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Hail a cab or ride a bike? A travel time comparison of taxi and bicycle-sharing systems in New York City

Ahmadreza Faghih-Imani [a], Sabreena Anowar [b], Eric J. Miller [a], Naveen Eluru [b,*]

[a] Department of Civil Engineering, University of Toronto, Canada
[b] Department of Civil, Environmental and Construction Engineering, University of Central Florida, United States

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ABSTRACT

In this paper, we examine the hypothesis that bicycles can compete with cars in terms of travel time in dense urban areas. We conduct a detailed investigation of the differences in observed travel times by taxi and a bicycle-sharing system (BSS) in New York City in 2014. The taxi trips with origins and destinations in proximity to BSS stations are identified and compared to BSS trips from the same origin and destinations. The travel time comparison is conducted along following dimensions: (a) all trips, (b) temporal dimension including different time periods of the day, weekday versus weekend, and seasonal variation, and (c) distance categories. It is found that during weekdays' AM, Midday and PM time periods for more than half of OD pairs with distance less than 3 km, BSS is either faster or competitive with taxi mode. To further shed light on the travel time comparison, we develop a multivariate analysis using a random utility framework in the form of a panel mixed multinomial logit model. Identifying and understanding the factors that influence the travel time differences can help planners to enhance the BSS service offerings. The provision of information to bicycling-inclined individuals on the "faster" alternative could be used as a marketing tool to attract higher usage for BSS within dense urban cores. The comparison of BSS and taxi can also shed light on the competition between bicycle and car modes in general in dense urban areas.

1. Introduction

In most urban regions, individuals who do not have access to, or prefer not to use, personal vehicles have the option of either using public transit or hailing a taxi. While public transit systems are constrained by predefined routes and fixed schedules, taxi services provide on-demand service from practically any location and at any time of day (particularly with increasing adoption of ridesharing apps such as Uber and Lyft). For a fare, taxi services provide individuals with convenient door-to-door car trips without the stress of having to find a parking spot. Taxi services in an urban region are particularly useful for visitors, elderly individuals, individuals with disabilities, and individuals travelling during off-peak hours or locations with low transit accessibility. The share of taxi trips is less than 1% of all trips in the United States. However, as expected, this share is higher in dense urban areas with high congestion, limited and expensive parking provisions. For

* Corresponding author.
E-mail addresses: a.faghihimani@utoronto.ca (A. Faghih-Imani), Sabreena.Anowar@ucf.edu (S. Anowar), miller@ecf.utoronto.ca (E.J. Miller), naveen.eluru@ucf.edu (N. Eluru).

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example, the taxi share in New York City is about 7 times higher than the US national average (NHTS, 2009). Despite its small share, taxi plays an important role in our transportation system.

Recently, urban regions have added a new on-demand transportation service in the form of bicycle sharing systems (BSS). BSS offer a reliable, practical and sustainable transportation option for short to medium distance urban utilitarian and recreational trips. BSS has also enhanced the public perception of cycling as an everyday travel mode and thus have contributed to expanding the cycling demographic (Goodman et al., 2014). Evidence from earlier studies also showed that the existence of BSS in a city improves cyclists' safety (Murphy and Usher, 2015; Fishman and Schepers, 2016). With the excellent coverage provided by most BSS in urban core regions, these systems offer spatial and temporal accessibility that rivals taxi services within urban cores. The two modes also have access time associated with them; for a bicycle, it is the walking time to a station while for a taxi it corresponds to the waiting time for a taxi to arrive. While the BSS service does not offer door-to-door service, the walking distances involved in dense urban areas is not prohibitively large to dissuade usage. BSS services are usually priced lower relative to taxi services while also providing physical activity benefits to the individual and environmental benefits to the society. To be sure, not all trips are equally competitive between taxi and BSS. Not all individuals, depending on their physical condition and trip purpose, are able/willing to bicycle in urban conditions with heavy automobile traffic. Further, individuals are unlikely to consider BSS during inclement weather and for long trips (>6 km or so). At the same time, with the growing prevalence of urban bicycling in most cities (McLeod, 2014), it is worthwhile investigating the differences between taxi services and BSS.

A preliminary analysis of data from the Lyon BSS demonstrated that bicycles can compete with cars in terms of speed in core downtown areas, particularly during the morning peak hours (Jensen et al., 2010). Building on this work, in our study, we conduct a detailed investigation of the differences in travel times by taxi and BSS. The taxi trips with origins and destinations in proximity to BSS stations are identified and compared in our analysis. The analysis examines various dimensions, including: different time periods of the day, weekday versus weekend, seasonal variation, and distance. In addition to a detailed comparison, a multivariate analysis using a random utility framework is developed to identify factors that affect the competitiveness of the two modes. Towards this purpose, our study defines a spatio-temporal dependent variable - BSS station-station competitiveness by time period - with three levels: (1) auto is faster, (2) bicycle is faster and (3) both alternatives are competitive. The three alternatives are generated to allow for the recognition that depending on traffic conditions (for taxi) and individual level bicycling characteristics travel time is likely to exhibit significant variability. The research exercise is undertaken for the New York City region using detailed trip level data from the CitiBike system and geocoded taxi data for 2014.

The rest of the paper is organized as follows: Section 2 reviews earlier studies and positions the current effort. Data preparation steps are described in the third section. A detailed descriptive analysis is presented in Section 4. The fifth section discusses the multivariate analysis and presents potential policy implications. Finally, Section 6 concludes the paper.

2. Earlier work and research context

The two modes of interest in our research effort – taxi and BSS – are substantially different in terms of their existence in North American cities. Taxi services have been prevalent for a long time while BSS is an emerging system. Several research efforts have examined these systems independently. A brief review of the literature for each mode is provided below.

There is a vast body of literature on taxi services. Earlier studies examined taxi services from different perspectives, including regulation (Schaller, 2007; Çetin and Eryigit, 2011), demand and pricing (Chang and Chu, 2009; Milioti et al., 2015; Zhang and Ukkusuri, 2016), and impact of emerging technologies such as electric and autonomous vehicles (Jung et al., 2014; Burghout et al., 2015; Chrysostomou et al., 2016). Several studies analyzed different aspects of taxi operations including taxi passenger search schemes and routing of vacant taxis to improve the efficiency of taxi services (Yang and Wong, 1998; Kim et al., 2005; Wong et al., 2008, 2014, 2015; Zhan et al., 2015; Zhang et al., 2016). Crash injury severity and safety issues related to taxi services are also examined by several researchers (Dalziel and Job, 1997; Peltzer and Renner, 2003; Lam, 2004; Tseng, 2013; Tay and Choi, 2016). Recently, several studies investigated the rise of app-based, on-demand ride services such as Uber and their impacts on taxi market and transportation systems (Sun and Edara, 2015; Cramer and Krueger, 2016; Harding et al., 2016; Rayle et al., 2016). Further, several investigations used taxi data to estimate link-level travel time on the street network considering taxis as vehicle probes (Zhan et al., 2013; