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Abstract

Transport modal choice is considered to be influenced by natural environmental change and transport network improvement. This paper reveals how these impacts affect individuals' decisions on selecting transport mode under an extension plan of Osaka Monorail Loop-line. To estimate these impacts, a Stated Choice (SC) experiment is carried out for collecting the neighborhood data around the monorail's extended area. Our model is estimated by the Heteroscedastic Extreme Value (HEV) specification in order to avoid Independence from Irrelevant Alternatives (IIA) assumption in the Multinomial Logit (MNL) model. Both the results of full-sample and sub-sample data imply that residents prefer public transport modes (monorail or bus) to private car when either natural environment becomes worse or transport network is improved.

Keywords: Environmental Deterioration; Network improvement; Network externality; Choice Model (CM); Heteroscedastic Extreme Value (HEV) Model

JEL classification: C35, D12, Q51, R41

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1. Introduction

Public transport is an essential element for urban life since it reduces car traffic and gives mobility to city residents. In addition, more use of public transport modes instead of private cars is also considered being able to reduce emissions such as carbon dioxide from urban transport. This feature has been getting more important after the Kyoto Protocol had been taken effect in March 2005. These social situations require policy makers to support modal change from private cars to public transportation. Differences in accessibility to destinations such as city center affect users' decision on choosing transport modes. In well developed cities of Japan like Osaka and Tokyo, new public transports are built to improve connectivity and accessibility of existing lines and stations. Introducing a new line to such cities is thought to bring the improvement of network accessibility and to promote transport modal shift of residents in its neighborhood. Besides direct effect of the public transport investment, additionally-generated traffic caused by the network externality (indirect effect) would be distributed over the whole city. These direct and indirect effects could be examined by the analysis of transport modal choice.[2]

Analyses of transport modal choice have been implemented in various ways. Discrete choice model is a mainstream among them. In this approach, transport modal choice analysis is usually treated as an application of the random utility theory which assumes that an individual makes a rational choice among discrete alternatives so as to maximize his/her utility. There have been a number of studies on transport modal choice in literature based on discrete choice approach (see, for instance, McFadden 1974, Garrod and Millius 1983, Ben-Akiva and Lerman 1985, Bates 1987, Louviere 1988, Hensher 1994, Louviere *et al.* 2000, Asensio 2002, Cervero 2002, Rodriguez and Joo 2004, Schwanen and Moktarian 2005, etc.). The traditional determinants in selection of transport modes are attributes associated with travel time and cost. Alternatively, the determinants of transport modal choice can also be estimated by other modeling using revealed preference data, for example, Bresson *et al.* (2004) analyzed the determinants of demand for public transport by using panel data in France.

The climate change problem requires transport policy to regard sustainability as an important element (e.g. Ech 2005, Steg and Gifford 2005). Some evidences suggest that the growing concern of environmental protection, which has important external effects on our life, has begun to affect residents' behaviors including transport modal choice (Himanen *et al.* 2005, Shen *et al.* 2005).

The effect of individual environmental concern on transport modal choice comes not only from the recognition of negative impacts on the environment caused by various transport modes, but also from the awareness on local natural environmental state. There are a number of factors which affect local natural environment, such as industrial activities, geographical features or built

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[2] In this study, due to the financial constraint, we only focus on the direct effect of an extension of Osaka Monorail Loop-line on residents around the Eastern Osaka of Japan.

environment, consumers' behaviors including transport modal choice, and weather condition, etc. A feedback effect caused by local natural environment seems also possible to influence these constitutional factors. For instance, heavily polluted environment may encourage people to look for the less pollution-intensive goods. In transportation, it is well known that public transport modes are relatively "cleaner" than private car. If individual environmental consciousness does work as a determinant in transport modal choice (Shen *et al*. 2005), then his/her recognition of a bad local natural environment from the position of victim might lead to a higher probability of choosing public transport modes than private cars. There are several previous studies analyzing how local physical environment affects transport modal choice (see, for instance, Cervero 2002, Rodriguez and Joo 2004, etc.). Concerning about the impact of local natural environment on modal choice, however, we find that it is not yet well studied.

In addition, utilization of public transport can also be stimulated by improvement of its network accessibility. Overall, changes in travel conditions are commonly summarized by the generic concept of accessibility, which can be defined as "the ease of access between spatial opportunities". This definition implies that variables like travel time and costs, associated with a trip to a location, are the key components that determine accessibility. Alternatively, accessibility can be defined as "the potential attainment of a set of transportation choices" (Banister and Berechman, 2000, p.174). The latter definition indicates that transport network accessibility would influence individuals' decision on making a selection from different transport modes.

