USDOT Region V Regional University Transportation Center Final Report

NEXTRANS Project No. 159PUY2.2

Information and Transportation Choices, Long- and Short-Term, that Link Sustainability and Livability – Phase II

By

Yuntao Guo
Ph.D. Candidate
Purdue University
guo187@purdue.edu

and

Srinivas Peeta
Jack and Kay Hockema Professor
Purdue University
peeta@purdue.edu

and

Yongfu Li
Associate Professor
Chongqing University of Posts and Telecommunications
laf1212@163.com

DISCLAIMER

Funding for this research was provided by the NEXTRANS Center, Purdue University under Grant No. DTRT12-G-UTC05 of the U.S. Department of Transportation, Office of the Assistant Secretary for Research and Technology (OST-R), University Transportation Centers Program. The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the information presented herein. This document is disseminated under the sponsorship of the Department of Transportation, University Transportation Centers Program, in the interest of information exchange. The U.S. Government assumes no liability for the contents or use thereof.

USDOT Region V Regional University Transportation Center Final Report

TECHNICAL SUMMARY

NEXTRANS Project No.159PUY2.2 Final Report, 4/28/2017

Title

Information and Transportation Choices, Long- and Short-Term, that Link Sustainability and Livability – Phase II

Introduction

This project will develop practical approaches to the delivery of accessibility related information and new decision-making models in the full time-scale range that are informed by multiple disciplines including cognitive science, behavioral economics, marketing, transportation, and urban planning. It will design information interventions intended for the full range of transportation-relevant decisions and test their impacts on people moving to the Greater Lafayette area, Indiana. The research is designed to test the sensitivity of: (i) long-term decision of residential location choice to information, and (ii) the sensitivity of short-term travel characteristics to long-term residential location choice.

To enable this study, in a collaborative Phase I project, researchers at the University of Michigan and Purdue University designed and developed an interactive on-line accessibility mapping tool for the Greater Lafayette area to assess long-term residential location decision-making under information provision by linking to measures of accessibility and livability. This interactive on-line accessibility mapping tool would allow participants to visualize different levels of accessibility using different transportation modes based on their work locations and the importance of different trip purposes (including trips to work and non-work locations). Four transportation modes are incorporated in the interactive on-line accessibility mapping tool including walking, bicycling, public transit, and driving. The transportation accessibility is calculated based on the travel time from each census block groups in the Greater Lafayette area to different types of activities using Google Maps.

Findings

The key benefit of this project stems from data that will be used to understand the role of accessibility to various activity locations using multiple modes to characterize notions of livability. In addition, these findings and insights can help to develop accessibility-based livability index structured to capture the six principles of livability established by the Department of Transportation (http://www.dot.gov/livability/101).

Recommendations

The results illustrate that the proposed strategy can assist participants in their residential location decisions by being more informed on neighborhoods that can better address their travel needs. The results suggest that the proposed strategy can foster sustainable behavior by impacting participants' long-term travel-related behavior through their residential location choice. Furthermore, the interactive online accessibility mapping application is built on generally available data and provides personalized accessibility information to users. Hence, it can be readily deployed by planners and policy-makers.

ACKNOWLEDGMENTS

The authors would like to thank the NEXTRANS Center, the USDOT Region V Regional University Transportation Center at Purdue University, for supporting this research.

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER 1. INTRODUCATION AND METHODOLOGICAL

1.1 Introduction

Travelers' decisions regarding transportation can be conceived of along a long-term to short-term spectrum. Decisions of residential locations, vehicle ownership, and work destination are usually established over the scale of years. Over a shorter time period of perhaps months, people make decisions regarding parking purchase and non-work destinations. Choice of mode may be a day-to-day decision, while choice of routes may be altered virtually instantaneously. Despite this broad range of time frames, current strategies for the dissemination of transportation information concentrate at the short-term end of the spectrum (Peeta and Mahmassani 1995; Paz and Peeta, 2009). For example, real-time information on travel time (Ben-Elia and Shiftan 2010) can be relevant to route-choice behavior, but will rarely affect decisions made over longer time frames. For the long-term end of the spectrum, researchers and planners rely on planning models, which typically cannot capture the impact of information.

To foster more sustainable transportation choice behavior, an effective information strategy should be ideally designed to work along the full time-scale range, particularly since longer-term decisions frequently constrain the shorter-term options. However, the insights on the sensitivity of choices at varying time scales to information interventions, or the impact of long-term choices on those made over the shorter terms are limited. Rodriguez and Rogers (2014) show that information related to accessibility of transit stops and shopping locations has the potential to affect people's renting location and travel behavior. However, the participants are limited to graduate students, and hence the study is not representative of the general population. Further, the accessibility tool used is not personalized to suit individual needs/constraints.

This project will develop practical approaches to the delivery of accessibility related information and new decision-making models in the full time-scale range that are informed by multiple disciplines including cognitive science, behavioral economics, marketing, transportation, and urban planning. It will design information interventions intended for the full range of transportation-relevant decisions and test their impacts on people moving to the Greater Lafayette area, Indiana. The research is designed to test the sensitivity of: (i) long-term decision of residential location choice to information, and (ii) the sensitivity of short-term travel characteristics to long-term residential location choice.

To enable this study, in a collaborative Phase I project, researchers at the University of Michigan and Purdue University designed and developed an interactive on-line accessibility mapping tool for the Greater Lafayette area to assess long-term residential location decision-making under information provision by linking to measures of accessibility and livability. This interactive on-line accessibility mapping tool would allow participants to visualize different levels of accessibility using different transportation modes based on their work locations and the importance of different trip purposes (including trips to work and non-work locations). Four transportation modes are incorporated in the interactive on-line accessibility mapping tool including walking, bicycling, public transit, and driving. The transportation accessibility is calculated based on the travel time from each census block groups in the Greater Lafayette area to different types of activities using Google Maps.

Rare among policy investigations, information-related questions can be researched through true experimental design. In Phase II of this project, these experimental designs are created by utilizing the interactive on-line accessibility mapping tool created in Phase I to analyze the role of information related to accessibility/livability on residential location choice decisions of people moving to the Greater Lafayette area. These relocators will be randomly assigned to experimental and control groups. The experimental group will be exposed to the interactive on-line accessibility mapping tool built in Phase I; the control group participants will not. Participants in the control and experimental groups will be surveyed for travel behavior and residential location choices related questions before and after they relocate to the Greater Lafayette area. The intergroup differences will be analyzed to study the impacts of accessibility/livability related information on residential location choice using standard statistical models.

The key benefit of this project stems from data that will be used to understand the role of accessibility to various activity locations using multiple modes to characterize notions of livability. In addition, these findings and insights can help to develop accessibility-based livability index structured to capture the six principles of livability established by the Department of Transportation (http://www.dot.gov/livability/101).

1.2 Methodology

Models associated with residential location's neighborhood average weighted accessibility and automobile usage in minutes travelled per week, can be used to analyze the impact of interactive online accessibility information on residential location and travel-related behavior. However, previous studies (e.g. Ewing and Cervero, 2010; Cao et al., 2010) suggest that neighborhood accessibility is correlated with vehicle usage. This implies that these two models are interrelated whereby the dependent variable (residential location's neighborhood average weighted accessibility) in one equation is the independent variable in the other. This limits the use of ordinary least squares (OLS) regression, as a potential estimation problem exists due to the violation of a key OLS assumption in that a correlation exists between regressors and disturbances, and common unobserved factors may exist affecting both dependent variables (Washington et al., 2010). Ignoring such endogeneity can lead to erroneous conclusions (Shankar and Mannering, 1998; Tielemans, et al. 1998). To address this limitation of OLS regression for estimating the two models separately, a simultaneous equation system is used:

$$ln(A) = \beta_A Z_A + \varepsilon_A \tag{7}$$

$$ln\,(V) = \beta_V Z_V + \lambda_V \ln(A) + \varepsilon_V \tag{8}$$

where A is the average weighted accessibility of the neighborhood that an individual selected after relocation, V is the automobile usage in minutes travelled per week, Z is the vector of exogenous variables (other contributing factors related to participants' socio-economic characteristics) influencing A and V, β are vectors of estimable parameters, λ is the estimable scalar, and ε is the disturbance term. Given that the dependent variables are always positive, semi-logarithmic transformations are used. Two types of estimation methods can be used to estimate the simultaneous equation system, including single-equation methods (e.g. two-stage least squares (2SLS)) and system estimation methods (e.g. three-stage least squares (3SLS)). 3SLS is used in this study as it produces more efficient parameter estimates (Washington et al., 2010).

CHAPTER 2. SURVEY DESIGN

Purdue_Post_Survey

Q1 Dear Participant:Thank you for participating in our study.We are researchers at the NEXTRANS Center, the U.S. Department of Transportation Region 5 University Transportation Center, headquartered at Purdue University. The study 'Information and Transportation Choices, Long- and Short-Term, that Link Sustainability and Livability" seeks a better understanding of residential location choices of people based on information related to accessibility using different modes of transportation. Your participation would be greatly appreciated as it can contribute to the development of better methods to provide accessibility information on the general public and enhance the quality, sustainability and livability of the community. Participation in this study consists of (i) completing this post-experiment survey, (ii) use the online accessibility website to assist you with residential location decision making and (iii) complete post-experiment survey after you made your residential location decision. Purpose of Survey: This survey will help us understand your residential location choices and the accessibility information towards different activities.Duration of Participation: This survey will take approximately 10-15 minutes to complete.Confidentiality: All responses will be kept confidential and will not be used for any other purpose than this study.Risk: No risk greater than everyday activities is in this study.Compensation: This study will not provide you with direct benefits. Voluntary Nature of Participation: We would appreciate your honest answers based on your experience. However, if you feel uncomfortable with the questions, you can skip these questions or quit the survey any time.Contact Information: If you have any questions about this study or need further information, you can visit our website or contact Ross Guo at (765) 496-9768 or guo187@purdue.edu.

