Online Supplement to

"Analysis of The Impact of Technology Use On Multi-Modality and Activity-Travel Characteristics"

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Descriptive Statistics of the Survey Sample

Table 1 provides descriptive statistics of the dependent variables that are common for both years (2014 and 2015). It can be observed from the table that the differences in distributions of dependent variables across survey years are relatively small. This finding reinforces the 'transferability of behavior' assumption made in utilizing the pooled survey dataset (see footnote 1 from the original paper).

Figure 1 is a graphical representation of the relationship between age cohorts, smartphone apps use, and mode choice. For each of the five age categories in the final survey sample, the graphs depict the percentage of individuals that fall in each of the categories defined by smartphone level of use (3 levels) and transportation mode (6 modes). For example, the first blue bar towards the left in the first graph can be interpreted as: about 20% of the individuals between 18 and 34 years old never use their smartphone (to obtain travel information) and usually use a car for their travel needs. The graphs clearly show how the newer modes of transportation (car-sharing and ride-sourcing) are related to the use of smartphone. For younger (18-34 years) individuals, the use of smartphone also increases the use of transit, walking and biking. It can also be observed from the graphs that for older individuals (≥ 55 years), car is clearly the dominant mode of choice.

Computation of the Average Treatment Effects

For the ordinal and binomial variables (multi-modality, tour accompaniment, and recreational tours), the measure of treatment effect due to a change in smartphone ownership is estimated as follows:

$$\hat{\mathrm{ATE}}_g = \frac{1}{Q}\sum_{q=1}^{Q}\left[P(\text{ordinal/binomial variable} = g \mid a_q = 1) - P(\text{ordinal/binomial variable} = g \mid a_q = 0)\right]$$

where a_q is the dummy variable for the smartphone ownership for the individual q, and g is any category of the ordinal/binomial variable. Similarly, the ATE measure can be computed when a_q represents the dummy variable for smartphone use (0 if the individual does not own and does not use a smartphone for travel information, and 1 if the individual owns and uses a smartphone for travel information). For the continuous variable (average number of stops), the actual predicted value is computed instead of the probability. Since recreational tours impact two other endogenous variables (multi-modality and tour accompaniment), it must be predicted before the other variables. The standard error of the measure is computed using bootstraps from the sampling distributions of the estimated parameters.

Performance of GHDM and IHDM for market segments

In order to use all the information possible in the estimation of a complex model, no observations were left out for an "out-of-sample" fit assessment. To ensure that the superior data fit of the GHDM is not simply an artifact of overfitting on the estimation sample, the performance of the GHDM and IHDM in replicating activity-travel characteristics was evaluated for various market segments of the estimation sample. The market segments were defined using independent variables that played a significant role in the GHDM specification. Results of the market segmentation analysis are presented in Table 2. The predicted and actual (observed) shares for each category for each market segment were compared using the root mean squared error (RMSE) and the absolute percentage error measures.

For each selected variable, the data fit for the market segment with the most number of observations is presented. The results clearly show that the predicted shares from the GHDM are closer to the true shares than the predicted shares from the IHDM for the full sample and for each market segment. All of the measures of fit point to the superior performance of the GHDM over the IHDM.

Table 1. Sample Characteristics of Independent Variables

Socio demographic	Categories	2014 Distribution	2015 Distribution
Average number of stops per tour	Mean	2.08	2.10
Importance of having a walkable neighborhood	Very unimportant	7.2%	7.1%
	Unimportant	6.1%	6.0%
	Neutral	10.4%	10.6%
	Important	30.0%	30.0%
	Very important	46.3%	46.3%
Importance of being close to public transit	Very unimportant	15.5%	15.2%
	Unimportant	10.6%	10.5%
	Neutral	14.2%	14.4%
	Important	22.3%	22.4%
	Very important	37.4%	37.5%
Importance of being within a 30 minutes commute to work	Very unimportant	11.3%	11.1%
	Unimportant	6.4%	6.4%
	Neutral	16.0%	15.8%
	Important	20.6%	20.9%
	Very important	45.7%	45.8%
Tour accompaniment	Individual makes all tours alone	59.1%	60.2%
	Individual makes at least one tour with accompaniment	40.9%	39.8%
Recreational tours	Individual makes no recreational tours	60.5%	56.7%
	Individual makes at least one recreational tour	39.5%	43.3%

