Estimating the Joint Accessibility of Group Travel: A Case Study of Leisure Activities in The Greater Tokyo Area

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1 INTRODUCTION

In transportation and geography research, space-time accessibility measures are generally used to evaluate the potential for activity participation of individuals. However, many activities are conducted with other members of one's social network. In Japan, 88% of eating-out activities, 66% of sport activities, and 59% of other leisure activities are conducted with others. For weekends, these figures go up to 90%, 75% and 61%, respectively (Qian *et al.*, 2019). Departing from Miller (1999)'s work on space-time accessibility, and in order to account for the joint nature of activity-travel behavior, theoretical models of joint accessibility have been proposed (Neutens et al., 2008), which takes into account network-based travel times, individual activity schedules, the attractiveness of facilities and their temporal availability, and can explicitly account for the relative influence of participants. However, due to lack of empirical data on actual group schedules and travel behavior, parameters have yet to be derived empirically. This paper aims to fill this gap by estimating the joint accessibility of group travel for leisure activities in the Greater Tokyo Area, Japan. To do so, we used data from joint activities in the Tokyo Metropolitan Area where the activity schedule of all group members are observed (Parady, Oyama and Chikaraishi, 2023).

2 METHODS & DATA

2.1 Formulation

Joint accessibility is a function of the (1) attractiveness of a location, (2) the time interval available for all members of a group to conduct an activity and (3) the travel impedance for all members of the group. In this study we follow the definition of Neutens et al.(2008) :

$$A_{GK_Ge_G} = \sum_{k \in K_G} B_{GKe_G} = \sum_{k \in K_G} \exp\left(\alpha \cdot lna_k + \beta \cdot lnT_{e_Gk} - \lambda \cdot t_{e_Gk}\right) \qquad (1)$$

where

$A_{GK_Ge_G}$ is the accessibility of joint activity K_G to group G for the available activity/travel time budget e_G

K_G is the joint activity location choice set available to Group G

B_{GKe_G} is the benefit of location k to group G for the available activity/travel budget

a_k is a measure of location attractiveness, $a_k > 0$

T_{e_Gk} is the time interval available for group G to jointly perform an activity at location k, $T_{e_Gk} > 0$

$t_{e_Gk} = \sum_{i \in G} w_i t_{e_ik}$ is the separation cost expressed as travel time associated with k and e_i with w_i the relative influence of individual i on the transportation component $\sum_{i \in G} w_i = 1$. While this formulation of allows different individuals to have different weights w_i to account for their relative influence in the group, in this study we assume all individuals have the same influence. As such, average travel time was used.

$\alpha,\ \beta,\ \lambda$ are unknown parameters .

Unknown parameters are estimated via a multinomial logit model of joint destination choice.

2.2 Data

To estimate the joint accessibility parameters, we use three main datasets.

1. **Activity schedule information** was collected by Parady, Oyama and Chikaraishi (2023), who proposed a novel method to collect data on joint activities from all members of a given clique.

Through this method, in addition to individual and group characteristics, a 1-day schedule for each group member was collected, which was used to estimate available activity/travel time budgets e_G, and the time interval available for group G to jointly perform an activity, $T_{e_G k}$, based on scheduling constraints and travel time data. The data used for this study focuses on the execution of a joint eating-out activity.

2. **Travel time data** was collected via the PFlow API provided by the University of Tokyo Center for Spatial Information Science (CSIS). Since the vast majority of trips in the data were transit trips, this study is limited to joint accessibility on transit.
3. **Attractiveness of location k** was defined as the number of restaurants zone k. Data was collected from a popular online restaurant rating service in Japan. This measure was deemed adequate given that the purpose of the activity used in this study is eating-out.

3 RESULTS

The results of the destination choice model are summarized in Table 1. Signs for all coefficients are as expected, with travel time being negative and both the available travel time interval and attractiveness of locations being positive. The attractiveness variable, that also functions as a size variable in the model is very close to one, suggesting the utility function is correctly specified.