Q5 If you understand and would like to participate in this study, please check the answer "I understand and want to continue the survey below.

- ❍ I understand and want to continue the survey (1)
- ❍ I do not want to continue the survey (2)

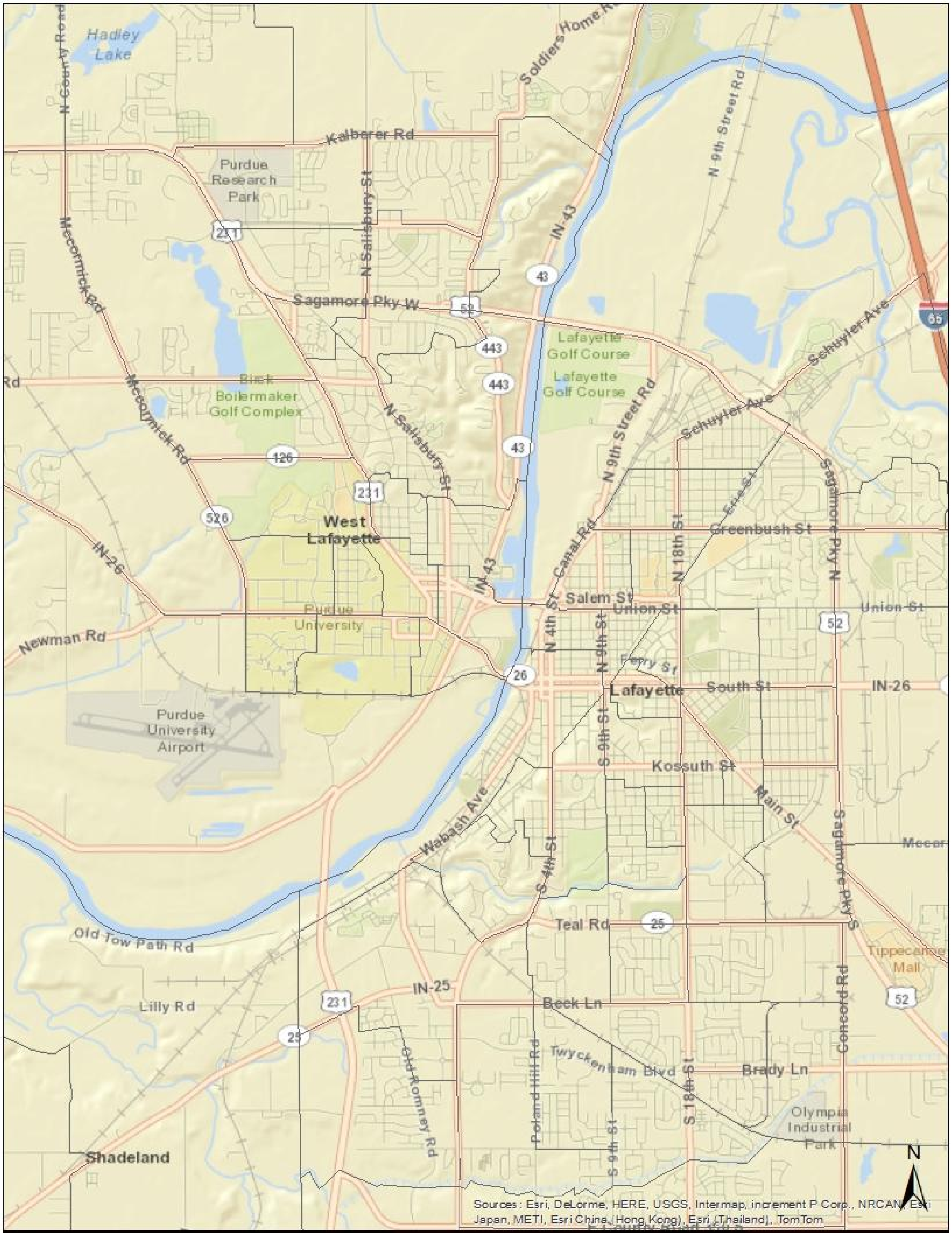
If I do not want to continue t... Is Selected, Then Skip To End of Survey

Q2 1. Please indicate the usefulness of this online accessibility tool on your final housing location.

- Not useful (1)
- Somewhat useful (2)
- Useful (3)
- Very Useful (4)
- Extremely useful (5)

Q6 2. Please identify your final housing location by clicking on the appropriate region on the map. If you need to identify your housing location in downtown West Lafayette or Lafayette, you can go to a zoomed-in map of this region below.

Q20 This is the zoom in housing location.



Q9 3. What is or will be your house type in Great Lafayette area?

- Single-family detached home (1)
- Row house/townhouse (2)
- Apartment (3)
- Mobile home (4)
- Other, please explain (5) ____________________

Q11 4. What is or will be the ownership of the housing unit you live in Great Lafayette area?

- I own the housing unit with a mortgage (1)
- I own the housing unit without a mortgage (2)
- I rent the housing unit (3)

Display This Question:

If 4. What is or will be the ownership of the housing unit you live in your new work location? I own the house, but I do not need to pay my mortgages Is Selected

Q15 5. What is the expected range of total cost?

- Under $150,000 (1)
- $150,000-$199,999 (2)
- $200,000-$299,000 (3)
- $300,000-$499,999 (4)
- $500,000 or more (5)

Display This Question:

If 4. What is or will be the ownership of the housing unit you live in your new work location? I own the house, but I need to pay my mortgages Is Selected

Q17 5. What is the expected monthly mortgage range?

- Under $1,000 (1)
- $1,000-$1,499 (2)
- $1,500-$1,999 (3)
- $2,000 or more (4)

Display This Question:

If 4. What is or will be the ownership of the housing unit you live in your new work location? I rent house Is Selected

Q19 5. What is the expected monthly rent?

- Under $500 (1)
- $500-$749 (2)
- $750-$999 (3)
- $1,000-$1,499 (4)
- $1,500 or more (5)

Q13 6. When choosing this house in the new location, what are the importance of these factors to your decision?

Cost of renting or buying (1)	❍	❍	❍	❍	❍
Number of bedrooms/bathrooms (2)	❍	❍	❍	❍	❍
Aesthetic value (3)	❍	❍	❍	❍	❍
Access to education (4)	❍	❍	❍	❍	❍
Access to work (5)	❍	❍	❍	❍	❍
Access to parks, recreation, and public facilities (10)	❍	❍	❍	❍	❍
Access to restaurants (11)	❍	❍	❍	❍	❍
Access to retail, grocery or other destinations (12)	❍	❍	❍	❍	❍

Access to healthcare (13)	❍	❍	❍	❍	❍
Safety of neighborhood (14)	❍	❍	❍	❍	❍
Parking availability (15)	❍	❍	❍	❍	❍

Q22 7. Please indicate how many single work trips (from home to work and vice versa) did you take by these modes on average per week? If you take more than twenty single work trips, please put twenty.

______ Drive alone (1)

______ Carpool/Vanpool (3)

______ Public transit (4)

______ Bicycle (5)

______ Walking (6)

Q23 8. Please indicate the estimated travel time (in minutes) of single work trips (from home to work and vice versa) did you take by these modes on average? If the estimated travel time is over 120 minutes, please put 120. If you are not sure about the travel time, please put zero.

______ Drive alone (1)

______ Carpool/Vanpool (2)

______ Public transit (3)

______ Bicycle (4)

______ Walking (5)

Q25 9. Please indicate how many single trips to healthcare related activities (from home to these activities and vice versa) did you take by these modes on average per week? If you take more than twenty trips, please put twenty.

______ Drive alone (1)

______ Carpool/Vanpool (3)

______ Public transit (4)

______ Bicycle (5)

______ Walking (6)

Q26 10. Please indicate the estimated travel time (in minutes) of single trips to healthcare related activities(from home to these activities and vice versa) did you take by these modes on average? If the estimated travel time is over 120 minutes, please put 120. If you are not sure about the travel time, please put zero.

______ Drive alone (1)

______ Carpool/Vanpool (2)

______ Public transit (3)

______ Bicycle (4)

______ Walking (5)

Q35 11. Please indicate how many single trips to recreational related activities (from home to these activities and vice versa) did you take by these modes on average per week? If you take more than twenty trips, please put twenty.

______ Drive alone (1)

______ Carpool/Vanpool (3)

______ Public transit (4)

______ Bicycle (5)

______ Walking (6)

Q28 12. Please indicate the estimated travel time (in minutes) of single trips to recreational related activities(from home to these activities and vice versa) did you take by these modes on average? If the estimated travel time is over 120 minutes, please put 120. If you are not sure about the travel time, please put zero.

______ Drive alone (1)

______ Carpool/Vanpool (2)

______ Public transit (3)

______ Bicycle (4)

______ Walking (5)

Q27 13. Please indicate how many single trips to restaurants related activities (from home to these activities and vice versa) did you take by these modes on average per week? If you take more than twenty trips, please put twenty.