Then, based on the above discussions, we can formally propose two hypotheses in relation to the influences of transport milieu upon individual modal choice: (1) environmental deterioration will cause people more likely to choose public transport modes; (2) improved accessibility of public transport network will lead people to have higher probability of selecting public transport modes. To test these two hypotheses, the transport modal choice data recently collected in Eastern Osaka of Japan are used. As a result, both hypotheses are strongly supported by the estimated results.

The rest of the paper is organized as follows. In the next section, the empirical models are presented, while in section 3, the experimental design and brief summary of the surveyed areas are described. In section 4 we examine our estimated results, and finally we sum up our main fact-findings in section 5.

2. Model

Individual preference for transport modes can be estimated by using a choice model, which started to be applied to transportation research around thirty years ago and has rapidly developed since then (e.g. McFadden 1974; Garrod and Millius 1983; Maier *et al*. 2002). The choice model (CM) had been historically developed in Mathematical psychology (Luce and Tukey 1964) and marketing research (Actio and Jain, 1980; Green and Srinivasan 1990).[3] In the 1990s, CM has been widely applied to environmental economics for evaluating non-market goods and to transport economics for modal choice analysis (Haefele 2001; Hensher 1994; Louviere 1988; Louviere *et al.* 2000; Takeuchi *et al.* 1999). Recently, the application of CM has been extended to various areas such as health economics (Miguel *et al.* 2000) and waste management (Sasao 2002, Sakata 2005).

Choice model is based on random utility theory. The basic assumption embodied in the random utility approach to choice modeling is that decision makers are utility maximizers, i.e. given a set of alternatives the decision maker will choose the alternative that maximizes his/her utility. Usually the utility of an alternative for an individual (U) cannot be observed, however, it could be assumed to consist of a deterministic component (V) and a random error term (ε). Formally, the utility function for choosing a mode k by individual i can be denoted as follows:

$$U_{ik} = V_{ik} + \varepsilon_{ik} \qquad (1)$$

According to utility maximization, individual i chooses a mode k which prefers to any $j(\neq k)$ from choice set J if $U_{ik} > U_{ij}$. Hence, the probability of choosing a mode k over choice j ($k, j \in J$) can be written as:

$$P_{ik} = (U_{ik} > U_{ij}; \forall j(\neq k) \in J) = P(\varepsilon_{ij} < \varepsilon_{ik} + V_{ik} - V_{ij}; \forall j(\neq k) \in J) \qquad (2)$$

To transform the random utility model into a choice model, certain assumption about the joint distribution of the vector of random error terms are required. If the random error terms ε are assumed to follow the extreme value type I (EV1) distribution and be independently and identically distributed (IID) across alternatives and cases (or observations), the multinomial logit (MNL) model (McFadden 1974) is obtained. In the MNL model, the choice probability in Equation (2) is expressed as:

$$P_{ik} = \frac{\exp(\mu V_{ik})}{\sum_{j=1}^{J} \exp(\mu V_{ij})} \qquad (3)$$

where μ is a scale parameter, which is usually set to 1 in the MNL model. Then, making further assumption for the deterministic component of utility to be linear in parameters, $V_{iq} = \beta' X_{iq}$, the probability in Equation (3) is given as:

$$P_{ik} = \frac{\exp(\beta' X_{ik})}{\sum_{j=1}^{J} \exp(\beta' X_{ij})} \qquad (4)$$

where X_{iq} are explanatory variables of V_{ik}, normally including alternative-specific constants (ASCs), the attributes of the alternative k and the social-economic characteristics of the individual i, β' is the parameter vector associated with the matrix X_{ik}.

MNL is often criticized because it requires the assumption of independence from irrelevant

[3] Several literatures include CM as one of approaches of Conjoint Analysis (CA). However, due to the differences between judgment data (from conjoint rating and ranking) and choice data (from choice modeling), we define CM as an additional method other than CA in this study.

alternatives (IIA). IIA assumption is a very strong constrain on applying the choice model to policy studies. To relax this assumption, Generalized Extreme Value (GEV) models are proposed (e.g. Train, 2003, p.80). The Nested logit (NL) model (e.g. Tsuge 2001) and the Heterosckedastic Extreme Value (HEV) model are typical examples of the GEV models.

In the HEV model, the choice probability is changed to

$$P_{ik} = \frac{\exp(\mu_k \beta' x_{ik})}{\sum_{j=1}^{J} \exp(\mu_j \beta' x_{ij})} \tag{5}$$

which differs in allowing scale parameters (μ_k) to vary across alternatives from the MNL model. A nested logit model with a unique inclusive value parameter for each alternative (with one arbitrarily chosen variance to 1 for identification) is equivalent to an HEV specification (Louviere *et al.* 2000, p. 189). Compared with the NL model, the HEV model is especially valid in the case that the tree for a nested model is difficult to be specified. In addition, the magnitude of the estimated alternative-specific scale parameters and their standard deviations may help analysts determine the tree structure of a nested model.

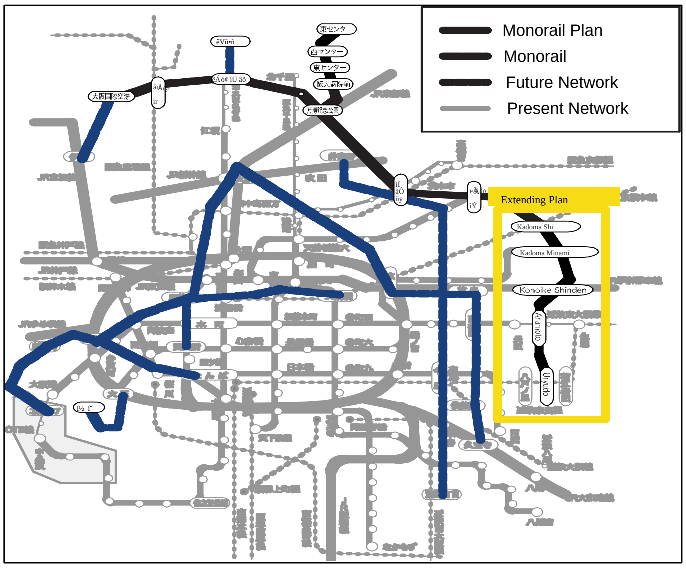
3. Choice experiment

3.1. The plan of extending Osaka Monorail Loop-line

Osaka monorail has two lines currently in operation. One is called Osaka Monorail Loop-line, running from Osaka International (Itami) Airport toKadoma-Shi. Another one is currently running from Banpaku-Kinenkoen to Handai-Byoin-Mae, named as Osaka Monorail Saito line. Osaka Monorail Loop-line at present covers an area from Northwestern Osaka to Eastern Osaka. [4]

In 2003, Kinki Public Transport Committee (KPTC) has authorized the plan of extending the Loop-line from one of the current terminals, Kadoma-Shi, to Uryudo station (south to Kadoma-Shi). Although the date of operation of this plan has not been fixed yet, it can be obviously viewed as an essential part of public transport network composing of monorail and other railways or subways. According to the plan, there will be four new stations in this extension from north to south: Kadoma-Shi → Kadoma-Minami → Konoike-Shinden → Aramoto → Uryudo (Figure 1). Table 1 provides information about these connections to other lines. The most

Figure 1 The planning area



[4] Osaka Monorail Loop-line is listed in the Guinness Book of Records with the longest total operational line of monorails.

Table 1
Prospected stations and connections to other lines

Monorail station	Connection	Main Destinations of connected line	Population within 1 km of neighborhood
Kadomashi	Keihan Railway	Kyoto, Yodoyabashi, Kitahama	45,113
Kadomaminami	Subway Tsurumi Ryokuchi Line	Kyobashi, Shinsaibashi	34,614
Konoikeshinden	Japan Railway Gakkentoshi Line	Gakkentoshi, Kitashinchi, Kobe	42,997
Aramoto	Kintetsu Higashi Osaka Line	Higashiikoma, Honmachi	17,873
Uryudo	Kintetsu Nara Line	Nara, Ikoma, Nanba	48,278

notable characteristic of this link is that each station has a connection to other lines which have different destinations as shown in Table 1. The new monorail extension is therefore expected to bring better accessibility to residents and to shift modes from private cars to the monorail.

Several large plants are also located in the main residential areas along the planned monorail line. Most of residents commute to Osaka City Center or work in those plants. In addition, metropolitan trunk roads (Osaka Central Loop Road and Kinki Highway) run in the parallel with the planned line. Traffic volume of cars on the roads is huge and congestions daily occur in rush hours. Air pollution caused by emission from cars, and noise & hubbub are serious.

3.2. Survey design

The questionnaire used for this study is composed of three parts. The first part is intended to be an introduction of the questionnaire and to give respondents basic information of the new line and the environmental changes in these days. The second part is an experiment on transport modal choice and the last part is a face sheet for individual social-economic characteristics. In the choice experiment, respondents are asked to choose one transport mode from a choice set which is consisted of monorail, bus and car with each different combination of attribute levels. In the face sheet, respondents are asked not only their social-economic characteristics but also their current travel behavior including whether they hold cars or not and they use them or not.

Trying to estimate impacts of the planned monorail which is a part of improvement of larger public transport network, we must specify the attributes levels which are comparable among those

Table 2
Attributes and their levels

Attributes	Levels of attributes		
	Monorail	Car	Bus
Average in-vehicle time for 1 section	3 minutes 6 minutes	2 minutes 4 minutes	5 minutes 10 minutes
Average delay time for 1 section	0 minutes	0 minutes 8 minutes	0 minutes 10 minutes
Frequency	10 minutes 15 minutes	at any time	6 minutes 12 minutes
Average cost for 1 section	100 JP yen 200 JP yen	200 JP yen 400 JP yen	60 JP yen 120 JP yen
Local natural environment	Current state/ Worse than current state	Current state/ Worse than current state	Current state/ Worse than current state
Network accessibility	Only monorail/ Fully realized	Only monorail/ Fully realized	Only monorail/ Fully realized

Table 3
Sample choice sheet

Transport mode	Monorail	Car	Bus
Average in-vehicle time for 1 section (minutes)	6	4	5
Average delay time for 1 section (minutes)	0	8	10
Average cost for 1 section (JP yen)	100	400	60
Frequency (numbers/hour)	4	at any time	10
Local natural environment (Please refer to the examples in Sheet A)	Current state	Current state	Current state
Network accessibility (Please refer to the map in Sheet A)	Fully realized	Fully realized	Fully realized
Please choose one most preferable transport mode and ✔ in ☐	☐	☐	☐

alternatives. Therefore, we design the levels on the basis of traveling 1 section between the new stations of monorail which is about 2 km on average and ask respondents to select the most preferable transport mode in a choice set when you are going to trip any part of these sections.

A choice set used in this experiment has 3 alternatives and each of them has 6 attributes. Two attributes (state of local natural environment and public transport network) are manipulated to be common among 3 alternatives. Table 2 shows the attributes of each alternative and the levels of each attribute. With these attributes and their levels, we obtained 32 choice sets by fractional factorial design from 4096(=2^{12}) combinations. 8 choice sets are combined as one version and distributed to the respondent. A sample choice sheet is shown in Table 3. Respondents are asked 8 times in total to choose one most preferable mode in each different choice set.

Most of attributes except for natural environmental state and transport network are chosen from typical transport modal choice experiments. Their levels used in this experiment were adjusted based on the results of pilot tests held in July 2005. We found it impossible to specify the patterns of individual trips in the surveyed area, and therefore calibrated the levels of in-vehicle time, delay time and cost based on the distance of one section of the monorail. On top of that, due to the reason that residents are likely to include parking cost into an average cost of car using, we decide to fix the level to car running and parking costs.

The environmental state used in the choice experiment is intended to reveal respondents' attitudes to transport modal choices caused by the environmental change like air pollution, global warming problems, and so on. Two environmental scenarios ('current state' and 'worse than current') are used to evaluate this point.[5] The environmental state is treated as a common condition in each choice set and allowed not to be variable across alternatives, but choice sets.

On the other hand, KPTC has 19 plans to improve network accessibility of public transport in Osaka Prefecture. Most of them will extend an existing line to link with other lines to improve transit and access to city center. The improvement of network accessibility brings network externality to each line. According to the KPTC's plans, we find that the monorail loop-line extension combined with other plans is obviously beneficial to the residents in the surveyed areas. One typical impact of the network accessibility can be observed in a change of modal choice. To estimate this impact, an attribute of 'Network' is divided into two levels, i.e. 'Only monorail extension is realized' or 'All proposals are fully realized', and included as a common attribute in the choice profile. If we could estimate a significant change of respondents' choice behavior between the two levels, we may conclude that external effects of the public transport network on the residents could be observed.

