Modeling joint eating-out destination choices incorporating group-level impedance
A case study of the Greater Tokyo Area
グループレベルの移動抵抗を組み込んだ同伴外食目的地選択のモデル化
東京都市圏におけるケーススタディ

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Individuals undertake both solo and joint activities as part of their overall activity-travel patterns. Compared to work and maintenance activities, social and leisure activities differ in that they exhibit high levels of temporal and spatial flexibility. In this study we used data from an ego-centric social networks survey in the Greater Tokyo Area and follow-up group activity survey to estimate a joint eating-out destination choice model explicitly incorporating group-level impedance. Consistent with the literature, travel time has a large impact on destination choice as measured by its elasticity; however, the elasticities of group-level maximum, average or median travel times are larger than individual-level travel times. Furthermore, we show that incorporating group-level impedance increases model performance up to 49% against the ego-level impedance model, a substantial increase that underscores the need to incorporate group-level characteristics in travel behavior models.

1. Introduction

Our travel behavior is interdependent with the travel behavior of the people that compose our social group, be it family, friends, or colleagues. This is particularly so for leisure activities, which due to high spatial-temporal variability are very hard to predict. While some light has been shed on various aspects of leisure activities, such as frequency1), duration and associated travel time2), destination choice for leisure activities has not been widely studied. Furthermore, the inherently social nature of leisure activities underscores the need to incorporate social networks characteristics in the analysis. As such, the aim of this study is to model joint leisure activity (eating-out, in particular) incorporating the utility of the group.

2. Methodology

The main research questions we seek to answer are:

1. What factors affect joint eating-out destination choice and what is the effect magnitude of the identified factors?
2. How much does group-level utility improve model performance relative to individual-level utility?
3. What group level utility specification yields the best performance?

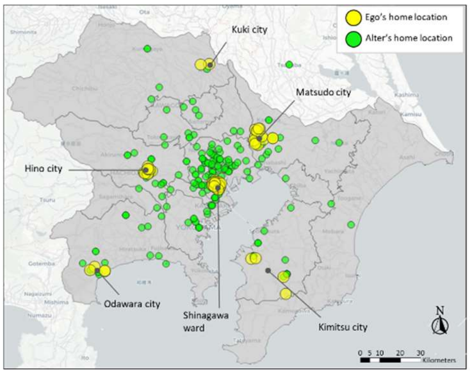
Therefore, the research framework follows three steps:

1. A survey designed to measure social network characteristics and attributes of joint eating-out activities was conducted in the Greater Tokyo Area3) in early 2020.
2. Descriptive analysis of the survey data was conducted to extract temporal, spatial and other related characteristics of joint eating-out activities.
3. Using the survey data as input, a Multinomial Logit Model (MNL) was formulated to evaluate the factors affecting destination choice for joint eating-out activities and their magnitude. We tested several model formulations that explicitly incorporate the utility of the group and compared these models against a model considering only individual utility. Effect magnitude is evaluated by calculating elasticities.

The original intention of this study is the explicit consideration of the link between social networks and travel behavior and the incorporation of group utilities in behavioral models. Traditional travel behavior models mostly focus on individuals and disregard group interactions, while incorporating group utility might help increase the predictive ability of behavioral models.

2-1. Outline of survey design

To capture network characteristics and attributes of joint eating-out activities, respondents were asked to recall related information about last eating-out activities like time, number of members, place and so on. In the survey, “Ego” stands for respondents, “Clique” stands for the social group and “Alter” stands for other members of the group. What’s more, other places often visited with the same clique are reported.



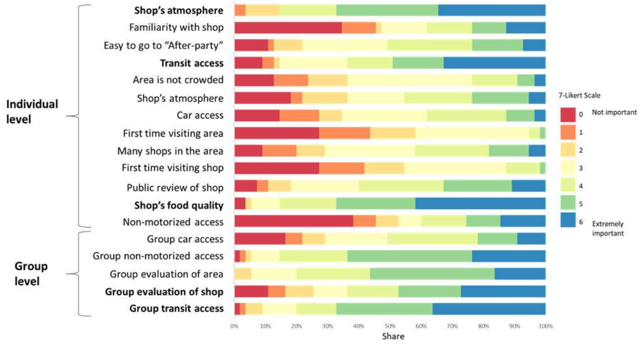


Fig. 1 Spatial distribution of egos and alters in the sample

Fig. 2 Rating score of importance of location attributes

2-2. Model specification and variables

The spatial scale of analysis is the "small zones" (the smallest zone of the zone systems applied in Tokyo Metropolitan Region Person Trip Survey). Due to sample size limitations, we defined (i) the actual activity destination location and the (ii) alternative activity locations as chosen alternatives, and use importance-based sampling to generate a feasible choice set in each choice situation (as explained below). This allows us to increase the sample size from 101 to 261, and essentially means that we are estimating a model of potential destination choices within cliques. Besides, a high participation with an average ratio of 94.64% was observed in samples, meaning that most of the clique members participated in the actual activity reported in the survey, so segmentation is valid for both the "actual activity" and "frequently visited places with that clique". As such, regarding origin locations, we used the best information available in each case. When the dependent variable corresponds to the actual last activity conducted, for egos the origin corresponds to the actual origin location (which was observed in the data) while for alters it corresponds to their home locations. When the dependent variable corresponds to alternative locations, origins for egos and alters correspond to their home locations.

