2 \exp[b_2 y-c_2 p_2] +a_3 \exp[b_3 y-c_3 p_3].$$

The value of EV which satisfies the above equation system is the benefit by the newly introduced transport facility that we are looking for. Recent computer technology allows all parameters and measurement can be computed quickly if given all the available market data.

The proposed model seems to be worthwhile on three aspects:

(1) In contrast to the invalidity of the consumer's surplus method this approach can be used to measure the welfare change both for the improvement and the new mode case.

(2) Instead of the approximate value yielded in the conventional approach, by this approach we derive the exact EV and CV, that provides an exact welfare measurement.

(3) Since the development of the proposed model begins with the Logit type of demand model which has an advantage of dealing with the generated traffic, so that the benefit measurement could cover the effect of the additional generated transport demand which would otherwise accrue under assuming fixed demand patern in conventional approach.

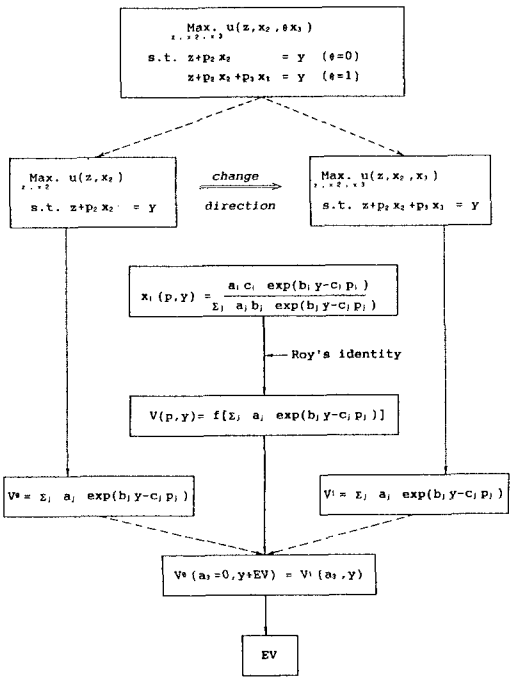

Fig.(2) Flowchart of Benefit Measurement Model

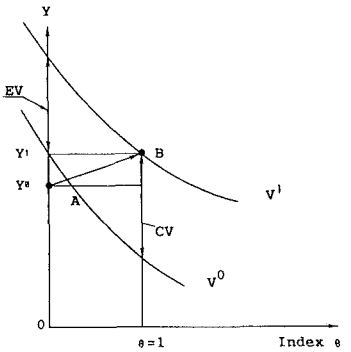

Fig.(3) Benefit of Newly Introduced Mode

4. REFERENCES

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