______ Drive alone (1)

______ Carpool/Vanpool (3)

______ Public transit (4)

______ Bicycle (5)

______ Walking (6)

Q29 14. Please indicate the estimated travel time (in minutes) of single trips to restaurants related activities(from home to these activities and vice versa) did you take by these modes on average? If the estimated travel time is over 120 minutes, please put 120. If you are not sure about the travel time, please put zero.

______ Drive alone (1)

______ Carpool/Vanpool (2)

______ Public transit (3)

______ Bicycle (4)

______ Walking (5)

Q30 15. Please indicate how many single trips to educational related activities (from home to these activities and vice versa) did you take by these modes on average per week? If you take more than twenty trips, please put twenty.

______ Drive alone (1)

______ Carpool/Vanpool (3)

______ Public transit (4)

______ Bicycle (5)

______ Walking (6)

Q31 16. Please indicate the estimated travel time (in minutes) of single trips to educational related activities(from home to these activities and vice versa) did you take by these modes on average? If the estimated travel time is over 120 minutes, please put 120. If you are not sure about the travel time, please put zero.

______ Drive alone (1)

______ Carpool/Vanpool (2)

______ Public transit (3)

______ Bicycle (4)

______ Walking (5)

Q32 17. Please indicate how many single trips to retail/grocery shopping related activities (from home to these activities and vice versa) did you take by these modes on average per week? If you take more than twenty trips, please put twenty.

______ Drive alone (1)

______ Carpool/Vanpool (3)

______ Public transit (4)

______ Bicycle (5)

______ Walking (6)

Q33 18. Please indicate the estimated travel time (in minutes) of single trips to retail/grocery shopping related activities(from home to these activities and vice versa) did you take by these modes on average? If the estimated travel time is over 120 minutes, please put 120. If you are not sure about the travel time, please put zero.

______ Drive alone (1)

______ Carpool/Vanpool (2)

______ Public transit (3)

______ Bicycle (4)

______ Walking (5)

Q34 19. Please rate the importance of different trip purposes by allocation the amounts in the document below. (Amount can range from 0 to 100, but should total 100)

______ Work (1)

______ Healthcare (2)

______ Social activities and recreational activities (3)

______ Education (4)

______ Restaurants (5)

______ Retail shopping and grocery shopping (6)

Q36 20. How long are you planning to stay in your current home before you move?

- Less than 1 year (1)
- 1 - 5 years (2)
- 6 - 10 years (3)
- More than 10 years (4)

Q20 21. Do you have any recommendations or suggestions related to our website

Q22 Identification code Please provide us your email address. Your address identifies the survey as unique to you. This information will be kept confidential and will not be used for any other purposes than identification. If you do not have an email address, please provide us your telephone number instead.

Q24 My email address is

Q26 I do not have an email address. Instead, my telephone number is

Q28 Thank you for your time and effort to complete the survey. By clicking "Next >" button, complete this survey. If you have any other questions or concerns, feel free to contact us at (765) 496-9768 or guo187@purdue.edu. Thank you. ** Please click "Next >" button to successfully save your answers. **

CHAPTER 3. RESULTS

3.1 Descriptive Statistics

Only individuals who completed both pre-experiment and post-experiment surveys were included in the analysis. 282 completed responses were collected, including 147 in the experimental group and 135 in the control group. As shown in Figure 1, the pre-experiment survey questions are classified into three parts: (1) individual and household socio-economic characteristics, (2) travel-related behavior before relocation, (3) housing-related characteristics. Tables 1-3 illustrate some descriptive statistics.

The first part of the pre-experiment survey captures participants' individual and household socio-economic characteristics, including age, gender, education level, ethnicity, household structure, and household income. Table 1 illustrates the aggregated individual and household socio-economic characteristics. A majority of participants in both the control and experimental groups are Caucasians between the ages of 25 and 54, with higher than high school degree and more than 2 automobiles in the household. About 50% of participants were Caucasian, followed by Asians and African Americans. More than 80% of participants had higher than high school degree, and the proportions of single and married participants (around 45%) are similar. Over 70% of participants are between ages 25 and 54, and about 25% have children.

Tables 2 and 3 show participants' travel-related behavior and housing-related characteristics before relocation, respectively. Participants in both groups have similar travel-related behavior and housing-related characteristics before relocation. Table 2 shows that trips using automobile ("drive alone" and "drive with passenger(s)") represents the largest trip share for both work and non-work related trips for participants in both groups before relocation. The reason for separating participants' usage of "drive alone" and "drive with passenger(s)" for the automobile mode is to investigate if their residential location meets some travel needs of household members. Individuals in a household sharing the same automobile are likely to drive more with household members to save time and cost if their residential location satisfies other members' travel needs. All participants have used transit before, but only a few currently use it. "Transit service is not frequent enough" and "riding transit is not comfortable" are the two most important factors that discourage participants to use transit. Most participants check transportation-related information more than 3 times a week, and radio is the most commonly used device to access such information. Table 3 illustrates participants' housing-related characteristics before relocation in terms of housing type and ownership, housing type of interest for relocation, and expected ownership and costs after relocation. Most participants own a single-family detached home, and expect to purchase a single-family detached home with mortgage after relocation to Tippecanoe County.

Post-experiment surveys are classified into two parts: (1) self-reported housing type, ownership, and residential location, and (2) importance of different factors affecting residential location choice. Table 4 illustrates the self-reported housing type and ownership after relocation. Most participants in the experimental group (over 95%) had the housing type and ownership after relocation consistent with their expectation, and the remaining participants chose to own a house instead of renting one (Table 3). By contrast, only about 70% of control group participants had the housing type and ownership per expectations before relocation, and more than 10% changed housing ownership from owning to renting after relocation. In addition, experimental group participants planned to stay longer in their current property compared to control group participants, suggesting greater satisfaction with their residential location choice. The results indicate that a perceptibly significant portion of control group participants could not find residential locations that satisfied their needs, and chose to rent for a shorter period instead, implying the likelihood of moving again to another residential location.

Figures 2 and 3 show the aggregated participants' self-reported residential location in Tippecanoe County for the control and experimental groups, respectively. A key observation is that the experimental group participants live closer to downtown areas (downtown Lafayette and West Lafayette) and their work locations. The average estimated distance from their neighborhoods to downtown Lafayette (the shortest network distance from the centroid point of the selected neighborhood to downtown) is about 20% shorter, and to downtown West Lafayette is over 30% shorter compared to those of the control group participants. In addition, the average estimated distance for the experimental group participants from their neighborhood to work locations is about 25% shorter compared to that of control group participants.

3.2 Importance of Different Factors that Affect Residential Location Choice

Participants were requested to rate the importance of various factors that affect their residential location choices on a scale of 1-5, where 1 indicates "not important at all" and 5 indicates "extremely important." Eleven factors are included, and classified into three categories: (1) physical characteristics of housing unit (cost, number of bedrooms/bathrooms, and parking); (2) neighborhood environment (aesthetic value and safety); and (3) transportation accessibility (education, work, park/recreational/public facilities, restaurants, retail/grocery, and healthcare accessibilities). Table 5 illustrates the average ratings of the control and experimental groups indicating the importance of these factors.

Before relocation, the cost of renting or buying (3.90 and 3.95), safety of neighborhood (3.21 and 2.99), accessibility to work (3.03 and 2.99), and number of bedroom/bathrooms (2.97 and 3.01) are rated as the four most important factors by participants in their residential location decision-making process. A t-test comparison of means of these factors reveals that none of them are statistically significantly different (at the 0.05 level) across the two groups. In addition, Spearman's rank correlation coefficients (Guo and Peeta, 2015; Guo et al., 2016a) were used to analyze the statistical dependence for within-group ranking differences between the ratings given by the participants of the two groups for these factors. The within-group ranking represents the relative ranking given to these factors based on the average rating of each factor. The rankings for the two groups on these factors were found to be statistically significantly correlated. Both tests suggest a high degree of similarity among participants of the control and experimental groups in terms of their ratings of the importance of the factors that affect their residential location decision-making process before relocation.

The t-test comparison and Spearman's rank correlation coefficients were used to compare the participants' ratings of the factors used for decision-making before and after relocation for the control and experimental groups. The t-test indicated that none of the factors (at the 0.05 level) were statistically significantly different for the control group before and after relocation, while 4 out of 11 factors for the experimental group participants were. Among these 4 factors, 3 factors (accessibilities to education, parks/recreational/public facilities, and retail/grocery/other destinations) are related to transportation accessibility, and the average ratings of participants after relocation were higher than before relocation. Control group participants rank "parking availability" four positions higher and "accessibility to parks, recreational, or public facilities" four positions lower compared to the experimental group participants after relocation. The results illustrate that there is high degree of dissimilarity in the ratings of the experimental group participants before and after relocation on the factors that affect their residential location decisions, unlike for the control group participants. This suggests that the proposed strategy had a significant impact on experimental group participants' ratings of the importance of various factors that affect their residential location decision-making process. That is, such a long-term information intervention strategy can enable relocators to be more informed on transportation accessibilities, thereby influencing their residential location decision-making process.

3.3 *Neighborhood Accessibility to Different Trip Purposes*

In the post-experiment surveys, participants were requested to identify the neighborhood where their housing is located rather than their address, to protect their privacy. Table 6 illustrates the averages of neighborhood accessibilities for the six different trip purposes using the four different modes. These averages are higher for the experimental group compared to the control group, especially for neighborhood accessibility using non-automobile modes. Experimental group participants chose neighborhoods with better access to potential destinations compared to control group participants. This implies that the proposed information intervention strategy can assist participants to select neighborhoods with better access to their potential destinations using different modes of transportation, especially involving non-automobile modes.