The 119 zones chosen in survey data are taken as the universal choice set. The average area of all alternative zones is 260 hectares and the standard deviation is 209.8 hectares. Model variable definitions are summarized in Table 1:

Table 1 Model variable description

Variable	Description
Major station area	Dummy variable, takes value 1 if the zone is within a 1km radius from six major stations with a concentration of restaurants (Shinjuku, Shibuya, Ikebukuro, Ginza, Tokyo and Shimbashi). Data from the Economic Census for Business Activity of Japan in 2016 was used to get the geographical boundary information at the "small zone" level. 21 out of 119 alternative zones (17.64% alternatives) are within Major station areas.
Travel time	OD travel times were used as measures of impedance. Specifically, the following five different cost variables are empirically tested in the analysis: Cost1: maximum travel time of group members Cost2: minimum travel time of group members Cost3: average travel time of group members Cost4: median travel time of group members Cost5: ego's travel time
Size variable	Logarithm of the number of restaurants in the zone. Alternative zones have on average 300 restaurants. Data was collected from a popular restaurant review site in Japan.

3. Findings and Discussion

3-1. Descriptive analysis of survey data

The descriptive analysis of data characteristics showed a moderate level of activity frequency (1-3 times/year and 4-11 times/year) and relatively small group sizes (no more than 4 people) in terms of activity participation. Respondents were more likely to choose places within 10 km from their origin place and public transit and walk were mostly chosen for eating-out activity.

Regarding factors considered in the destination choice process, transit accessibility and evaluation of shops on both individual and group level, especially food quality and atmosphere are recognized as the most important. On the other hand, car accessibility and a variety-seeking attitude were less important (see Figure 2.

3-2. Model results

The classical multinomial logit model of destination choice evaluates the probability of choosing the location alternatives based on location attributes. The results of the estimation are presented in Table 3.

Table 3 MNL model results for joint eating-out activity destination choice

	Maximum distance model	Minimum distance model	Average distance model	Median distance model	Individual distance model
Estimated coefficients					
Major station area	0.0379	0.1206	0.0093	0.0488	0.0507
Size variable:	0.3225	0.6735	0.5590	0.4898	0.5137
Cost1: maximum time of group	-0.1262				
Cost2: minimum time of group		-0.3080			
Cost3: average time of group			-0.2943		
Cost4: median time of group				-0.2343	
Cost5: ego's individual time					-0.1517
Goodness of fit					
Num. observations	261	261	261	261	261
Rho-square	0.1621	0.2346	0.2672	0.2430	0.1757
Adjusted rho square	0.1581	0.2304	0.2631	0.2389	0.1716
Validation performance (10-fold cross validation)					
Percentage of correct prediction	23.70	36.30	32.59	33.33	24.44
Increase against individual model	-3.03	48.53	33.35	36.37	-
Fitting factor	16.67	20.77	23.43	21.57	15.69
Increase against individual model	6.24	32.38	49.33	37.48	-

Coefficients statistically significant above the 0.10 level in bold

Internal validation results suggest that models explicitly considering group utility outperform models that consider only individual utility. In terms of estimated effects, destination choice is influenced by (1) the number of restaurants in the area as a measure of attractiveness and (2) travel distance of all members of the party.

Direct elasticities of travel cost and number of restaurants are reported in Table 4. The elasticity of travel cost is largest for the model that uses average travel time among group members as an impedance measure, indicating an average 3.88% reduction in choice probability given a 1% increase in the average distance among group members, a very large effect. The second largest was the maximum travel time among group members. This suggests that groups consider locations that are on average convenient to all members and are more sensitive to the most inconvenienced member of the party and might weight his inconvenience when making a choice. Direct elasticities of number of restaurants indicate an average 0.15%-0.44% increase in choice probability given a 1% increase in the number of restaurants.

