Observing and modeling Interdependencies between ICT use and travel in the presence of multi-service transport platform: A case from Jakarta, Indonesia

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Abstract

The concept of time-space constraints has been discussed in many decades emphasizes that time and space delimit individual's opportunities to participate in activities and travel, imposing important restrictions on people's access and mobility. Base on the time-space constraints concept, several activity-based models have been developed together with the assumption that travel is a derived demand of activity engagement at destination. On the other hand, several researchers have discussed how the usage of ICT affects travel behavior from various angles such as how ICT affects the mode choice, route choice, and scheduling. However, most studies focus on the overall impact of ICT on activity-travel behavior, while they do not consider the context-dependent factors affecting ICT use and activity-travel behavior. In this study, we aim to (1) develop a comprehensive travel survey scheme to observe interdependencies between ICT use and travel behavior and report the results, and (2) extend an existing dynamic discrete choice activity-travel model to incorporate the impacts of ICT use on activity-travel patterns. This study focuses on a situation in Indonesia where multi-service transport platforms (MSTPs), particularly GOJEK and Grab, have been widely used and have now become a vital part of people's daily lives, leading to unignorably changes in people's travel behavior and activity patterns. With the presence of the MSTPs, the way of interacting between supply-side (merchants) and demand-side (users) might change, essentially because the platform would relax users' time and space constraints to reach the services. We have developed a comprehensive two-week travel-ICT use survey to capture interdependencies between ICT use and travel in such a context and will conduct the survey with more than 300 respondents in South Jakarta, Indonesia. We have attempted to develop a survey and modeling framework to comprehensively understand the impacts of MSTPs on travel behavior with a focus on Indonesia where MSTPs services have been widely used and have now become a vital part of people's daily lives. We believe that it is worth sharing the proposed framework together with empirical findings with other travel behavior scholars, since the MSTPs has been showing both unignorably positive and negative impacts on the society in Indonesia, and putting the MSTPs on a proper position of entire transport systems is one of the major challenges we face.

Keywords: *Multi-service Transport Platform (MSTPs); ICT Use; Activity-Travel Behavior; Dynamic Discrete Choice Model; Smartphone-based Survey;*

1. Introduction

Time-space constraint is a concept that has been discussed by experts in human geography since the late 1960s and 1970s. It emphasizes that time and space delimit individual's opportunities to participate in activities and travel, imposing important restrictions on people's access and mobility (Hägerstrand, 1970; Burns, 1979; Schwanen, 2008). A number of activity-based models (e.g., Kitamura and Fujii, 1998; Pendyala et al., 2002; Liao et al., 2013) have been developed based on this time-space concept, together with the assumption that travel is a derived demand of activity engagement at destination (i.e., people are traveling for extrinsic motivations rather than intrinsic

motivations). On the other hand, recent studies, together with the rapid progress of ICT, have questioned on these two foundations of the model. Shaw and Yu (2009) claim that virtual activity engagement via ICT cannot be represented and explained by the classical time-space constraint framework. Also, such virtual activity engagement would reduce travel if travel is a pure derived demand of activity engagement, but this may not be completely true since people would travel not only for extrinsic but also for intrinsic motivations (Mokhtarian et al., 2015). These arguments call for further investigations on observing and modeling interdependencies between ICT use and travel. In this study, we aim to (1) develop a comprehensive travel survey scheme to observe interdependencies between ICT use and travel behavior and report the results, and (2) extend a existing dynamic discrete choice activity-travel model to incorporate the impacts of ICT use on activity-travel patterns. In the remaining sections, after introducing our study area, we explain the details of the proposed survey and activity-travel model for exploring interdependencies between ICT use and travel.

2. Study area

This study focuses on a situation in Indonesia where multi-service transport platforms (MSTPs), particularly GOJEK and Grab, have been widely used and have now become a vital part of people's daily lives, leading to unignorable changes in people's travel behavior and activity patterns. These platforms provide not only ride-hailing services but also various services supporting their daily-life activities, including food delivery service, medicine delivery service, grocery shopping service, daily need services such as house cleaning service, online payment, on-demand fuel-delivery service, and so on. They allow people to access various services without travel at a relatively affordable cost, and now have become one of the best alternatives that many people choose. With the presence of the MSTPs, the way of interacting between supply-side (merchants) and demand-side (users) might change, essentially because the platform would relax users' time and space constraints to reach the services.