3.4 *Weekly "Drive Alone" Trips and the Share of Trips by Different Transportation Modes*

In the last part of the post-experiment surveys, participants were asked to provide information on their travel-related characteristics after relocation, including self-reported estimated average travel time of a "drive alone" trip, and the average number of "drive alone", "drive with passenger(s)", public transit, bicycle, and walk trips made per week for the six trip purposes. Table 7 illustrates the aggregated travel-related characteristics of participants in the control and experimental groups.

Control group participants made 47.7% of weekly trips by "drive alone", 25.4% by "drive with passenger(s)", 10.7% by walk, 10.6% by public transit, and 5.6% by bicycle, while experimental group participants made 38.2% of weekly trips by "drive alone", 25.7% by "drive with passenger(s)", 17.8% by walk, 13.1% by public transit, and 5.3% by bicycle. Experimental group participants used walk and public transit more often, and drive alone less often compared to control group participants after relocation.

For all trip purposes, experimental group participants experienced shorter average travel times for “drive alone” trips compared to control group participants, and these differences were statistically significant for work, social/recreational, restaurants, and retail/grocery shopping trips. In addition, the shares of trips using non-automobile modes (public transit, bicycle, and walk) were higher for experimental group participants compared to control group participants, especially for walk usage in social/recreational, restaurants, and retail/grocery shopping trips.

Additional tests were performed to examine whether certain subgroups among the experimental group participants experienced a larger impact due to the information intervention strategy. Gender, age, household income, marital status, automobile ownership, whether using public transit before relocation, and the frequency of accessing transportation-related information per week, were the criteria used to specify different subgroups. No difference in impact was found based on gender, age, household income, automobile ownership, and whether using public transit before relocation. However, married participants specified “drive with passenger(s)” more often compared to unmarried participants. This indicates that married participants may use the interactive mapping application to determine a housing location that meets the needs of all family members. Hence, they can make more coordinated travel plans, and use drive with passenger(s) more often, after relocation.

Participants who accessed transportation-related information more often (more than three times a week) and were exposed to the proposed strategy selected housing neighborhood with higher weighted accessibility. This suggests that participants who accessed transportation-related information more often may use the interactive online accessibility mapping application more effectively in their residential location decision-making process.

The next section discusses the estimation results of the simultaneous equation system to further analyze the impacts of the proposed strategy on residential location choice and travel-related behavior.

3.5 Simultaneous Equation Estimation Results

Table 8 shows the simultaneous equation model estimation results. For comparison, the two models were also run as separate ordinary least squares regression models. The comparison results illustrated that the two separate ordinary least squares regression models show noticeably higher standard errors resulting in lower t-statistics compared to the simultaneous equation models. Similar observations were also found in previous studies (e.g. Shankar and Mannering, 1998).

As shown in Table 8, six variables were found to have a statistically significant correlation ($t \geq 1.96$) with the average weighted accessibility of the neighborhood that an individual selected after relocation (hereafter labeled as the neighborhood average weighted accessibility), including three variables related to individual and household socio-economic characteristics, two variables related to travel-related behavior before relocation, and one variable related to whether an individual was in the experimental group or not.

Four variables were found to have a statistically significant correlation ($t \geq 1.96$) with automobile usage (minutes travelled per week) after relocation, including one variable related to individual and household socio-economic characteristics, one variable related to travel-related behavior before relocation, one variable related to whether an individual was in the experimental group or not, and the neighborhood average weighted accessibility.

The estimation results indicate that if an individual was in experimental group, he/she is more likely to choose a neighborhood with higher average weighted accessibility and travel less by automobile. This is consistent with the results of the t-test comparison of average neighborhood accessibility and travel-related outcomes after relocation between control and experimental groups (Tables 6 and 7). These suggest that the proposed strategy can assist participants to select neighborhoods with better average weighted accessibility and reduce their automobile usage.

The neighborhood average weighted accessibility was found to have a statistically significant negative correlation with automobile usage after relocation. Similar results were also found in previous studies (e.g. Cao et al., 2010); that is, individuals who lived in neighborhoods with higher accessibility travelled less using automobile compared to those who lived in neighborhoods with lower accessibility. This indicates that the proposed strategy can foster sustainable long-term travel-related behavior, in terms of reducing automobile usage, through participants' residential location choice by assisting them to select neighborhoods with better access to their potential destinations.

The average number of licensed and operable vehicles in a household was found to have a statistically significant negative correlation with the neighborhood average weighted accessibility, but was found to have a statistically significant positive correlation with automobile usage after relocation. A possible explanation is that households with more mobility resources may value neighborhood accessibility less, but value other factors (such as costs or renting or buying) more in their residential location decision-making process due to their high household mobility.

A residential property's price was not found to have a statistically significant correlation with neighborhood average weighted accessibility. This may seem to contradicting to the conclusions in many studies (e.g. Guo et al., 2016b) that a property's neighborhood non-work-related accessibilities are often positively correlated with its property price. However, such correlation may not exist between neighborhood average weighted accessibility and a property's price, because of the significant difference between neighborhood average weighted accessibility and neighborhood accessibility. A property's neighborhood average weighted accessibility depends not only on its varies types of non-work-related neighborhood accessibilities, but also on an individual's work location and travel needs. An individual's work location determines the neighborhood work accessibility, and his or her travel needs dictates how much he or she weights each type of accessibility. It means, for the same property, different people can have different assessment in terms a property's weighted accessibility. It also means that a property's weighted accessibility may not be correlated with a property's price. For example, an individual, who works in rural areas and weighted work accessibility much more than other types of accessibility, may be more likely to selected a property located near his or her work location and the property's price may also be low in rural region. In this case, a residential property's price is negatively correlated with neighborhood average weighted accessibility. For another individual with similar socio-economic characteristics, who works in downtown and weighted non-work-related accessibilities much more than work accessibility, may selected a property located with better access to non-work-related activities, and the property's price may be higher than the one located in rural region. In this case, a residential property's price is positively correlated with neighborhood average weighted accessibility. Hence, given that people have different work locations and diverse travel needs, it is reasonable that the estimation results show there is no statistically significant correlation between a residential property's price and its neighborhood average weighted accessibility.

Two variables related individual and household socio-economic characteristics, household income and marital status, were found to be statistically significantly correlated with the neighborhood average weighted accessibility, but not with automobile usage after relocation. If an individual's annual household income is over $49,999, he/she is more likely to select a neighborhood with higher average weighted accessibility. In 2014, the median annual household income in the Tippecanoe County was $44,474 (the U.S. Census Bureau, 2015). An individual with higher annual household income may be less sensitive to costs or renting or buying, and other factors such as accessibility may be more important in their residential location decision-making process. Hence, they are more likely to relocate to neighborhoods with higher average weighted accessibility. The results also show that if an individual is married, he or she is more likely to select a neighborhood with higher average weighted accessibility after relocation. This may be because married individuals are more likely to address the diverse travel needs and travel-related behavior in their household when making residential location decisions, while unmarried or separated/divorced individuals may only have to factor their own needs. Hence, married individuals are more likely to select a neighborhood with high accessibility for different trip purposes using different modes of transportation. This is consistent with the subgroup study results in section 4.4.

If an individual used “drive alone” for at least 60% of the trips made every week before relocation, he/she was more likely to choose a neighborhood with lower average weighted accessibility, and travelled more by automobile after relocation. This is similar to findings in previous studies (e.g. Choocharukul et al., 2008), that individuals with frequent car usage habit were less likely to relocate to a neighborhood with convenient public transportation. This indicates that an individual’s travel-related behavior before relocation has a strong impact on his/her residential location decision-making process and travel-related behavior after relocation.

The results also illustrate that individuals who access transportation-related information more frequently (three times or higher per week) are more likely to select neighborhoods with higher average weighted accessibility after relocation. This is because individuals who access transportation-related information often may be more amenable to using accessibility-related information, and value higher level of accessibility more when making residential location decisions. This result is also consistent with the insights from section 4.4.

Table 3.1 **Socio-economic characteristics of participants**

	Control Group (N = 135)	Experimental Group (N = 147)
Gender		
Male	50.4%	52.4%
Female	49.6%	47.6%
Race/Ethnicity		
African American	14.8%	21.1%
Asian	23.7%	13.6%
Hispanic/Non-white	8.9%	6.8%
Hispanic/White	5.2%	4.1%
Caucasian	47.4%	54.4%
Other	0%	0%
Marital Status		
Married	44.4%	47.8%
Single	45.2%	45.4%
Separated	3.7%	1.4%
Divorced	6.7%	5.4%
Education level		
Some high school	5.2%	7.5%
High school diploma	13.3%	11.6%
Technical college degree	25.2%	27.9%
College degree	29.6%	30.6%
Post graduate degree	26.7%	22.4%
Annual household income		
Under $14,999	5.9%	5.4%
$15,000 – $24,999	11.9%	13.6%
$25,000 – $34,999	15.6%	12.9%
$35,000 – $49,999	18.5%	17.0%
$50,000 – $74,999	16.3%	18.4%
$75,000 – $99,999	14.8%	13.6%
$100,000 or more	17.0%	19.0%
Age		
Under 25	16.3%	15.6%
25 – 34	29.6%	36.7%
35 – 44	31.1%	25.9%
45 – 54	13.3%	12.9%
Over 54	9.6%	8.8%
Average number of people living in a household	1.9	2.1
Participants with children under 6	11.9%	15.0%
Participants with children between 6 and 17	14.8%	10.2%
Average number of licensed and operable motor vehicles in a household	2.2	2.1

Table 3.2 **Travel-related behavior before relocation**

	Control Group (N = 135)	**Experimental Group (N = 147)**
Average number of single work trips per week		
Drive-alone	7.84 (74.6%)	7.52 (71.5%)
Drive with passenger(s)	0.44 (4.2%)	0.88 (8.4%)
Public transit	1.70 (16.2%)	1.50 (14.2%)
Bicycle	0.37 (3.5%)	0.41 (3.9%)
Walk	0.15 (1.4%)	0.20 (2.0%)
Average number of single non-work trips per week		
Drive-alone	5.04 (33.0%)	6.20 (38.9%)
Drive with passenger(s)	4.77 (31.2%)	4.57 (28.7%)
Public transit	1.35 (8.8%)	0.82 (5.1%)
Bicycle	1.41 (9.2%)	1.69 (10.6%)
Walk	2.71 (17.7%)	2.65 (16.7%)
Expected work-related parking behavior after relocation		
Monthly parking pass	20.0%	25.2%
Paid daily parking	3.7%	2.7%
Free parking provided by employer	18.5%	17.7%
Free street parking	38.5%	37.4%
Not driving to work	19.3%	17.0%
Public transit usage (percent)		
Using	29.6%	25.2%
Not using, but has experience	70.4%	74.8%
No experience	0.0%	0.0%
Most relevant factor that discourages public transit usage		
Transit service is not frequent enough	27.4%	29.9%
Riding transit is not comfortable	22.2%	20.4%
Transit service is not reliable	20.0%	19.0%
Wait time at transit stops is too long	16.3%	15.0%
Do not have access to transit related information	7.4%	6.8%
Riding and waiting for transit feels unsafe	6.7%	8.8%
Frequency of accessing transportation-related information per week		
Never	12.6%	12.9%
Once or twice	19.3%	21.8%
3 – 5 times	30.4%	29.9%
Once a day	26.7%	24.5%
More than once a day	11.1%	10.9%
Most frequently used device to access transportation-related information		
Radio	46 (39.0%)	42 (32.8%)
Television	28 (23.7%)	32 (25.0%)
Internet	26 (22.0%)	24 (18.8%)

Applications on cell phone	18 (15.3%)	30 (23.4%)
Others	0 (0.0%)	0 (0.0%)

Table 3.3 **Housing-related characteristics before relocation**

	Control Group (N = 135)	**Experimental Group (N = 147)**
Current housing unit type		
Single-family detached home	48.9%	42.2%
Row house/townhouse	23.0%	32.0%
Apartment	28.1%	25.9%
Mobile home	0.0%	0.0%
Other	0.0%	0.0%
Ownership of current housing unit		
Owning without mortgage	8.9%	10.2%
Owning with mortgage	56.3%	65.3%
Renting	34.8%	24.5%
Relocation purpose		
Going to work	93.3%	94.5%
Attending school	6.7%	5.5%
Housing type of interest (multiple choice)		
Single-family detached home	65.2%	63.3%
Row house/townhouse	33.3%	38.1%
Apartment	36.3%	31.3%
Mobile home	0.0%	0.0%
Other	0.0%	0.0%
Expected ownership		
Owning without mortgage	15.6%	14.3%
Owning with mortgage	57.0%	53.1%
Renting	27.4%	32.7%
Expected total costs if decided to own a house without mortgage		
Under $150,000	8 (38.1%)	11 (44.0%)
$150,000 – $199,999	11 (52.4%)	12 (48.0%)
$200,000 – $299,999	2 (9.5%)	2 (8.0%)
$300,000 – $499,999	0 (0%)	0 (0%)
$500,000 or more	0 (0%)	0 (0%)
Expected monthly mortgage if decided to own a house with mortgage		
Under $1,000	29 (57.1%)	33 (42.3%)
$1,000 – $1,499	47 (61.0%)	44 (56.4%)
$1,500 – $1,999	1 (1.3%)	1 (1.3%)
$2,000 or more	0 (0.0%)	0 (0.0%)
Expected rent if decided to rent		
Under $500	23 (62.2%)	30 (63.8%)
$500 – $749	11 (29.7%)	13 (27.7%)
$750 – $999	3 (8.1%)	4 (8.5%)
$1,000 – $1,499	0 (0.0%)	0 (0.0%)
$1,500 or more	0 (0.0%)	0 (0.0%)

Table 3.4 **Housing-related characteristics after relocation**

	Control Group (N = 135)	**Experimental Group (N = 147)**
Current housing unit type		
Single-family detached home	40.0%	46.2%
Row house/townhouse	25.9%	32.0%
Apartment	34.1%	21.9%
Mobile home	0.0%	0.0%
Other	0.0%	0.0%
Ownership of current housing unit		
Owning without mortgage	10.4%	14.9%
Owning with mortgage	54.0%	59.9%
Renting	35.6%	25.2%
Total costs if the ownership is owning without mortgage		
Under $150,000	2 (14.3%)	4 (18.2%)
$150,000 – $199,999	7 (50.0%)	10 (45.5%)
$200,000 – $299,999	5 (35.7%)	8 (36.4%)
$300,000 – $499,999	0 (0.0%)	0 (0.0%)
$500,000 or more	0 (0.0%)	0 (0.0%)
Monthly mortgage if the ownership is owning with mortgage		
Under $1,000	17 (23.3%)	32 (36.4%)
$1,000 – $1,499	44 (60.3%)	45 (51.1%)
$1,500 – $1,999	12 (16.4%)	11 (12.5%)
$2,000 or more	0 (0.0%)	0 (0.0%)
Rent if the ownership is renting		
Under $500	17 (35.4%)	11 (29.7%)
$500 – $749	14 (29.2%)	16 (43.2%)
$750 – $999	16 (33.3%)	10 (27.0%)
$1,000 – $1,499	1 (2.1%)	0 (0.0%)
$1,500 or more	0 (0.0%)	0 (0.0%)
Expected number of years of staying at the current property		
Less than 1 year	25.2%	17.7%
1 – 5 years	15.6%	10.9%
5 – 10 years	57.0%	68.0%
More than 10 years	2.2%	3.4%

Table 3.5 **Importance of different factors affecting participants' residential location choices**

	Before relocation			**After relocation**			
	Control Group	Experimental Group	p-value	Control Group	p-value	Experimental Group	p-value
Physical characteristics of housing unit							
Cost of renting or buying	3.90	3.95	0.72	3.96	0.68	3.79	0.42
Number of bedrooms/bathrooms	2.97	3.01	0.74	3.02	0.73	2.95	0.86
Parking availability	2.55	2.51	0.79	2.74	0.20	2.22	0.02*
Neighborhood environment							
Safety of neighborhood	3.21	2.99	0.15	3.31	0.55	3.14	0.64
Aesthetic value	2.91	2.86	0.74	3.03	0.46	2.97	0.70
Transportation accessibility							
Accessibility to work	3.03	2.99	0.79	3.06	0.86	2.88	0.31
Accessibility to restaurants	2.58	2.48	0.39	2.67	0.45	2.74	0.16
Accessibility to retail, grocery or other destinations	2.44	2.49	0.69	2.56	0.35	2.82	0.00*
Accessibility to parks, recreational, or public facilities	2.39	2.37	0.91	2.45	0.66	2.85	0.00*
Accessibility to education	2.36	2.44	0.65	2.27	0.56	2.82	0.00*
Accessibility to healthcare	1.44	1.36	0.47	1.33	0.28	1.62	0.15

* denotes significance at a 95% level of confidence

Table 3.6 **Average neighborhood accessibility for different trip purposes**

	Control Group (N = 135)	**Experimental Group (N = 147)**	**p-value**
Accessibility to work:			
Automobile	72.75	89.63	0.67
Public transit	62.83	84.52	0.03*
Bicycle	65.11	86.93	0.07*
Walk	61.34	77.84	0.05*
Accessibility to healthcare:			
Automobile	50.24	57.21	0.62
Public transit	52.42	55.72	0.80
Bicycle	56.48	58.67	0.72
Walk	55.90	59.72	0.52
Accessibility to social and recreational activities			
Automobile	67.75	85.22	0.04*
Public transit	61.04	86.27	0.00*
Bicycle	62.69	82.64	0.05*
Walk	63.10	87.62	0.03*
Average accessibility to restaurants			
Automobile	70.25	82.56	0.40
Public transit	69.02	84.55	0.32
Bicycle	65.42	86.21	0.08*
Walk	67.53	87.00	0.09*
Accessibility to educational activities			
Automobile	72.42	74.62	0.75
Public transit	70.20	73.45	0.80
Bicycle	71.25	75.69	0.69
Walk	72.21	76.01	0.65
Accessibility to retail/grocery activities			
Automobile	64.38	88.34	0.04*
Public transit	66.71	87.63	0.06*
Bicycle	65.17	89.21	0.02*
Walk	66.08	90.26	0.01*
Weighted accessibility			
Automobile	67.74	80.60	0.00*
Public transit	64.43	81.23	0.00*
Bicycle	65.42	84.54	0.00*
Walk	67.22	82.10	0.00*

