Smarter Transportation technologies for addressing Transportation Inequity

Introduction and Research Bio

Smarter transportation technologies – ranging from GPS data generated from smartphone usage, to connected and autonomous vehicle (CAV) technology - are transforming our transportation landscape as we know it today. These technologies hold the promise of significantly reducing traffic incidents and traffic delay, and enabling new and more far reaching transportation services (e.g. ride-sourcing, shared ridership, and microtransit). However, few research and industry efforts have focused on potential benefits/impacts transport disadvantaged communities (low income, minority, and/or transit dependent travelers). Without efforts to investigate how well smarter transportation and CAV technologies can serve as solutions for addressing the broadest set of travel needs among society (e.g. controlling for income and accessibility constraints), we risk excluding those with the greatest transportation needs from the vast benefits of smarter transportation technologies, and potentially reinforcing patterns of decline and underemployment for struggling cities across the United States.

1 (Dr. Tierra Bills) am an Assistant Professor in the Civil and Environmental Engineering Department at Wayne State university. I joined Wayne State (in Summer 2019) after spending 3 years as a Michigan Society Fellow and Assistant Professor at the University of Michigan. Much of my current research focuses on investigating the social impacts of transportation projects. I develop (activity-based) travel-demand models to investigate individual and household-level transportation-equity effects, for the purpose of designing transportation systems that will provide more equitable returns to society. Her latest projects (Funded by NSF and Ford Motor Company) aim to improve the ability to represent the distinct travel needs of transport disadvantaged communities in, using mixed modes of sampling and travel data collection. To date, scientists and practitioners have simply not done a good job with collecting representative travel behavior data across segments of the population, which brings to question our ability to model and represent transportation related outcomes for vulnerable population segments. In order to bridge this gap, my work focuses on the research spectrum from data collection, to model development and prediction, to transportation decision-making. My objective is not only to provide a clearer picture of how the transportation system affects society, but to support the design of more sustainable transportation interventions to meet to needs of all segments of the population, currently and for future generations. My research interests generally include discrete choice analysis and behavioral modeling, transportation equity, transportation planning, and emerging data sources in transportation modeling. I hold a B.S in Civil Engineering Technology from Florida A&M University (‘08), and M.S (’09) and PhD (’13) degrees in Transportation Engineering from the University of California, Berkeley.

SCC – NSF Project

The research project titled ”Data-Informed Scenario Planning for Mobility Decision Making in Resource Constrained Communities, ” is a 4-year research effort, funded through the National Science Foundation’s Smart and Connected Communities program. The project is being undertaken by a partnership of Faculty, researchers, and students across several universities (including University of Michigan, Georgia Tech, Wayne State University, and Howard University) as well as a network of public and private stakeholders in and around to City of Benton

Harbor, Michigan. This project is motivated by the need to understand how smart mobility solutions can be leveraged to empower community-based decision making around solutions to community transportation needs. The emphasis here in on low income, resource constrained communities in particular, because of the promise that smart mobility solutions can lead to significant gains in the quality of City service delivery, even under resource constraints.

The project is designed to impart the community with the capacity to define and deploy mobility solutions that support greater accessibility to employment opportunities, education, and healthcare. The projects four primary objectives are:

- Define a cost-effective data collection strategy that can assess the performance of the Benton Harbor transit system, track the mobility patterns of residents, and acquire resident perceptions of their mobility.
- Use the mobility data collected to calibrate analytical methods that predict resident demand for mobility services and the performance of these services given changes in user demand.
- Implement a community based decision-making framework, based on scenario planning methods with S&CC data visualization and predictive analytics used in the process to predict outcomes of considered scenarios.
- Implement consensus mobility solutions and assess their impact.

