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Evaluating public transit modal shift dynamics in response to bikesharing: a tale of two U.S. cities

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ABSTRACT

Public bikesharing—the shared use of a bicycle fleet—has recently emerged in major North American cities. Bikesharing has been found to decrease driving and increase bicycling. But shifts in public transit have been mixed. The authors evaluate survey data from two U.S. cities to explore who is shifting toward and away from public transit as a result of bikesharing. The authors explore this question by mapping geocoded home and work locations of respondents within Washington DC and Minneapolis. Respondents were mapped by their modal shift toward or away from bus and rail transit. The results show that in Washington DC, those shifting toward bus and rail transit live on the urban periphery, whereas those living in the urban core tend to use public transit less. In Minneapolis, the shift toward rail extends to the urban core, while the modal shift for bus transit is more dispersed. The authors analyze socio-demographics associated with modal shift through cross-tabulations and four ordinal regression models. Common attributes associated with shifting toward public transit include increased age, being male, living in lower density areas, and longer commute distances. The authors conclude with a discussion of the final results in the context of bikesharing's impacts on other cities throughout North America.

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1. Introduction

Bikesharing has emerged as one of the latest innovations in urban transportation to sweep North American cities and transform urban mobility. Public bikesharing systems operate by providing instant access to bicycles at docking stations located throughout an urban region. People who use bikesharing can be members of the system for an annual fee or can be walk-up casual users accessing the system on a trial or temporary basis. Bikesharing permits users to check-out a bicycle at any station and return it to any other station with an available dock. By facilitating one-way travel, bikesharing has opened new opportunities for individuals traveling by bicycle in situations that would otherwise not be possible. This new dynamic has resulted in modal shifts among those that use bikesharing.

In late-2011, the authors completed a survey of annual bikesharing members in collaboration with operators in four cities including: Montreal, Toronto, Washington DC, and Minneapolis/St. Paul (the Twin Cities). The survey was designed to understand the general profile of bikesharing users and to evaluate how bikesharing had changed annual member travel patterns.

Previous research has shown that public bikesharing almost universally reduces driving and taxi use and increases bicycling in most every city (Shaheen et al, 2012, 2013). In many of these same cities, bikesharing has been shown to also reduce the use of public transportation including rail, bus, and walking in favor of bicycle use. For example, in Washington DC, 48% of respondents indicated that they used rail less often as a result of bikesharing. In Montreal and Toronto, 50% and 44% reported the same respectively, while in the Twin Cities, only 3% reported using rail less often. Although these effects reflect the dominant trends in modal shifts among the survey population, all cities big and small have people that increased or decreased their public transit use as a result of bikesharing. For example, in Washington DC, 7% reported increasing their rail use, while in Montreal and Toronto, 11% and 9% respectively, also reported increasing rail use. However, in at least a few cities (that appear to be smaller), bikesharing has been shown to increase the use of some forms of public transit. For example, in the Twin Cities, 15% of respondents reported increasing rail use.

The dynamics of bikesharing that facilitate both increases and decreases to public transportation are unique to the direction of modal shift. As bikesharing systems position bicycles in locations

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throughout the city, new opportunities emerge to complete first-and-last mile connections to public transit networks that were not previously possible. At the same time, bikesharing also provides opportunities to move faster than public transit systems, particularly within the dense networks present in downtown areas. Thus, bikesharing can both increase and decrease public transit use depending on the specific circumstances of the traveler and the urban environment.

What are some key characteristics of people who increase and decrease their public transportation use in response to bikesharing? This paper advances understanding of modal shifts caused by bikesharing through a geographic evaluation of survey data collected through recently completed research (Shaheen et al., 2012). Working with surveys in two of the cities surveyed in the United States, the authors analyze the attributes of individuals who increased and decreased their rail and bus usage in a geospatial context along with the population density of respondent home and work locations. The results inform the nuances of bikesharing impacts on the modal shift of urban residents with respect to public transportation.

In the sections that follow, we proceed with a literature review of previous research in public bikesharing, including work that evaluates modal shift and the geospatial analysis of bikesharing systems, with an emphasis on North America. Then, we describe the data and methods applied in this analysis, followed by the results and conclusion.