Table 3.7 **Comparison of travel-related outcomes after relocation**

	Control Group (N = 135)	**Experimental Group (N = 147)**	**p-value**
Work trips			
Average travel time of a "drive alone" trip (minutes)	9.38	8.25	0.00*
Average weekly travel time of "drive alone" trips (minutes)	93.47	81.85	0.00*
Percentage of "drive with passenger(s)" trips	7.41	11.60	0.23
Percentage of public transit trips	13.19	19.51	0.15
Percentage of bicycle trips	3.26	3.68	0.84
Percentage of walk trips using	5.93	9.28	0.27
Healthcare-related trips			
Average travel time of a "drive alone" trip (minutes)	11.33	9.44	0.60
Average weekly travel time of "drive alone" trips (minutes)	24.25	21.50	0.68
Percentage of "drive with passenger(s)" trips	29.41	31.25	0.91
Percentage of public transit trips	5.88	0.00	0.32
Percentage of bicycle trips	0.00	0.00	--
Percentage of walk trips using	0.00	6.25	0.32
Social/recreational trips			
Average travel time of a "drive alone" trip (minutes)	8.21	7.66	0.08*
Average weekly travel time of "drive alone" trips (minutes)	32.65	27.60	0.04*
Percentage of "drive with passenger(s)" trips	36.29	36.34	0.64
Percentage of public transit trips	7.87	4.76	0.13
Percentage of bicycle trips	15.23	13.53	0.44
Percentage of walk trips using	19.04	28.82	0.07*
Restaurant-related trips			
Average travel time of a "drive alone" trip (minutes)	8.65	7.71	0.00*
Average weekly travel time of "drive alone" trips (minutes)	36.15	30.32	0.00*
Percentage of "drive with passenger(s)" trips	40.70	37.41	0.23
Percentage of public transit trips	4.91	6.47	0.70
Percentage of bicycle trips	1.75	1.80	0.74
Percentage of walk trips using	7.02	22.30	0.08*

Education-related trips			
Average travel time of a “drive alone” trip (minutes)	8.93	8.11	0.72
Average weekly travel time of “drive alone” trips (minutes)	52.29	45.47	0.84
Percentage of “drive with passenger(s)” trips	32.69	28.68	0.92
Percentage of public transit trips	15.38	14.73	0.87
Percentage of bicycle trips	5.77	3.88	0.74
Percentage of walk trips using	12.50	12.40	0.84
Retail/grocery shopping trips			
Average travel time of a “drive alone” trip (minutes)	9.13	8.05	0.01*
Average weekly travel time of “drive alone” trips (minutes)	19.29	16.19	0.00*
Percentage of “drive with passenger(s)” trips	39.89	36.84	0.77
Percentage of public transit trips	13.30	15.31	0.60
Percentage of bicycle trips	0.00	0.96	0.16
Percentage of walk trips using	15.43	24.88	0.04*

Table 3.8 **Simultaneous equation estimation results**

Variables	**Estimates**	***t*-Statistics**	**Standard error estimates**
Dependent variable: Neighborhood average weighted accessibility			
Constant	3.17	10.11	0.31
Experimental group indicator: 1, if individual was in experimental group; 0, otherwise	1.03	7.21	0.14
High income indicator: 1, if individual's annual household income is over $49,999; 0, otherwise	0.33	2.08	0.16
Married indicator: 1, if individual is married; 0, otherwise	0.14	2.43	0.06
Average number of licensed and operable motor vehicles in individual's household	-0.46	-2.77	0.17
Automobile-dependent user indicator: 1, if at least 60% of trips made by individual before relocation are "drive alone"; 0, otherwise	-0.96	-7.30	0.13
Frequent transportation information access indicator: 1 if an individual's frequency of accessing transportation-related information per week is 3 times or more; 0, otherwise	1.01	3.65	0.28
Dependent variable: Automobile usage after relocation (minutes traveled per week)			
Constant	4.13	14.19	0.29
Average weighted accessibility	-0.97	-7.47	0.13
Experimental group indicator: 1, if individual was in experimental group; 0, otherwise	-0.83	-5.53	0.15
Average number of licensed and operable motor vehicles in individual's household	0.37	3.41	0.12
Automobile-dependent user indicator: 1, if at least 60% of trips made by individual before relocation are "drive alone"; 0, otherwise	-0.74	3.27	0.23
Number of observations		282	
R-squared—Average weighted accessibility		0.41	
R-squared—Automobile travel per week		0.47	
3SLS system R-squared		0.46	

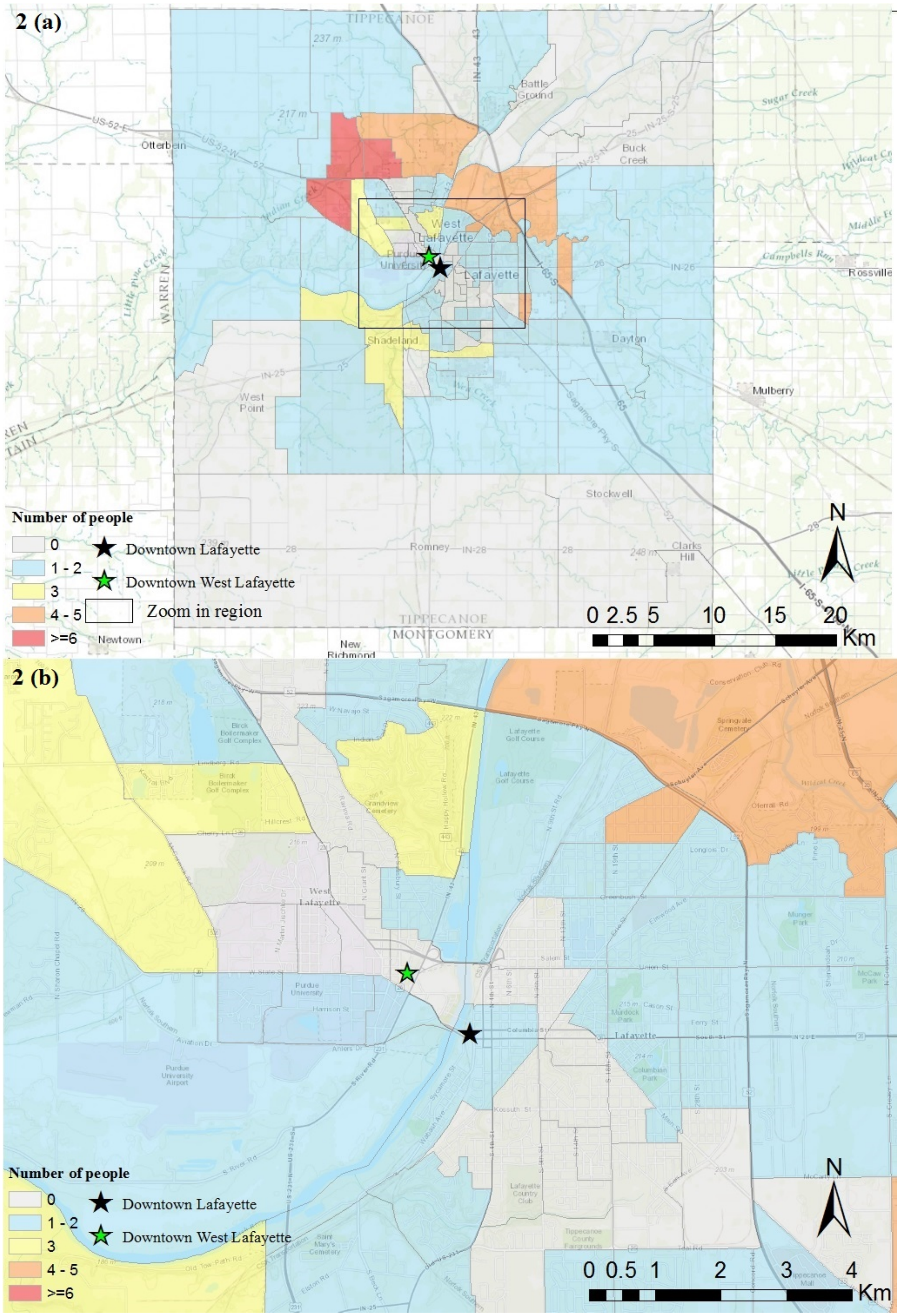


Figure 3.1 **Self-reported residential locations of control group participants in: (a) Tippecanoe County, and (b) downtown regions of Tippecanoe County.**