Why Benton Harbor

An existing engagement between the University of Michigan and the community of Benton Harbor, Michigan provided a strong foundation for this NSF project work. In October 2016, the University of Michigan Smart and Healthy Cities Initiative held a workshop on mobility in Benton Harbor, Michigan, and invited residents, government officials, and business community representatives to discuss transportation needs in Benton harbor. Benton Harbor (pop. 10,036) is a small city that stretches 4.7 square miles, and is located off the southwestern coast of Michigan. The common feeling among community members was that many residents either remain under/unemployed or are losing jobs due to unreliable transit service. However, only limited public access data exists on the quality of Benton Harbor's transportation system for measuring the system's progress toward real goals for improvement. In recent decades, Benton Harbor has fallen into a state of population and economic decline and is now one of the poorest communities in Michigan, with a per capita income of $10,309 and 50.3% of residents living below the poverty line. St. Joseph (the "twin city" to Benton Harbor) sits in stark contrast with a per capita income of $36,233 and 8.7% of residents living below the poverty line [1]. For these reasons and with the City's deep concerns about improving access to employment destinations in the region, this research was established to impart smart, meaningful, and sustainable transportation solutions.

Why focus on Transportation Equity?

Transportation equity analysis referrers generally to a process and set of tools for estimating the distribution of impacts resulting from transportation investment [2], and determining whether this result is fair or equitable. This is also sometimes referred to as Environmental Justice Assessment. This analysis is mandated at the Federal level by two pieces of legislation. First in the 1994 Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," which directs Federal agencies to adopt Environmental Justice as a mission, and seek to address equity related impacts of all programs, policies, and activities, vulnerable (e.g. low income and minority) communities. Second, Title VI

of the Civil Rights Act of 1964, states that "No person in the United States shall, on the grounds of race, color, or national origin, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance" [3].

Transportation equity analysis using accessibility as the indicator is not new. A study by [4] assesses the equity implications of bus rapid transit in Cali, Colombia, where they measured the distribution of transit access for five population segments. A study by [5] developed an equity measure for public transit equity and sought to maximize transit coverage based on the need of transit dependents. Further, [6] applied the Lorenze Curve/ Gini Index to measure the difference between an equal distribution of benefits (accessibility) to the observed distribution. Some studies have also focused on the issues around transportation equity in Detroit [7, 8], where gravity-based accessibility measures were applied to assess the distribution of employment accessibility across various sociodemographic groups. Yet, questions still remain about the potential to reduce inequities in accessibility through new smart mobility innovations like CAV and microtransit.

My Research

My particular role is this effort it to design and estimate components of an activity-based model (ABM) to define and model the demand-side response of Benton Harbor residents to proposed transportation solution. The ABM is an established transportation planning tool designed to model how people choose their travel modes on a daily basis [9]; they are the latest innovation in travel demand modeling and are fast becoming the standard in both research and practice [10]–[14]. In general, travel demand models serve as advanced transportation planning tools for measuring and forecasting fine-grain travel responses to large-scale transportation investments, such as system-wide transit improvements or new transit alternatives. These models link the effects of transportation system and land-use changes to various individuals' choice dimensions (*e.g.,* auto ownership, destination, time-of-day). ABMs estimate realistic travel choice outcomes by assigning behavior into a set of travel choice dimensions and models each using a (logit) discrete choice model. These travel choice dimensions include work location, auto ownership, (daily) activity pattern, time-of-day, stop location, and mode choice dimensions.

The principle of utility maximization for each travel choice dimension guides the mathematical form of the discrete choice travel model. The decision maker (*i.e.,* traveler) assigns a level of utility to each travel alternative in the choice set and selects the alternative that provide their highest level of utility. The expression for each alternative's utility includes parameterized observable variables (characteristics of the decision maker and attributes of the alternative). The parameters associated with each of the variables are estimated from a sample of travel activity data (representing choices made by the decision makers when presented with choice). These represent the value that the decision maker associates with the variables when choosing an alternative. The key here is that individual data used for utility estimation (and therefore the estimated choice outcomes) represent the travel behaviors of the various demographic segments of a community. Therefore, the ability to accurately predict travel choices and outcomes for all population segments is tied to how well such segments are represented in the travel dataset used for model estimation.

