



# Spatial microanalysis and equity assessment of joint relationships among destination choice, activity duration, and mode choice

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## Project Objective

Detailed spatiotemporal analysis of amenities provided to the California population are needed to identify geographical pockets for which current policy may have unintended and possibly negative consequences. The three most important needs identified are: 1) understand the possible difference in sensitivity of travel behavior to the land use policy variables such as density of opportunities; 2) identify places in which fragmentation of time allocation makes it necessary to use the private automobile; 3) understand what motivates people to visit multiple distinct destinations in a day and the relationship of this behavior to availability of opportunities.

## Problem Statement

To address the problem objective above we first examine the relationship between land use and social vulnerability of the resident population based on indices developed by the Center for Disease Control and Prevention (CDC). Then, we show that vehicles miles of travel (VMT) as used in California planning may lead to unintended consequences and is influenced in different ways depending on the amount of VMT a person accumulates in a day. This is followed by a demonstration of the geographies of fragmentation of daily schedules and a new way to measure land use travel behavior relationships in space and time as a possible substitution to VMT as policy parameter. Finally, disparities across different social segments in the provision of walking accessibility is illustrated using state-of-the-art techniques.

## Research Methodology

We use in this research data from activity-travel diaries of ten of thousands of California residents, details land use analysis of US Census blocks, Latent Profile Analysis (LPA) for classification of places, state of the art network analysis, sequence analysis and hierarchical clustering, spatial clustering, and quantile regression.

## Results

In terms of analysis we first explore the classification of every US Census block in California using Latent Profile Analysis and a detailed inventory of business establishments. We derive in this way four distinct types that depend on the business establishment density. Then, we use the Social Vulnerability Indices (SVI) developed by CDC to explore the correlation between place of residence land use characteristics and SVI. Coastal areas have the lowest SVI and in urbanized environments also higher density of opportunities. There are many rural areas that also have high vulnerability. This motivates the microanalytical model specification developed in the rest of the chapters in this report.

One core analytical chapter develops and presents a new type of regression model with vehicle miles traveled (VMT) as dependent variable. The motivation for doing this is that VMT is a primary policy variable because it is strongly correlated with greenhouse gas emissions and the density and diversity of urban environments. Policies that increase density and diversity of land

use are believed to decrease VMT presumably by replacing it with non-motorized travel. This causal inference has not been conclusive and may create further disparities by gentrification and an increase in long-distance travel for lower-income commuters. In this study, we explore the heterogeneity in the relationships between personal level VMT and the built environment, accessibility to opportunities and open spaces, and people's socio-demographic traits across various levels of travel demand. The present research first develops opportunity-based measurement of residential land-use indicators at the US census block level for the whole California. This is followed by the use of the Latent Profile Analysis as the land-use indicators identifying distinct land use patterns experienced by the respondents in the 2012-2013 California Household Travel Survey. Thus, we estimate quantile regression models to understand the heterogeneity in the relationships between VMT and residential built environment characteristics and people's socio-demographic traits. The results indicate different sensitivity to land use at various travel intensities implying different response to land use policies and challenges the wisdom of using VMT as the main policy variable.

Then, we turn to the data from the 2017 National Household Travel Survey in California from 26,078 survey participants, using sequence analysis to estimate a fragmentation indicator of people's daily schedules. This is followed by spatial clustering to find groups of observations with similarly high or low fragmentation using the longitude and latitude of their residential locations. Applying hierarchical sequence clustering within each spatial cluster we identify distinct patterns of time allocation. Using the Local Indicator of Spatial Association (LISA) we find a large portion (approximately 30%) of the sample with significant spatial clustering of fragmentation. We also find systematic and significant differences in membership to these clusters based on land use, county of residence, household and personal characteristics, and travel modes used. Sequence analysis pattern recognition within LISA spatial clusters shows systematically repeating time allocation patterns that include typical work and school schedules as well as staying at home patterns. However, each spatial LISA cluster is composed of different time allocation clusters. All this analysis taken together points out substantial and measurable heterogeneity in spatial clustering of fragmentation and the need for customized policy actions in different geographies.

The final analysis in this report explores the walking accessibility to opportunities by enumerating the distinct destinations visited in a day and the correlation between the number of destinations and accessibility. People that visit multiple locations also experience exponentially increasing with the number of locations walking accessibility. The 20 minute walking city is in essence composed of multiple destinations that are surrounded by many activity opportunities. We explore heterogeneity in experienced accessibility using multivariate regression for retail and education experienced accessibilities as a function of person and household characteristics, residence in one of the LPA types identified here, and SVI. Key findings include lower accessibility to retail and education opportunities for people living in places that are classified as populated by vulnerable residents (e.g., minority and lower income tracts). This analysis also indicates substantially higher and heterogeneous experienced accessibility among people that visit multiple distinct locations but with decreasing returns to the investment of visiting multiple locations. As expected living in higher density in terms of population and activity opportunities is also offering higher experienced walking accessibility even when we account for asymmetry in the distribution of accessibility indicators.