The network accessibility may also affect car users through the other route. Especially, there are little parking lots around the planned monorail stations and bus stops in the surveyed areas, thus, this improvement of public transport is additionally expected to cause a modal change from

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[5] In Osaka Prefecture, however, it is officially said that problems of air pollution have been almost overcome because SOx and NOx have become too little to be observed in the atmosphere these days. Despite few victims from serious air pollution, there are certainly growing concerns for PM (Particular Matter) from diesel, heat island, and global warming. It is unbelievable that natural environment has been getting better, especially in the surveyed areas. Another issue of treating environmental problem in our experiment is that ordinary respondents may feel difficult to understand meanings of detailed numerical data of pollution. Therefore, we divide environmental state into two levels, i.e. 'current state' or 'worse than current state', and use a dummy variable designating 0 to the former and 1 to the latter.

private cars to public transports.

3.3. Data collection

The survey is focused on the areas within 1 kilometer from each station which is listed in monorail extension plan shown in Figure 1. The questionnaires were randomly delivered to 1200 households per station between 25 July and 8 August 2005. The total number of delivered households for this experiment is 6000 (1200*5). As a result, we have 516 responses mailed back, and 453 (7.9%) of them are valid for this analysis.

4. Results

4.1. Descriptive statistics

An overview of respondents' social-economic characteristics and current pattern of behaviors is shown in Appendix. Of the 453 respondents, about 90% are above 30 years old and more than half have finished high school or special college (polytechnic).

Potential impacts of monorail extension plan on residents' daily lives are listed (see Appendix). Among their responses, 82% expect an improved traffic, and 49% expect that the neighborhood around each new station would get more activating, while about 10% concern possibly increased noise and decreased bus service.

At present, only 3.8% use Train or Subway and 7.4% use Car as their transport modes when currently traveling the monorail's extended sections. Many of them take Bus (27.1%) or Walk/Bicycle (30.7%). Responses about potentially using monorail in the future indicate that 81.1% will use monorail after the extension is realized.

4.2. Estimation result

Table 4 summarizes the results estimated by the Multinomial Logit (MNL) model and the Heteroscedastic Extreme Value (HEV) model in which the scale parameters of monorail and bus are set to be consistent to one. This assumption of equivalent scale parameters for monorail and bus in the HEV seems to be plausible since, in the surveyed areas, both monorail and bus are thought to play a same role of transporting customers in the north-south direction and/or linking with other lines. In addition, both impacts in local environmental state and transport network accessibility on individual modal choice can be almost viewed as selection between public modes and private modes.[6]

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[6] This setting is similar to the degenerated Nested Logit (NL) model which includes monorail and bus in a common branch for public mode and regards car as a degenerated branch for private mode, however, in the case of NL model specification, the independence of irrelevant alternatives (IIA) property is still assumed in the branch of public mode, while in the restricted HEV setting here, the scale parameters of monorail and bus are assumed to be same, but the IIA property is released

Table 4

Estimated results of transport modal choice (*t* statistics in parentheses)