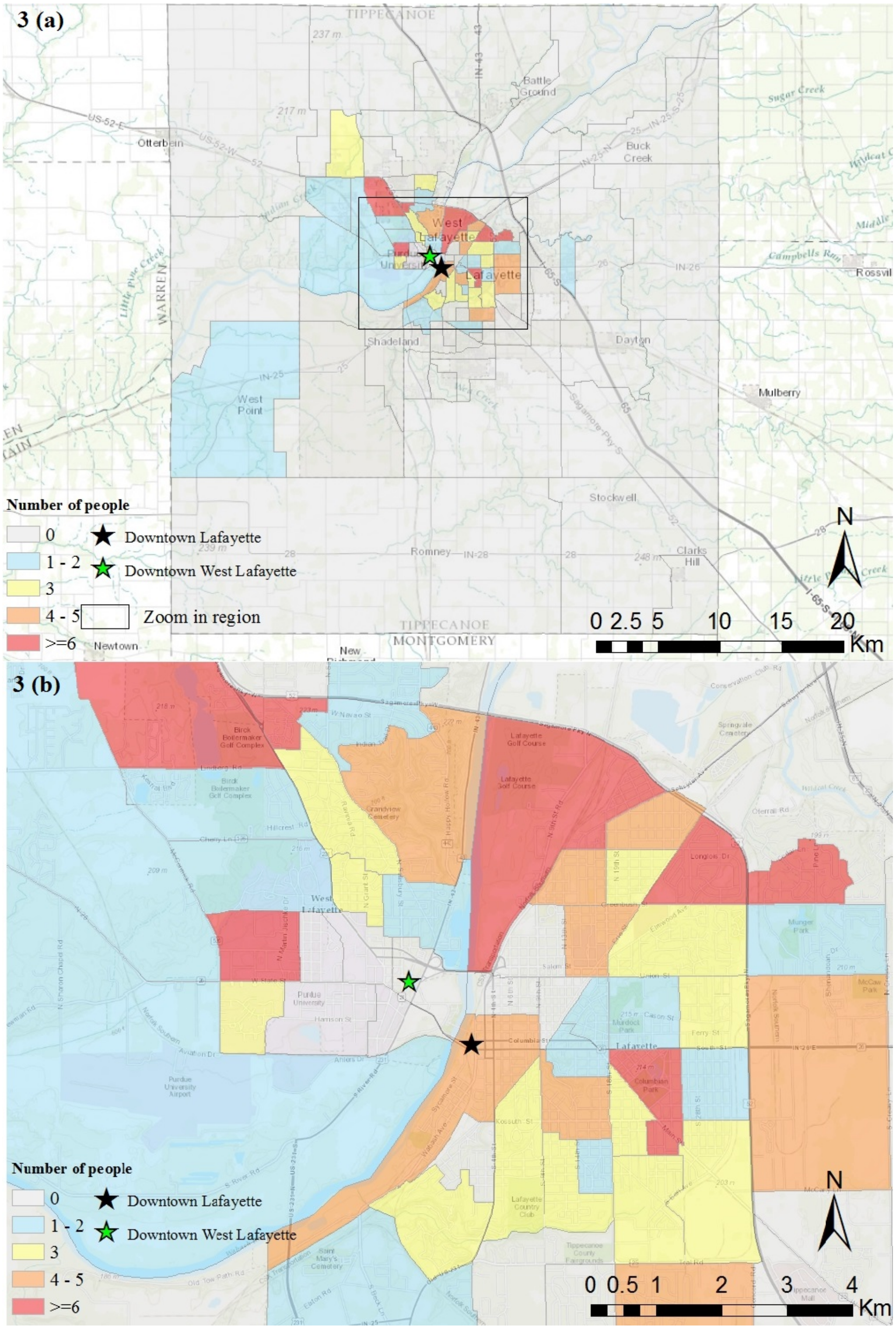


Figure 3.2 **Self-reported residential locations of experimental group participants in: (a) Tippecanoe County, and (b) downtown regions of Tippecanoe County.**

CHAPTER 4. CONCLUSIONS

This study proposes an interactive accessibility information intervention strategy to foster sustainable travel-related behavior by influencing the long-term residential location choice. Previous studies in this domain are limited in terms of the types and amount of accessibility information provided, study population characteristics, residential location options (housing type, location and ownership), and the ease of comparing multiple residential choices. To address these limitations, this study develops an online interactive accessibility mapping application as part of the proposed strategy, that provides personalized neighborhood weighted accessibility information which factors people's work location, travel needs and mode choice. Although other neighborhood-related information (such as school district, crime rate, etc.) can also influence people's long-term residential location choice, this study analyzes the influence of transportation-related information. The proposed strategy was administered to participants selected from a sample of relocators, with only the experimental group participants having access to the mapping application.

The effectiveness of the proposed information intervention strategy was analyzed by comparing the residential location choices and travel-related behavior of the relocators of the experimental and control groups. Further, using data for both groups, simultaneous equation models analyzed the impacts of the proposed strategy and other contributing factors on: (i) the average weighted accessibility of the neighborhood that an individual selected, and (ii) the automobile usage after relocation.

The study illustrates that the proposed information intervention strategy can influence people relocating to a new place to develop sustainable long-term travel behaviors by being more informed on transportation accessibilities of neighborhoods. Hence, there is value to enabling relocators to access tools such as the developed online mapping application before they choose their residential location in the new place. By influencing the long-term residential location choice, people's long-term travel-related behavior can also be altered, in terms of reducing automobile usage and increasing mode share of walk, bike and public transit. These insights have three important implications for planners and policy-makers in the context of designing information intervention strategies to improve the sustainability of travel-related behavior. First, the design of such strategies needs to factor the impacts of long-term decisions (such as residential location choice). Second, strategies can be more effective if they are implemented before the targeted people form habitual transportation-related behavior. Third, personalized information delivery and visualization can potentially improve a strategy's attractiveness and effectiveness compared to strategies based on a "one-size-fits-all" approach.

The study suggests that marital status, frequency of accessing transportation-related information, and automobile usage before relocation, also have a significant impact on residential location choice and long-term travel behavior. Married individuals select neighborhoods that can address the diverse travel needs and travel-related behavior of household members. A potential policy implication is that the design of information intervention strategies should factor travel needs and travel-related behavior of individuals as well as their household members. Individuals who more frequently access transportation-related information are more amenable to the influence of accessibility information intervention strategies. From a policy perspective, this implies an emphasis on information delivery mechanisms to enhance effectiveness. That is, information should be delivered through channels that people are more accustomed to, and the application should be easy to access and use. The effectiveness of the proposed strategy has a relatively lower impact on individuals with strong automobile use habit. A potential policy implication is that long-term information intervention strategies can be bundled with other long- and short-term strategies (such as real-time information about transit operation) to improve their ability to influence individuals with strong automobile use habit.

The online interactive accessibility mapping application is built on generally available data and can be easily replicated for deployment in other metropolitan regions. In addition, the designed application can also be used to assist relocators to select a residential location that is suitable to their travel needs. One potential limitation of this study is that participants in control and experimental groups are modelled together, and heteroscedasticity may exist (i.e. variance of unobserved factors in the models may vary across participants in each group). The main reason of modeling participants in control and experimental groups together is that the participants' sample size is relatively small to develop separate econometric models for each group. The number of relocators in Tippecanoe County is relatively small compared to some major metropolitan areas. A potential future research direction can address this limitation by implementing the proposed intervention strategy in a larger metropolitan area with larger sample size, and develop separate econometric models for participants in control and experimental groups to evaluate the proposed strategy's effectiveness. Another potential future research direction is to use the proposed intervention strategy as a foundation to support the development of a livability index from a transportation perspective with bundled information related to accessibility and neighborhood built environment (such as school district quality). It is also an interesting future research direction to evaluate if more personalized interactive accessibility information (with additional interactive features, such as adjustable threshold of travel time) can have a larger impact on people compared to the proposed interactive accessibility mapping application.

REFERENCES

Al-Deek, H. M., Khattak, A. J., and Thananjeyan, P. A combined traveler behavior and system performance model with advanced traveler information systems. *Transportation Research Part A: Policy and Practice*, Vol. 32, No. 7, 1998, 479–493.

Anas, A. The combined equilibrium of travel networks and residential location markets. *Regional Science and Urban Economics*, Vol. 15, No. 1, 1985, 1-21.

Bayoh, I., Irwin, E. G., and Haab, T. Determinants of residential location choice: How important are local public goods in attracting homeowners to central city locations? *Journal of Regional Science*, Vol. 46, No. 1, 2006, 97-120.

Ben-Elia, E., and Shiftan, Y. Which road do I take? A learning-based model of route-choice behavior with real-time information. *Transportation Research Part A: Policy and Practice*, Vol. 44, No. 4, 2010, 249-264.

Bhat, C. R., and Guo, J. Y. A comprehensive analysis of built environment characteristics on household residential choice and auto ownership levels. *Transportation Research Part B: Methodological*, Vol. 41, No. 5, 2007, 506-526.

Cao, X. J., Xu, Z., and Fan, Y. Exploring the connections among residential location, self-selection, and driving: Propensity score matching with multiple treatments.

Transportation Research Part A: Policy and Practice, Vol. 44, No. 10, 2010, 797-805.

Choocharukul, K., Van, H. T., and Fujii, S. Psychological effects of travel behavior on preference of residential location choice. *Transportation Research Part A: Policy and Practice*, Vol. 42, No. 1, 2008, 116-124.

Chorus, C. G., Arentze, T. A., Molin, E. J., Timmermans, H. J., and Van Wee, B. The value of travel information: Decision strategy-specific conceptualizations and numerical examples. *Transportation Research Part B: Methodological*, Vol. 40, No. 6, 2006, 504-519.

Dai, D., and Wang, F. Geographic disparities in accessibility to food stores in southwest Mississippi. *Environment and Planning B: Planning and Design*, Vol. 38, No. 4, 2011, 659-677.

Emmerink, R. H., Axhausen, K. W., Nijkamp, P., and Rietveld, P. Effects of information in road transport networks with recurrent congestion. *Transportation*, Vol. 22, No. 1, 1995, 21-53.

Ewing, R., and Cervero, R. Travel and the built environment. *Journal of the American Planning Association*, Vol. 76, No. 3, 2010, 265-294.

Fotheringham, A. S., Brunsdon, and C., Charlton, M., *Quantitative Geography: Perspective on Spatial Data Analysis*, 2000, Sage, Thousand Oaks, CA.

Guagliardo, M. F. Spatial accessibility of primary care: concepts, methods and challenges. *International Journal of Health Geographics*, Vol. 3, No. 1, 2004,1-13.

Guo, Z. Mind the map! The impact of transit maps on path choice in public transit. *Transportation Research Part A: Policy and Practice*, Vol. 45, No. 7, 2011, 625-639.

Guo, Y., and Peeta, S. Rail-Truck Multimodal Freight Collaboration: Truck Freight Carrier Perspectives in the United States. *Journal of Transportation Engineering*, Vol. 141, No. 11, 2015, 1-11.

Guo, Y., Peeta, S., and Mannering, F. L. Rail-truck multimodal freight collaboration: a statistical analysis of freight-shipper perspectives. *Transportation Planning and Technology*, Vol. 39, No. 5, 2016a, 484-506.

Guo, Y., Peeta, S., and Somenahalli, S. The impact of walkable environment on single family residential property values. *Journal of Transport and Land Use*, Vol. 10, No. 2, 2015, DOI: http://dx.doi.org/10.5198/jtlu.2017.824.

Guo, Y., Agrawal, S., Peeta, S., and Somenahalli, S. Impacts of property accessibility and neighborhood built environment on single-unit and multiunit residential property values. *Transportation Research Record: Journal of the Transportation Research Board*, No. 2568, 2016b, 103-112.

Guo, Y., Wang, J., and Peeta, S. The impacts of household registration and head of household travel behavior on travel mode choice in China. In compendium of Transportation Research Board 95th Annual Meeting, Washington D.C., U.S., 2016c.

Handy, S., Cao, X., and Mokhtarian, P. Correlation or causality between the built environment and travel behavior? Evidence from Northern California. *Transportation Research Part D: Transport and Environment*, Vol. 10, No. 6, 2005, 427-444.

Hechter, M., and Kanazawa, S. Sociological rational choice theory. *Annual Review of Sociology*, 1997, 191-214.

Interactive online accessibility mapping application. Accessed September, 2015 via: http://web.ics.purdue.edu/~guo187/mp/nextrans.php.

Joseph, A., and Phillips, R. *Accessibility and Utilization: Geographical Perspectives on Health Care Delivery*. New York: Harper and Row, 1984.

Kandt, J., Rode, P., Hoffmann, C., Graff, A., and Smith, D. Gauging interventions for sustainable travel: A comparative study of travel attitudes in Berlin and London. *Transportation Research Part A: Policy and Practice*, Vol. 80, 2015, 35-48.

Kenyon, S., and Lyons, G. The value of integrated multimodal traveller information and its potential contribution to modal change. *Transportation Research, Part F: Traffic Psychology and Behavior*, Vol. 6, No. 1, 2003, 1-21.

Kortum, K., Paleti, R., Bhat, C., and Pendyala, R. Joint model of residential relocation choice and underlying causal factors. *Transportation Research Record: Journal of the Transportation Research Board*, No. 2303, 2012, 28-37.

Krizek, K. J. Neighborhood services, trip purpose, and tour-based travel. *Transportation*, Vol. 30, No. 4, 2003, 387-410.

Lam, W. H., and Chan, K. S. A model for assessing the effects of dynamic travel time information via variable message signs. *Transportation*, Vol. 28, No. 1, 2001, 79-99.

Lee, B. H., and Waddell, P. Residential mobility and location choice: a nested logit model with sampling of alternatives. *Transportation*, Vol. 37, No. 4, 2010, 587-601.

Luo, W. Using a GIS-based floating catchment method to assess areas with shortage of physicians. *Health & Place*, Vol. 10, No. 1, 2004, 1-11.

Luo, W., and Qi, Y. An enhanced two-step floating catchment area (E2SFCA) method for measuring spatial accessibility to primary care physicians. *Health & Place,* Vol. 15, No. 4, 2009, 1100-1107.

Macfarlane, G. S., Garrow, L. A., and Mokhtarian, P. L. The influences of past and present residential locations on vehicle ownership decisions. *Transportation Research Part A: Policy and Practice*, Vol. 74, 2015, 186-200.

Majid, M. R., Nordin, A. N., and Medugu, I. N. Influence of housing development designs on household designs on household vehicle miles traveled: A case of Iskandar Malaysia. *Transportation Research Part D: Transport and Environment,* Vol. 33, 2014, 63-73.

Mannering, F. L. Effects of interstate speed limits on driving speeds: some new evidence. In *the proceedings of the Transportation Research Board 86th Annual Meeting*, Washington D. C., 2007.

Matthies, E., Kuhn, S., and Klöckner, C.A. Travel mode choice of women: The result of limitation, ecological norm, or weak habit? *Environment and Behavior,* Vol. 34, No. 2, 2002, 163-177.

Molin, E., Oppewal, H., and Timmermans, H. Group-based versus individual-based conjoint preference models of residential preferences: A comparative test. *Environment and Planning A*, Vol. 31, No. 11, 1999, 1935-1947.

Muth, R. F. *Cities and Housing; The Spatial Pattern of Urban Residential Land Use*. University of Chicago Press, Chicago, IL, 1969.

Palm, R., and Danis, M. A. Residential mobility: The impacts of Web-based information on the search process and spatial housing choice patterns. *Urban Geography*, Vol. 22, No. 7, 2001, 641-655.

Peeta, S., and Mahmassani, H. S. Multiple user classes real-time traffic assignment for online operations: A rolling horizon solution framework. *Transportation Research Part C: Emerging Technologies*, Vol. 3, No.2, 1995, 83-98.

Prashker, J., Shiftan, Y., and Hershkovitch-Sarusi, P. Residential choice location, gender and the commute trip to work in Tel Aviv. *Journal of Transport Geography*, Vol. 16, No. 5, 2008, 332-341.

Paz, A., and Peeta, S. Information-based network control strategies consistent with estimated driver behavior. *Transportation Research, Part B: Methodological*, Vol. 43, No. 1, 2009, 73-96.

Pinjari, A. R., Pendyala, R. M., Bhat, C. R., and Waddell, P. A. Modeling the choice continuum: an integrated model of residential location, auto ownership, bicycle ownership, and commute tour mode choice decisions. *Transportation*, Vol. 38, No. 6, 2011, 933-958.

Post-experiment survey for control group. 2014. Accessible via: https://purdue.qualtrics.com/SE/?SID=SV_dbqFxfB2gwgQM0B.

Post-experiment survey for experimental group. 2014. Accessible via: https://purdue.qualtrics.com/SE/?SID=SV_6xIknIURCaVyxa5.

Pre-experiment survey for control group. 2014. Accessible via: https://purdue.qualtrics.com/SE/?SID=SV_8qAcmdU6L050LmB.

Pre-experiment survey for experimental group. 2014. Accessible via: https://purdue.qualtrics.com/SE/?SID=SV_e9esAuD1Kis8wXH.

Reference USA. U.S. Business, 2014. Accessed November, 2014. http://www.referenceusa.com/Home/Home.

Rodriguez, D. A., Levine, J., Agrawal, A. W., and Song, J. Can information promote transportation-friendly location decisions? A simulation experiment. *Journal of Transportation Geography*, Vol. 19, No. 2, 2011, 304-312.

Rodriguez, D. A., and Rogers, J. Can housing and accessibility information influence residential location choice and travel behavior? An experimental study. *Environment and Planning B: Planning and Design*, Vol. 41, No. 3, 2014, 534-550.

Schwanen, T., and Mokhtarian, P. L. The extent and determinants of dissonance between actual and preferred residential neighborhood type. *Environment and Planning B: Planning and Design*, Vol. 31, No. 5, 2004, 759-784.

Shankar, V., and Mannering, F. L. Modeling the endogeneity of lane-mean speeds and lane-speed deviations; a structural equations approach. *Transportation Research Part A: Policy and Practice*, Vol. 32, No. 5, 1998, 311-322.

Simon, H. A. A behavioral model of rational choice. *The Quarterly Journal of Economics*, 1955, 99-118.

Simonsohn, U. New Yorkers commute more everywhere: Contrast effects in the field. *Review of Economics and Statistics*, Vol. 88, No.1, 2006, 1-9.

Tielemans, E., Kupper, L. L., Kromhout, H., Heederik, D., and Houba, R. Individual-based and group-based occupational exposure assessment: Some equations to evaluate different strategies. *Annals of Occupational Hygiene*, Vol. 42, No. 2, 1998, 115-119.

The U.S. Census Bureau. 2010 Population Finder. Accessed September 2015 via: http://www.census.gov/popfinder/index.php.

The U.S. Census Bureau. 2010-2014 American Community Survey 5-year Estimates. Accessed September 2015 via: http://factfinder.census.gov/faces/nav/jsf/pages/community_facts.xhtml.

Van de Kaa, E. J. Applicability of an extended prospect theory to travel behaviour research: a meta-analysis. *Transport Reviews*, Vol. 30, No. 6, 2010, 771-804.

Washington, S. P., Karlaftis, M. G., and Mannering, F. L. *Statistical and Econometric Methods for Transportation Data Analysis*. Chapman & Hall/CRC, New York, 2010.

Zhou, J. Sustainable commute in a car-dominant city: Factors affecting alternative mode choices among university students. *Transportation Research Part A: Policy and Practice*, Vol. 46, No. 7, 2012, 1013-1029.

Zondag, B., and Pieters, M. Influence of accessibility on residential location choice. *Transportation Research Record: Journal of the Transportation Research Board*, No. 1902, 2005, 63-70.

Contacts

For more information:

Srinivas Peeta
Principal Investigator
Professor of Civil Engineering & Director
NEXTRANS Center, Purdue University
Ph: (765) 496 9726
Fax: (765) 807 3123
peeta@purdue.edu
https://engineering.purdue.edu/~peeta/

NEXTRANS Center
Purdue University - Discovery Park
3000 Kent Ave.
West Lafayette, IN 47906

nextrans@purdue.edu
(765) 496-9724

www.purdue.edu/dp/nextrans