This study will be collecting data from more than 300 individuals who will complete 14 days (2 weeks) smartphone app-based travel-activity diary survey. The respondents are users of the online-based multi-service platforms who works (work place-based sampling) in South Jakarta City, Indonesia. South Jakarta City is one of 5 cities that are part of the Jakarta Special Capital Region, where all governmental activities, as well as business-trade and services, take place there. South Jakarta was chosen because South Jakarta has the highest number of offices, restaurants and shopping centers among the four other cities, with 668 units of office buildings, 1,570 units of eating places, and 18 units of shopping centers (based on Data Jakarta, 2018), and many of the restaurants and shops have joined the multi-service platforms.

We have developed a comprehensive two-week travel-ICT use survey to capture interdependencies between ICT use and travel in such a context as introduced in the next section, and will conduct the survey with more than 300 respondents from January 28th to February 10th, 2020 in South Jakarta.

3. Proposed survey design

A number of researchers have discussed how the usage of ICT affects travel behavior from various angles such as how ICT affects the mode choice, route choice, and scheduling (e.g., Lenz, B. & Novis, C., 2007, Aguiléra, A. et al., 2012, Fiore, F. D., et al., 2014, Ben-Elia, E., 2018). However, most studies focus on the overall impact of ICT on activity-travel behavior, while they do not take into account

context-dependent factors affecting ICT use and activity-travel behavior. For example, the use of online food delivery service for lunch may depend on the time pressure the person is under at that time. This obviously calls for the improvement of travel survey scheme, while there has been relatively little attempt to explore new data collection scheme unique to the problem.

To capture the effects of such context-dependent factors, we designed a data collection process that is summarized in Figure 1. Upon successful recruitment, a respondent will first answer a web-based survey on her social-demographic information. Following that, she will download an app onto her phone that will track her daily mobility activities automatically. Daily timeline for the user will be displayed in the app for users to verify and answer additional questions pertaining to trip and activity details and ICT usage. The tracking and verification process goes on for 14 days, during which a customized SP questionnaire will also be delivered to the user for selected eating-out or shopping activities. Finally, at the end of the two weeks, participants will be required to take a short survey on their attitude towards ICT.

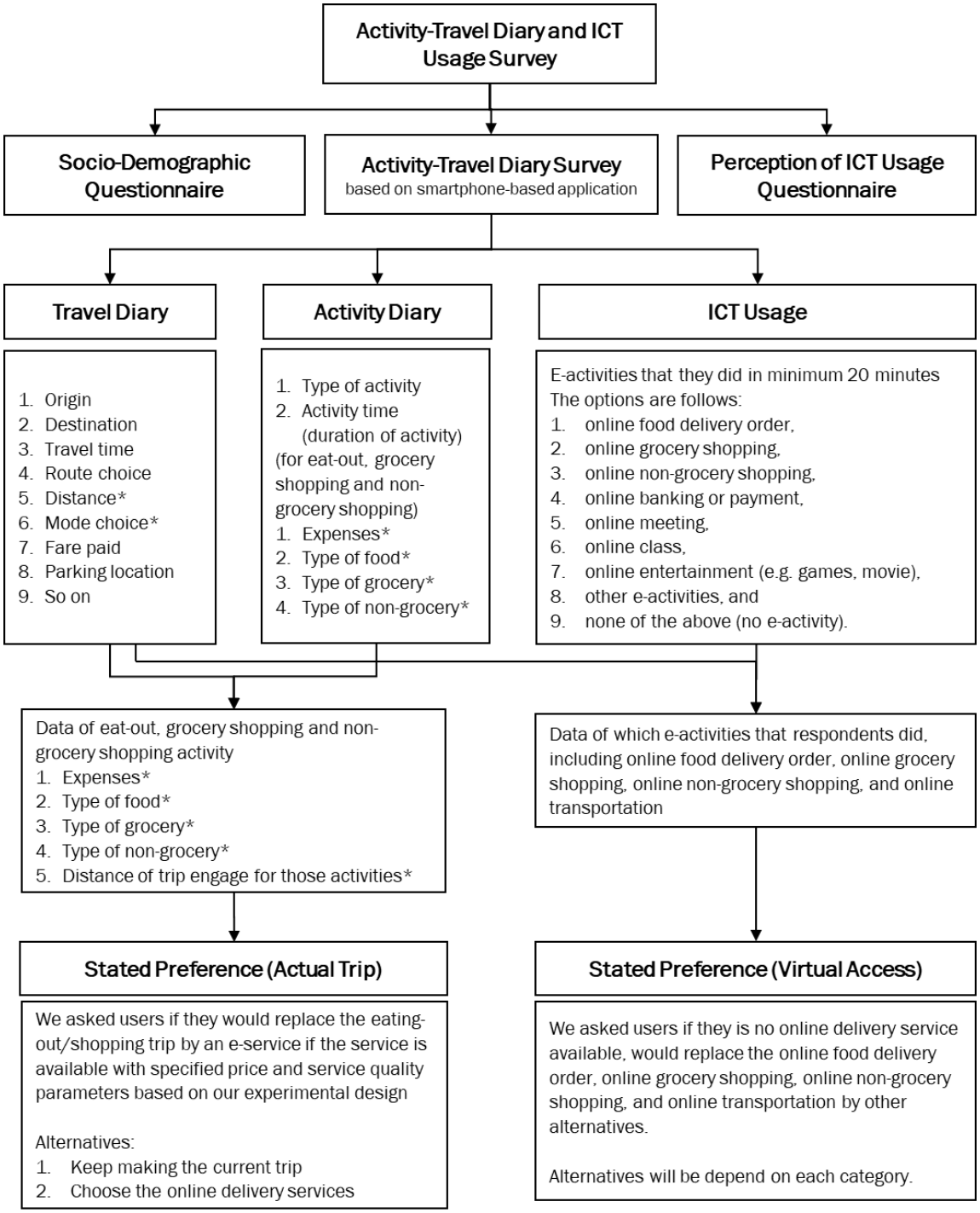

Figure 1. Survey Content

The core part of the survey is an app called X-ING (by Mobile Market Monitor (MMM), www.mobilemarketmonitor.com). The MMM platform records and infers a wide range of travel attributes including location (origin and destination), travel time, travel purpose (activity), route choice (by GPS tracking), and mode choice, and provides a user-friendly interface for users to verify the auto-generated timeline and answer additional questions. For the purpose of this study, we have extended this travel survey by adding the following three components. First, in the daily diary verification, we added a question about ICT usage for every travel and non-travel activity whose duration is more than 20 minutes. The question asks participants to select all the e-activities

performed during the specific trip or stop. This is to capture revealed preferences on both activity-travel and ICT use. Second, for each of the reported ICT use, we asked respondents to report what they would do if the relevant ICT-based service was unavailable. Respondents were asked to choose one of the alternatives for different e-activity types as shown in Table 1.

Table 1. SP Alternatives

Category	Alternatives
Actual Trip for the eating-out/shopping trip	1. Keep making the current trip 2. Choose the online delivery services
Online Food Delivery Service	1. Give up for having meal 2. Make a trip to the nearby restaurant/shop 3. Cook by them self 4. Use the traditional food delivery services (call the restaurant) 5. Ask other people to bring food 6. Others
Online Grocery Delivery Services	1. Give up having grocery 2. Make a trip to the nearby market/shop 3. Ask other people to bring/buy the grocery 4. Others
Online Non-Grocery Delivery Services	1. Give up having the good 2. Make a trip to the nearby market/shop 3. Ask other people to bring/buy the good 4. Others
Online Motorbike Transportation	1. Give up making the trip 2. Use another ride-hailing service 3. Use your own vehicle 4. Asking someone to pickup 5. Others

This allows us to confirm whether the ICT use substituted a trip or not. Third, we added an individually customized stated preferences question on ICT use for selected eating-out and shopping trips. Specifically, we asked users if they would replace the eating-out/shopping trip by an e-service if the service is available with specified price and service quality parameters by pivoting the revealed preferences (e.g., Hensher and Greene, 2003). Importantly, this pivoted stated preference design allows respondents to represent their preferences given all context-dependent factors such as motivation and constraints they actually had at that time. This feature is of particular importance to capture the complex interdependencies between ICT use and travel, since their travel decisions may come from not only extrinsic motivations (e.g., getting lunch meal), but also intrinsic motivations (e.g., interacting with friends while traveling and having lunch). The respondent will not choose e-service even when the service level is very high, if they made a trip for intrinsic motivations.

4. Proposed activity-travel model

Dynamic discrete choice models have received widespread acceptance in transport research and being used in travel demand modelling and behavioral analysis. In the context of travel behavior analysis, dynamic discrete choice models have been used for modeling route choice behavior (Fosgerau et al., 2013; Oyama and Hato, 2019), and recently used for modeling whole activity-travel patterns in a given period of time (Västberg, O. B., Karlström, A., Jonsson, D., & Sundberg, M., 2019), i.e., a sequence of activity-travel decisions is considered as a path choice in a time-space prism (Chikaraishi et al., 2018). While the model strictly reflects time-space constraints, the current version

does not allow for representing virtual activity engagement through MSTP that would virtually nullify time-space constraints. This study attempts to fill in this gap.