Variable	*Alternative*	*MNL*	*HEV*
Average in-vehicle time	*All*	*-0.1241 (-8.635)*	*-0.1178 (-6.987)*
Average delay time	*All*	*-0.0613 (-8.239)*	*-0.0623 (-6.826)*
Frequency	*All*	*-0.0324 (-3.156)*	*-0.0473 (-3.874)*
Average cost	*All*	*-0.0050 (-13.371)*	*-0.0105 (-11.786)*
ASC_Monorail	*Monorail*	*1.0957 (8.976)*	*1.5564 (10.589)*
ASC_Car	*Car*	*-0.2056 (-1.036)*	*-1.7766 (-3.363)*
Environment (worse=1)	*Monorail*	*0.3481 (2.608)*	*1.3264 (3.775)*
	Bus	*0.1247 (0.764)*	*1.0465 (2.881)*
Network (fully realized=1)	*Monorail*	*0.3318 (2.489)*	*0.9158 (2.847)*
	Bus	*0.4865 (3.025)*	*1.0873 (3.240)*
Age above 65	*Monorail*	*0.3506 (2.900)*	*0.3679 (3.018)*
	Car	*-0.3529 (-2.006)*	*-1.1285 (-2.790)*
Household annual income above 6 million JP yen	*Car*	*-0.1590 (-1.48)*	*-0.3105 (-1.264)*
Numbers of car held	*Car*	*0.5019 (6.808)*	*1.1403 (5.490)*
*Current bus user * worse environment*	*Monorail*	*-0.5615 (-2.469)*	*-0.5846 (-2.394)*
	Car	*-0.7273 (-2.086)*	*-1.1531 (-1.493)*
*Current bus user * fully realized network*	*Monorail*	*-0.5374 (-2.558)*	*-0.5491 (-2.490)*
	Car	*-1.1789 (-3.092)*	*-2.0356 (-2.433)*
*Current car user * worse environment*	*Monorail*	*-0.0152 (-0.095)*	*-0.0626 (-0.386)*
	Car	*0.6460 (3.334)*	*1.9788 (4.676)*
*Current car user * fully realized network*	*Monorail*	*0.0759 (0.509)*	*0.0974 (0.639)*
	Car	*0.5686 (3.040)*	*1.1347 (3.049)*
Scale parameters			
Monorail and bus	*Monorail, Bus*		*1 (fixed)*
Car	*Car*		*0.3921 (8.553)*
Standard deviation			
Monorail and bus	*Monorail, Bus*		*1.2825 (fixed)*
Car	*Car*		*3.2713 (8.553)*
Log likelihood		*-2824.817*	*-2802.078*
ρ^2 *(McFadden)*		*0.0865*	*0.0939*
Observations		*3624*	*3624*

Comparing the specifications between the MNL and HEV models, the Likelihood Ratio (LR) test indicates that the LR statistics 45.478 (=2∗(-2802.078-(-2824.817))) is larger than $\chi^2(1)$=7.88 (the difference in the degree of freedom of the two models is 1) at 0.5% significance level, suggesting that the HEV model is superior to the MNL model.[7] According to this test, the following discussions

between monorail and bus.

[7] The independence of irrelevant alternatives (IIA) assumption in the MNL model can be rejected

are therefore based on the results of the HEV specification.

Time and cost coefficients are estimated generically for all alternatives. As expected, all of them are strongly significant with negatives signs, which indicates that more time spent on travel, delay and waiting, and more cost needed for traveling cause residents more disutility. The values of time savings (VOTS) for in-vehicle time, delay time, and frequency are calculated through dividing the coefficients of time variables by the coefficient of cost variable. The VOTS of in-vehicle time is estimated at 673 JP yen per hour (about 6 US$ per hour), which is the highest one among the three types of time. Whilst, for delay time and frequency, the VOTS are estimated at 356 and 270 JP yen per hour respectively. The difference between these two VOTS can be explained by the different stresses caused by these additional times during the travel line. It is to say that frequency can be pre-checked so that people may go to the station or bus stop just before departure in order to decrease wait time, however, delay time which is usually varied by road congestion can not be well predicted by the passengers.

Local natural environment variable (‘worse than current state’ = 1; ‘current state’ = 0) and transport network accessibility variable (‘fully realized’ = 1; ‘monorail only’ = 0) are estimated by interaction terms with alternative-specific constants (ASCs) of monorail and bus.[8] All the estimated coefficients of these four interaction terms are positive and significantly different from zero. This result suggests that, in the case of either a worse local natural environment or a more improved accessibility of public transport network, individual will prefer his/her choosing public transport modes (monorail or bus) to private car. Furthermore, a deterioration of local natural environment suggests that the marginal utility of selecting monorail is slightly higher than that of choosing bus (see the magnitudes of Environment with Monorail and Bus in Table 4). In contrast, when all the public transport investments are fully realized, the marginal utility of selecting bus is slightly higher than that of choosing monorail (see the magnitudes of Network with Monorail and Bus in Table 4). At first glance, the latter result seems counter-intuitive. However, it is probably true due to the reason that respondents may be influenced by the fact that current bus lines would have, in some cases, a better linkage with other new lines planned by KPTC, e.g. individuals frequently going to Shin-Osaka station and taking a Shinkansen will find that current bus service can link more easily with a new line directly bound for Shin-Osaka than monorail.

With respect to other variables in Table 4, the respondents who are older than sixty-five are liable to prefer selecting monorail to car (see terms of Age above 65). In addition, household’s income interacted with ASC of car is not significant here, whilst the interaction term of numbers of

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on the basis of the result that scale parameter of car in the HEV model is quite different from 1.0.