A major contribution of this effort is in determining the extent to which new data collection methods and novel community engagement approaches could improve the representation of target group behavior in ABM results. This is an especially pressing issue when applying ABM to small,

under-resourced communities like Benton Harbor. In particular, there are two potential causes of severe underrepresentation of groups (such as low-income households, un- and under-employed travelers, and transit dependents) that motivate the travel survey design presented here. First, is the *digital divide* [15] which defines the socioeconomic disparity in access and ability to use communication technologies (*e.g.,* internet, smartphones). With the progression of travel survey data collection moving rapidly toward electronic modes [16], known challenges with the *digital divide* raises concerns about accessing input from specific groups. This raises questions about how well the travel behaviors of target groups (namely, transport disadvantaged communities) are represented in emerging travel data sets. Second, unit nonresponse in household travel surveys (*i.e.,* complete nonparticipation of a potential respondent, perhaps due to digital divide issues) can result in significant biases that propagate through to demographic summary statistics from the data sample, even after applying standard household weighting adjustments [17].

Our survey data collection approach – a distinguishing factor in our study and travel model development – employs a mix of traditional and electronic survey modes in order to achieve higher representation for transport disadvantage communities. Prior work in Benton Harbor validates the soundness of the approach. The focal point of this data collection approach is a series of 2-hr survey workshops, offered to provide a personal point of contact for survey respondents. At these workshops, research staff and trained facilitators are available to assist participants in completing the activity survey (given a choice of the paper or online version using on-site computers) and then registering for the 1-week GPS survey. The strategy includes a $15 visa gift card as incentive for each participant who completes both surveys.

Preliminary Results

As of October 2019, we have completed a total of 4 data collection workshops in Benton Harbor (this most recent of these being 9/25/19), resulting in a total of 134 survey respondents. Of these respondents, 40 were GPS tracked. While these are small sample sizes, it is clear that the respondents to the paper version of the survey respondents were found to be more transit dependent (35% rely solely on the TCATA system) compared to the online respondents. This demonstrates the significance of offering multiple survey modes, as more than one third of the survey respondents were found to be transit dependent; this is our target group who would have gone underrepresented in the sample had online surveys been relied on solely. Current ongoing efforts include planning for the next workshop, processing existing data to identify distinct travel groups in preparation, and estimating components of the activity-based travel demand model.

Other Research on Smart Mobility and Equity

One of my other research efforts aims to understand how well microtransit can directly address transportation equity issues. Recent study on the benefits of shared mobility suggests that new microtransit services have the potential to help mitigate transportation equity issues and this may hold significant promise for addressing poor transportation accessibility experienced by disadvantage communities. This has long been a pain point for the City of Detroit, where communities experience drastic differences in employment accessibility based on location, racial and income classes, and auto ownership/ transit dependent status. However, the solution may not be as simply as installing more shared mobility. Important questions remain about how well microtransit service can align with specific communities needs and may affect the gap in accessibility between vulnerable and affluent communities.

In this study (Funded by Ford Motor Company) makes two significant contributions: 1) we evaluate multimodal transportation accessibility across the 7-County Metro Detroit Region, with specific attention to the differences in accessibility within the City of Detroit and the remainder of the Detroit Region, and we perform an equity analysis along two social dimensions; income and auto ownership. We also 2) implement a scenario analysis of the equity impacts of a hypothetical micro-transit alternative in Detroit. The analysis is performed using the Southeast Michigan Council of Government's travel demand model for the Detroit region.

While this study is ongoing, our preliminary results suggest that without close attention to cost structure and affordability, microtransit may not provide the much needed accessibility gains for transport disadvantaged communities in comparison to more affluent communities. Further study assessing the potential effects of realistic microtransit scenarios (with realistic cost structures), coupled with appropriate policy interventions are warranted.

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