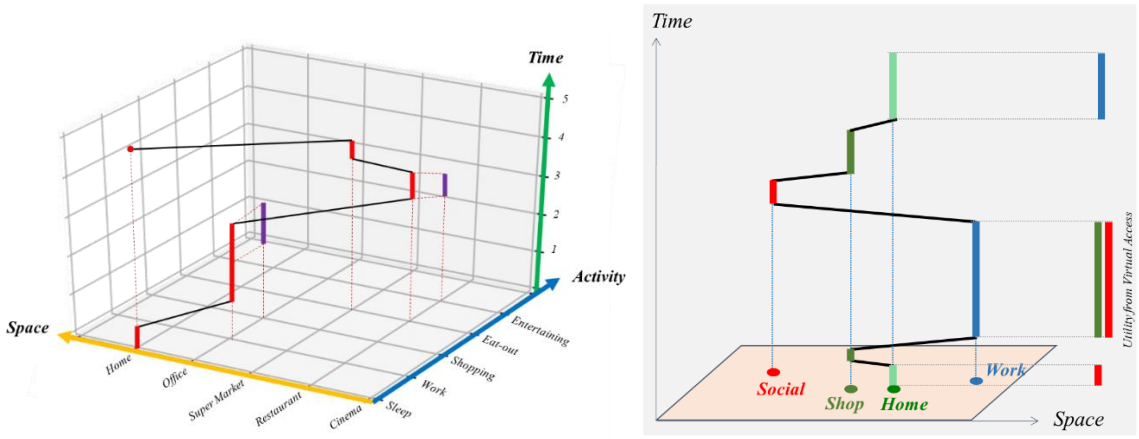

Figure 1. The daily travel-activity behavior embedded with ICT usage

Figure 1 shows a person's activity-travel behavior in a time-space prism together with ICT use. The vertical line represents activity engagement at each location (called "activity link"), and the line connecting two successive activity engagements represents travel (called "travel link"). In the proposed model, we assume that people will choose a path, i.e., the sequence of activity and travel links, that maximizes his or her utility.

The presence of MSTP will increase utility of activity links by allowing people to virtually access services in other areas nearby without travel, i.e., drivers who join MSTP will bring the service to his or her place. To reflect it, we first develop a choice model of virtual activity engagement at location j as follows[1]:

$$P_{ij}^{e} = \frac{\exp\left(V_{ij}^{e}\right)}{\sum_{j} \exp\left(V_{ij}^{e}\right)} \tag{1}$$

where P_{ij}^{e} is the probability of choosing location j for virtual activity engagement, and V_{ij}^{e} is the systematic component of utility obtained from virtual activity engagement at location j for individuals who stay at location i. The term V_{ij}^{e} is a function of service level of MSTP (delivery cost and waiting time) and attributes representing attractiveness at location j (such as food types provided at the place). Location j can be either each restaurant/shop or its aggregate zone, depending on the availability of the data. In our empirical study, we will employ the latter due to the limited access to the location information of the selected merchants.

We then calculate the expected maximum utility from virtual activity engagement for a person staying at location i, which is defined as $E_i = \log\left(\sum_j \exp\left(V_{ij}^{e}\right)\right)$. We then simply add αE_i to the instantaneous utility of activity link, where α is a parameter to be estimated. Although it is not really realistic, if (1) α is equal to one, and (2) utility obtained from virtual activity engagement, V_{ij}^{e}, is equal to the utility obtained through physical visit to location j for all j (i.e., no additional cost to use MSTP service, and quality of services obtained are the same between physical and virtual access), all

[1] We can also take into account individual attributes in defining utility function in a straightforward way, though it is omitted to simplify the notation.

activity links would provide the same level of utility. In reality, α would be less than one, and the utility obtained through virtual visit would be lower than the utility obtained through physical visit partially due to the existence of intrinsic motivations for travel and activities at destination. In other words, the utility that they get from the "real" experience may be different from the utility that they get from the "virtual" access, though the widespread use of MSTP service indicates that benefits that they get is higher than the cost they are made for the trip.

5. Conclusions and way forward

Although this is still on-going research, we have attempted to develop a survey and modeling framework to comprehensively understand the impacts of multi-service transport platform (MSTP) on travel behavior with a focus on Indonesia where MSTPs services have been widely used and have now become a vital part of people's daily lives. We believe that it is worth sharing the proposed framework together with empirical findings with other travel behavior scholars, since the MSTP has been showing both unignorable positive and negative impacts on the society in Indonesia, and putting the MSTP on a proper position of entire transport systems is one of the major challenges we face.

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