[8] A possible cross effect between local natural environmental state and transport network accessibility has been tested and found not statistically significant. Therefore, concerning these two variables, main effects are only specified in this study.

Table 5
Predicted probabilities of four sub-samples

	Sub-sample 1 (1)	Sub-sample 2 (2)	Difference (2) – (1)	Sub-sample 3 (3)	Sub-sample 4 (4)	Difference (4) – (3)
Monorail	39.261	71.146	31.885	73.310	75.174	1.864
Bus	10.725	17.013	6.288	17.220	22.853	5.633
Car	50.014	11.841	-38.173	9.470	1.974	-7.496

Note: Probabilities are in percentage (%).

car held by a household with ASC of car is estimated with a significantly positive sign. This implies that the more cars a household holds, the higher is the probability with which its members choose car as a traffic mode.

Finally, let us turn to investigating how current bus users and current car users behave under the conditions of local environmental deterioration or improved network accessibility when traveling the extended sections. For current bus users (occupying 27% of the sample), in any case, almost all the coefficients of interaction terms with ASCs of monorail and car are estimated with significantly negative signs, indicating that despite the monorail extension, bus users are not willing to shift from bus to either monorail or car. This evidence could be plausible because most of the samples are selected within one kilometer from each monorail new station and bus stops are usually located more nearly to residents than monorail.[9] On the other hand, for current car users (occupying 7.4% of the sample), interaction terms with ASC of monorail are not significant, while the coefficients of interaction terms with ASC of car in either condition are estimated with significant and positive signs, implying that car users are still willing to select car for passing through the extended sections of monorail.

4.3. Further discussions for natural environment and network accessibility

Further estimations by using sub-samples are carried out to confirm the above results about impacts of local natural environment and network accessibility on individuals' transport modal choice. Sub-samples 1 and 2 are divided from the full sample based on two different environmental states – current state or worse than current state. Alternatively, sub-samples 3 and 4 are generated from the full sample based on two situations of network accessibility – monorail only or fully realized. All these four sub-samples are estimated by the same HEV specification as before.

[9] Within the surveyed area of a circle with radius of 1 kilometer (almost equals to a half of a monorail section), it is said that four or five bus stops are normally allocated in Eastern Osaka. Thus, bus is an extremely convenient mode for a short traveling within these areas.

Table 5 summarizes the predicted choice probability of these four sub-samples. From the table, we can find that for a change in local natural environment (a change from *Sub-sample 1* to *Sub-sample 2*), the variations of the induced choice probabilities for monorail, bus and car are 31.885%, 6.288% and -38.173%, respectively, while, for a change in public transport network accessibility (a change from *Sub-sample 3* to *Sub-sample 4*), the variations of the induced choice probabilities for monorail, bus and car are 1.864%, 5.633% and -7.496%, respectively. This result is exactly consistent with the full-sample result discussed above, i.e. when local natural environment is worse than current or public transport network accessibility becomes more convenient, individuals will have a higher probability to choose public transport modes (monorail or bus). Further consistency to the full-sample estimation can be exhibited from the results of a relative higher probability variation in monorail than bus in the case of environmental deterioration, and a relative higher probability variation in bus than monorail in the case of improved network accessibility.

In summary, the estimates in this study highlight the impact of local natural environment and network accessibility on individuals' transport modal choice. They are significantly supporting the two hypotheses proposed in the Introduction. However, the induced values of time savings seem lower than most previous studies in Japan and other developed countries. One possible reason is that VOTS may be influenced by relatively lower household income in the surveyed areas. A further systematical study on this issue is necessary and left for future research.

5. Conclusions

Estimating the impacts of local natural environment and network accessibility on individual transport modal choice is not an easy task by a stated choice experiment, partly because it is quite difficult to deliver the analyst's message to individuals. Trying to make the questionnaire easily understood by ordinary residents, we specify, in this study, both local natural environment and network accessibility into two respective states and affix an additional detail introduction sheet combining figures and graphs.

By a restricted HEV specification, both results from full-sample and sub-sample estimations suggest that the probability or utility of public transports selected by individual are higher than that of private car under either condition of local environmental deterioration or improved public transport accessibility. Linking this result to sustainable transport development, this study suggests that, for transport policy makers, the relations among natural environment, network accessibility and individual modal choice should be recognized as an essential part of present transport policy.

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Appendix .