Table 4. Average direct elasticity of significant variables of all alternative zones

	Maximum distance model	Minimum distance model	Average distance model	Median distance model	Individual distance model
$\ln(Number\ of\ Res)$	0.15	0.44	0.30	0.32	0.40
95% C.I.	0.14 to 0.16	0.43 to 0.44	0.29 to 0.31	0.31 to 0.33	0.39 to 0.40
Maximum distance of group	-3.41				
95% C.I.	-3.44 to -3.38				
Minimum distance of group		-1.97			
95% C.I.		-1.98 to -1.96			

Average distance of group	-3.88		
95% C.I.	-3.91 to -3.85		
Median distance of group		-3.24	
95% C.I.		-3.26 to -3.22	
Individual distance			-2.30
95% C.I.			-2.31 to -2.28

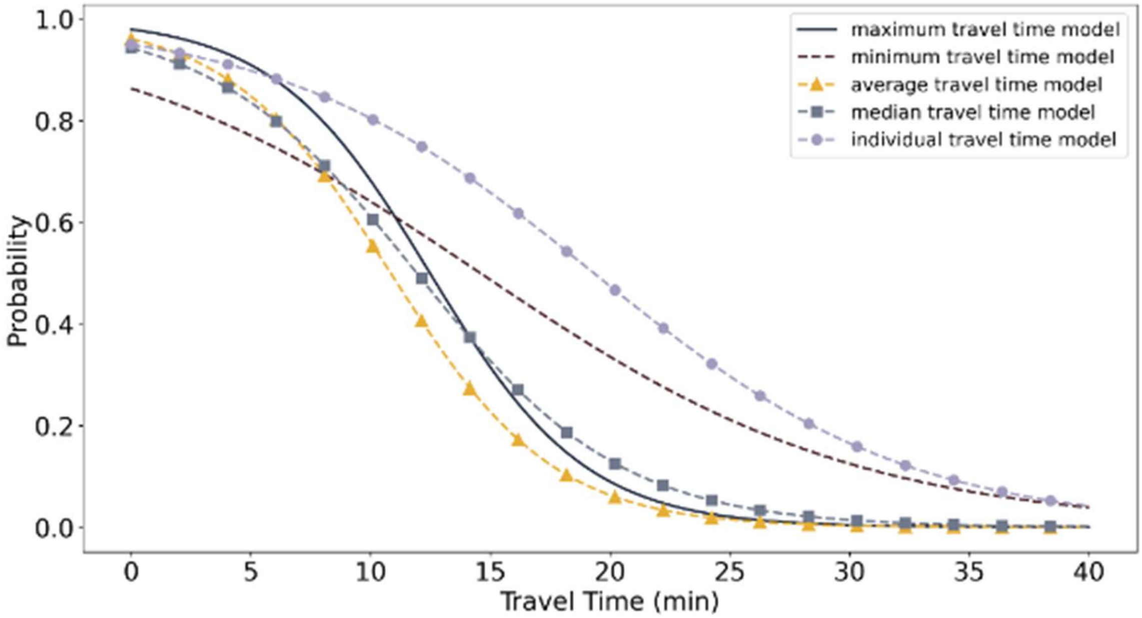


Fig. 3 Plot of simulation on probability to travel time.

Number of restaurants was fixed to the average value of 300.

3-3. Effect magnitude in different market segmentation

To explore effect differences given group or event characteristics, we conducted a segmentation analysis. Note that due to sample limitations, segmentation was conducted one category at a time. Eight types of standards are applied for segmentation: socio-demographic information, event information and clique characteristics information.

Generally speaking, the effect size of travel time and number of restaurants to choice probability differs in different segmentations. However, the effect difference of number of restaurants are close to zero (see the differences in the y axis) and just the difference of travel time is worth mentioning.

When segmenting by socio-demographic attributes, results suggest that mostly-elder groups are more sensitive to travel time, which might be related to more limited levels of physical mobility compared to their younger counterparts.

When segmenting by event characteristics, results suggest that parties with less than 5 members are more sensitive to travel time, indicating that for larger groups, group members tend to be more tolerant and tend to consider the benefits of the group as a whole.

When separating by clique characteristics, results suggest that people are more sensitive to travel time when the party is held by cliques consisting of old friends or members that have lower eating frequency or met less recently. It could be seen from that for longer relationships or for parties with cliques often eat-out, people might be franker and more direct when making decisions, while for weaker ties or for parties with cliques have fewer eating-out activities, people might be less inclined to do so.