Table 1 – *Estimation results of joint destination choice model*

Variable	*Coefficient*	*t-statistic*
Travel time $t_{e_G k}$	-0.12	-9.21
ln available time interval $T_{e_G k}$	4.17	2.15
ln attractiveness a_k	0.97	18.89
Sample size	205	
LL(0)	-1482.25	
LL(β)	-891.71	
Rho-square	0.398	

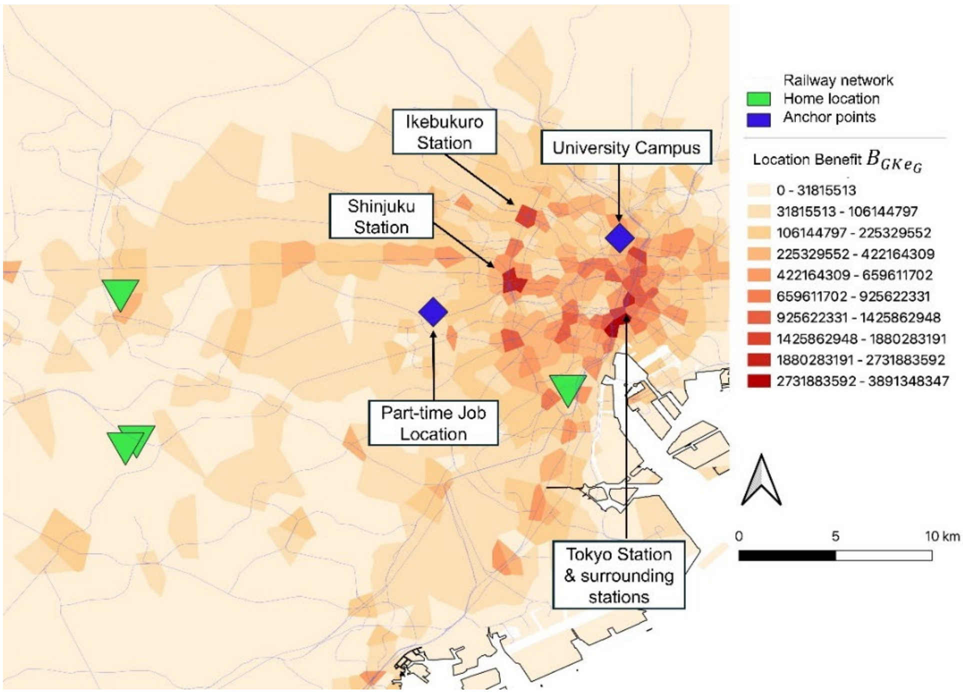

Figure 1 – *Location Benefit of zones k to group G for the available activity/travel budget*

Using the estimated model, as an example, we estimate the location benefits B_{GKe_G} of different zones, for a group G of 4 members given their available activity/travel budget. The blue polygons represent anchor points, that is, locations where some members have scheduling constraints such as work or school. It can be seen that the Tokyo subcenters of Shinjuku, Ikebukuro and Tokyo have the highest locational benefits for group G. This is in line with our expectations, given that Historically, the Tokyo sub-centers have exhibited high degrees of agglomeration of commercial and other facilities due to their high levels of access both from the railway-connected suburbs as well as other central areas (Parady, Oyama and Chikaraishi, 2023).

4 CONCLUSIONS & FURTHER WORK

To the best of the authors' knowledge, this is the first study to empirically derive joint accessibility parameters. Using the estimated joint accessibility model, a more accurate picture of the benefits of a transport-activity system can be derived from the perspective of joint activities, as opposed to the traditional individual-level perspective. Next, we will evaluate the degree to which joint accessibility estimates and observed choices match and explore further improvements to the formulation to better account for relational dynamics. Then, we will conduct a simulation study to (1) quantify the spatial distribution of joint accessibility for all the sample data, and (2) evaluate how changes in the transportation network and the land use system, and changes in the social network distribution affects joint accessibility levels. Such findings are expected to be incorporated in the TRISTAN conference presentation. Ultimately, we expect such joint accessibility measures can be incorporated in agent-based activity-travel models that explicitly account for social networks (Ji et al., 2024).

5 REFERENCES

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