Descriptive Statistics of respondents

a. Behavior and Knowledge

Data	Answers	Count	%	Mean	Median	Mode	St. Dev
Knowledge for the plan				1.8030	2	2	0.9607
	Very well	44	9.3%				
	I have heard of it	141	29.9%				
	hardly heard of it	151	32.0%				
	Don't know	136	28.8%				
Effect							
	No Effect	42	8.9%	0.0890	0	0	0.2850
	Better Transport	385	81.6%	0.8157	1	1	0.3882
	Inconvenient using Bus	38	8.1%	0.0805	0	0	0.2724
	Reducing Car Traffic	90	19.1%	0.1907	0	0	0.3933
	Increase Tax	78	16.5%	0.1653	0	0	0.3718
	Station get more active	229	48.5%	0.4852	0	0	0.5003
	Reduce Air Pollution	84	17.8%	0.1780	0	0	0.3829
	Increase Noise	38	8.1%	0.0805	0	0	0.2724
Change in City Environment				1.4322	1	1	0.8189
	Know Very Well	46	9.7%				
	I have heard of it	218	46.2%				
	hardly heard of it	178	37.7%				
	Don't know	18	3.8%				
		12	2.5%				
Main Transport Usage				2.5784	3	4	1.2795
	Train/Subway	18	3.8%				
	Bus	128	27.1%				
	Car/Taxi	35	7.4%				
	Walk/Bicycle	145	30.7%				
	Other	146	30.9%				
Primary Transport Usage				2.2055	3	1	1.4680
	Commute	189	40.0%				
	Go to School	7	1.5%				
	Daily Use	168	35.6%				
	Leisure	34	7.2%				
	Use for work	30	6.4%				
	Other	8	1.7%				
Secondary Transport Usage				3.2585	3	4	1.5710
	Commute	11	2.3%				
	Go to School	8	1.7%				
	Daily Use	159	33.7%				
	Leisure	173	36.7%				
	Use for work	24	5.1%				
	Other	37	7.8%				
Future Potential of Usage				1.1165	1	1	0.4188
	I don't know	17	3.6%				
	Yes	383	81.1%				
	No	72	15.3%				

b. Face

Data	Answers	Count	%	Mean	Median	Mode	St. Dev
Sex				1.4301	1	1	0.5328
	Don't know	9	1.9%				
	Male	251	53.2%				
	Female	212	44.9%				
Age				4.2097	4	5	1.4144
	Don't know	7	1.5%				
	-19	5	1.1%				
	20-29	41	8.7%				
	30-39	107	22.7%				
	40-49	83	17.6%				
	50-64	127	26.9%				
	65-	102	21.6%				
Goout				4.1186	5	7	2.1819
	Don't know	12	2.5%				
	0-1	64	13.6%				
	2-3	98	20.8%				
	4-5	135	28.6%				
	6-7	163	34.5%				
Job				3.7309	3	2	2.3643
	Don't know	15	3.2%				
	Self Employment	55	11.7%				
	Private Company	159	33.7%				
	Public Company	25	5.3%				
	Parttime job	53	11.2%				
	Student	8	1.7%				
	Housewife	58	12.3%				
	Pension	79	16.7%				
	Other	20	4.2%				
Education				2.2352	2	1	1.5205
	Don't know	15	3.2%				
	High School	204	43.2%				
	Special School	45	9.5%				
	University	151	32.0%				
	Graduate School	13	2.8%				
	Student	8	1.7%				
	Other	36	7.6%				
Family				2.6525	2	2	1.2678
	Don't know	2	0.4%				
	1	74	15.7%				
	2	159	33.7%				
	3	94	19.9%				
	4	92	19.5%				
	More than 5	42	8.9%				
Havecar				1.2691	1	1	0.4807
	Don't know	8	1.7%				
	Yes	329	69.7%				
	No	135	28.6%				
Household Income				2.4089	2	2	1.2501
	Don't know	59	12.5%				
	-3 million	99	21.0%				
	3-6 mil.	179	37.9%				
	6-10 mil.	100	21.2%				
	over 10 million	35	7.4%				
Station	Kadomashi	66	14.0%	0.1398	0	0	0.3472
	Kadomaminami	69	14.6%	0.1462	0	0	0.3537
	Konoikeshinden	139	29.4%	0.2945	0	0	0.4563
	Aramoto	89	18.9%	0.1886	0	0	0.3916
	Uryudo	106	22.5%	0.2246	0	0	0.4177