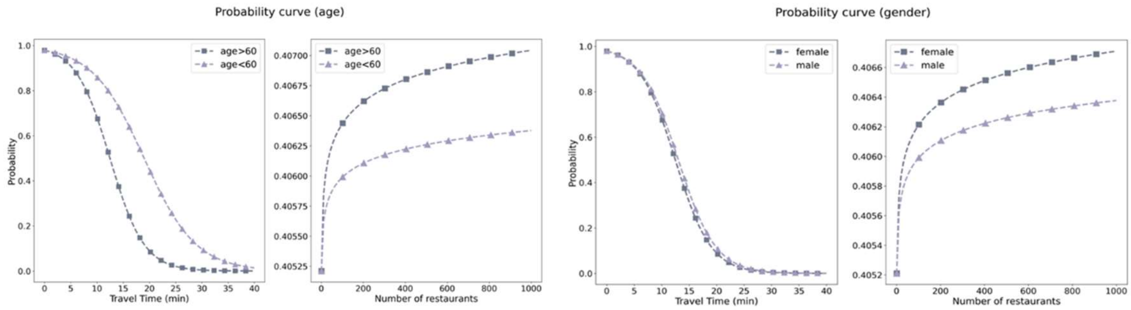


Fig. 4 Plot of simulation on probability to travel time and number of restaurants in different age and gender groups

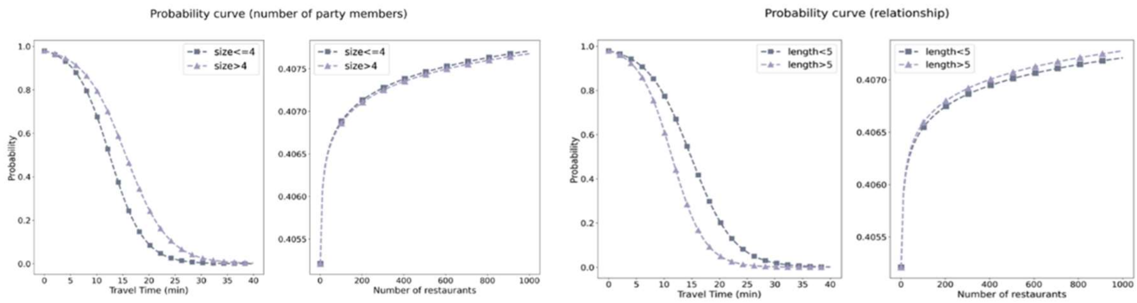


Fig. 5 Plot of simulation on probability to travel time and number of restaurants in groups with different number of party members or in groups with party held within cliques of different relationship length

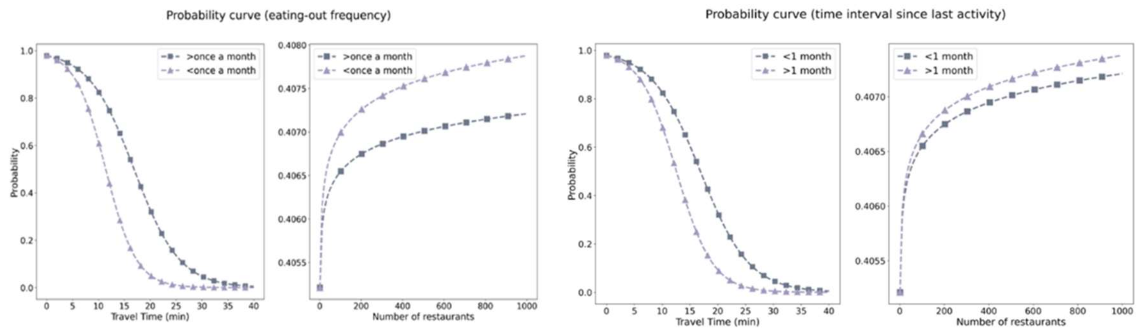


Fig. 6 Plot of simulation on probability to travel time and number of restaurants in groups with party held within cliques of different eating-out frequency or different time interval since last eating-out activity

4. Conclusions

In this study we used data from an ego-centric social networks survey in the Greater Tokyo Area and follow-up group activity survey to estimate a joint eating-out destination choice model explicitly incorporating group-level impedance. Estimation results showed that models incorporating group utility markedly outperformed the individual utility model. This underscores the fact that the utility of group members is a non-ignorable factor to consider. Furthermore, taking social situational factors into consideration could contribute to a better analysis on human behavior.

Although this study provided some insights in terms of destination choice process, some limitations and future work directions need to be highlighted. First of all, due to difficulty of collecting information about people's private activities and survey response burden, the effective sample size is small. In addition, information of social networks is based on ego self-reporting, so the information provided on group members is limited. New survey methodologies are required to properly observe the decision-making process of groups as well as the spatio-temporal constraints, not only of ego, but of all group members. The work of Parady, Oyama and Chikaraishi (2022) is a possible step forward in this direction. However, it is important to highlight that in spite of these limitations, this is, to the best of our knowledge the first study that explicitly incorporates group-level impedance in a destination choice model.

In terms of modeling, we have tried to incorporate some other indicators of zonal attractiveness like public review scores of restaurants, and have tried to separate restaurants into several types like café, (Japanese) izakaya, bar etc., but these attempts did not improve the model. Thus, work can be done to incorporate better measures of zone attractiveness.

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