2. Background: previous research on public bikesharing

Bikesharing evolution has been characterized as a generational process, passing through four generations to the present day technology (DeMaio, 2003; Shaheen et al., 2010). The first generation was established in Europe during the 1960s, comprising deployments of free bikes, often painted white that could be freely used by anyone without access controls. These programs eventually failed due to theft and vandalism. A second generation of bikesharing emerged that required deposits of either money or identification for bicycle access, and some of these systems still operate today in North America. The third generation of bikesharing programs constituted those that have rapidly expanded through North American cities today (DeMaio, 2009; Shaheen et al., 2010). These systems evolved as information technology was incorporated into remote management of rental and payment systems (Shaheen et al., 2013). A fourth generation is emerging; this generation is defined by flexible, clean docking stations; bicycle redistribution innovations (e.g., on-board computers with real-time information on redistribution trucks); smart card integration with other modes (e.g., public transit); and technological advances including GPS tracking, touchscreen kiosks, and electric bikes (Shaheen et al., 2010).

In 2011–2012, Shaheen et al. (2012, 2013) surveyed public bikesharing members in four North American cities: Montreal ($n = 3322$); the Twin Cities (Minneapolis and Saint Paul) ($n = 1238$); Toronto ($n = 853$); and Washington DC ($n = 5248$). Relative to the population within the four cities, bikesharing members had slightly higher incomes, were younger, more educated, and had a higher percentage of Caucasians than the general population. In addition, bikesharing members in all cities were of a male majority, even though females were in the majority of the population in three of the four cities. While bikesharing users were skewed toward the young adult demographic, there was notable representation among middle-aged and older respondents, as about 40% of all respondents were 35 years of age or older. Overall, 88% of respondents reported having a minimum of a four-year college degree, and nearly half of the entire sample (46%) also had an advanced (Masters or Doctorate) graduate degree. Such characteristics have also emerged as distinguishing features in carsharing (short-term vehicle access) members. For example, previous research has found that more than 80% of carsharing members had a four-year degree or more (Shaheen et al., 2012, 2013).

Buck et al. (2013) studied how the newest generation of bikesharing users differs from traditional cyclists in the Washington DC region. Survey data showed Capital Bikeshare users were split evenly between genders, although males tended to make more frequent trips than females. Males were predominant among traditional cyclists. Langford et al. (2013) conducted a study profiling the users of the first electric bikesharing system piloted at the University of Tennessee. Fifty-nine percent of users in the cycleUshare electric bikesharing program were male. Langford et al. (2013) noted that the majority of trips taken on the electric bikes were made by a small percentage of the subscribed users.

Webster and Cunningham (2013) conducted a study using data from a series of focus groups in Chattanooga, Tennessee on preliminary beliefs and attitudes toward biking to understand how to best implement a bikesharing program in the city. Participants revealed that they believed biking was a good form of physical activity but did not think that biking could be employed as a primary transportation mode. Langford et al. (2013) found some related results as 40% of all activity was due to school-related trips and 15% were for leisure and exercise. The only transportation mode that e-bikes replaced was walking. Overall, cycleUshare participants still relied on cars as their primary transportation mode, particularly during the winter months.

In larger cities, commute-related trip purposes were more common with public bikesharing. Our research in the four cities mentioned earlier found that the most common trip purpose was work or school-related. However, in the two U.S. cities, this trip purpose was not a majority (about 38%). While this was the most common single trip purpose, it could also be argued that "non-work" trips were the most common when aggregated together. In both Canadian cities, work trips comprised at least 50% of all trips (Shaheen et al., 2012, 2013). In addition, a study completed in Jiangyin, China, Tingting et al. (2011) found that 42% of public bicycle usage was to connect to public transit stations. This study found the main effect of public bicycles was to increase the travel reach of urban residents as opposed to increasing leisurely bicycle travel.

Recent work in bikesharing has also explored the dynamics of station network effects. Wang et al. (2013) used an ordinary least square regression to analyze the effects of socio-demographics, the built environment, availability of transportation infrastructure, and economic activity variables on bikesharing stations within the Nice Ride Minnesota network. Rixey (2013) studied the same four categories of variables using multivariate regression models across three bikesharing systems: Capital Bikeshare, Denver B-Cycle, and Nice Ride Minnesota. The study found a statistically significant correlation between variables in all four categories of independent variables at the one percent level, while most variables were significant at the five percent level in the Wang et al. (2013) study.

Rixey focused his spatial analysis on ridership and emphasized a strong positive correlation between the ridership levels at a station with the availability of other stations within 4800 m. For Wang et al. (2013), the proximity of food and restaurants nearby bikesharing stations showed a particularly strong positive correlation to ridership. Schoner and Levinson (2013) present another perspective by using survey data to study how public transit routes, neighborhood characteristics, trip purpose, and station area amenities affect station choice decisions. The study used data gathered from a survey of Nice Ride Minnesota subscribers and constructed a model predicting station use by using the subscriber's perceived expected utility. The study concluded that for commuter trips, members had a strong preference for shorter distances to

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