Table 2. Measures of Fit in the Estimation Sample

Variable Category/ Measure of Fit	Full Sample			65 years or older			Full-time workers			Income 100k or more		
	Actual share	GHDM prediction	IHDM prediction	Actual share	GHDM prediction	IHDM prediction	Actual share	GHDM prediction	IHDM prediction	Actual share	GHDM prediction	IHDM prediction
Multi-modality measure												
1 mode	6.6%	7.0%	7.3%	9.0%	9.4%	9.6%	4.3%	4.9%	5.0%	3.2%	3.7%	4.0%
2 modes	23.5%	24.3%	24.7%	34.2%	34.5%	34.9%	16.2%	16.8%	17.0%	13.3%	13.9%	14.4%
3 modes	34.9%	35.2%	35.6%	44.0%	45.9%	46.2%	31.0%	31.7%	32.0%	33.9%	34.2%	34.3%
4 modes	25.6%	24.2%	23.9%	11.9%	9.8%	9.0%	33.2%	29.9%	29.3%	34.9%	31.7%	30.5%
5 modes	7.3%	6.6%	6.0%	0.9%	0.4%	0.2%	11.5%	11.4%	11.0%	11.0%	10.6%	10.0%
6 modes	2.1%	2.7%	2.5%	0.0%	0.0%	0.1%	3.8%	5.3%	5.7%	3.7%	5.9%	6.8%
Tour accompaniment												
All tours alone	59.1%	56.5%	52.1%	61.7%	58.6%	57.0%	60.5%	58.0%	56.7%	53.9%	49.9%	48.7%
At least one tour with accompaniment	40.9%	43.5%	47.9%	38.3%	41.4%	43.0%	39.5%	42.0%	43.3%	46.1%	50.1%	51.3%
Recreational tours												
No recreational tours	60.5%	58.7%	55.6%	53.6%	50.7%	48.6%	63.4%	60.3%	59.1%	61.2%	60.1%	58.9%
At least one recreational tour	39.5%	41.3%	44.4%	46.4%	49.3%	51.4%	36.6%	39.7%	40.9%	38.8%	39.9%	41.1%
Number of Observations	1371			345			653			436		
Root Mean Square Error	--	0.10	0.25	--	0.15	0.23	--	0.17	0.20	--	0.13	0.21
Absolute Percentage Error	--	13.0%	29.8%	--	17.2%	26.6%	--	18.0%	25.0%	--	17.4%	25.8%

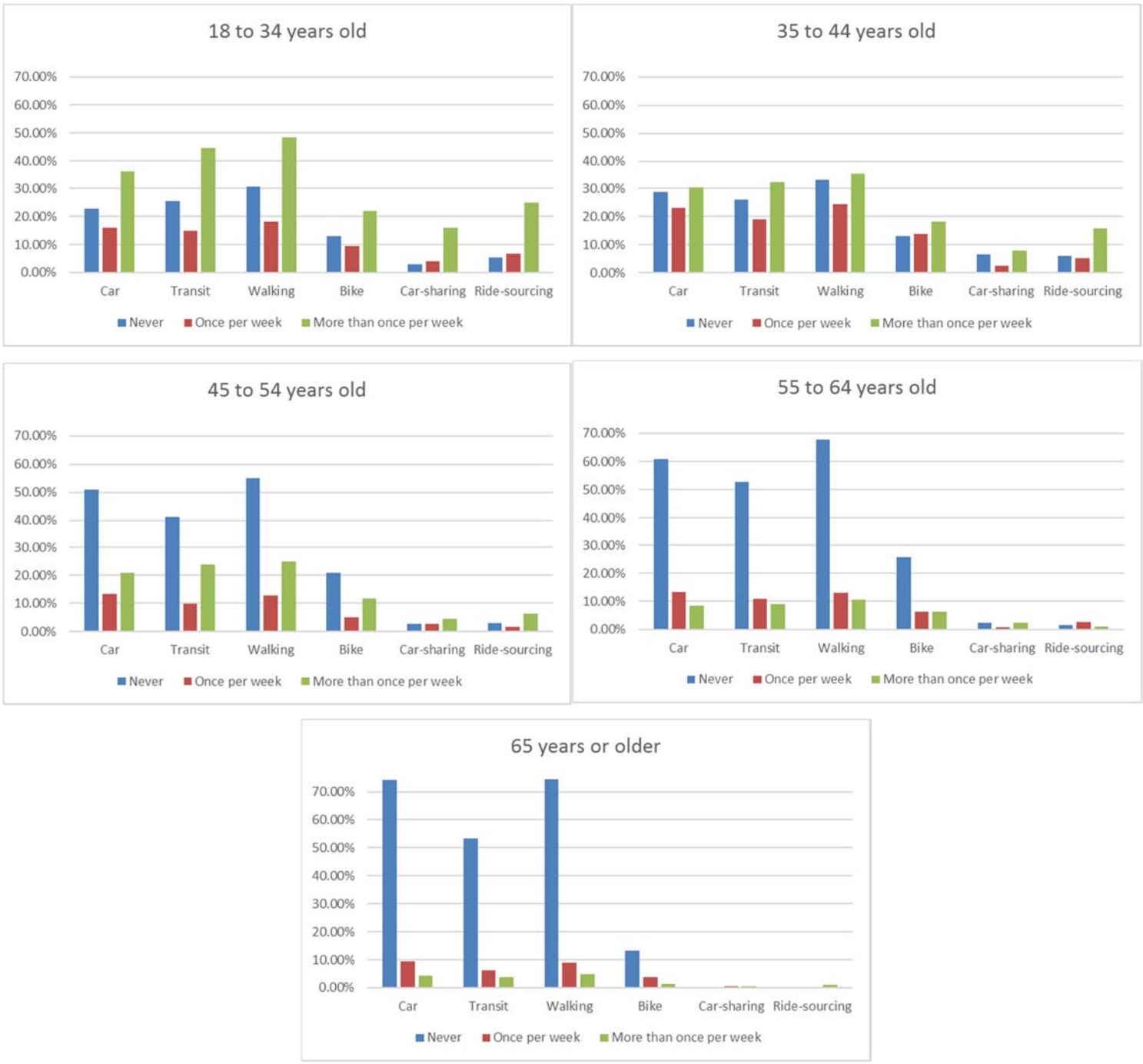

Figure 1. Distribution of Smartphone Use and Transportation Mode by Age Range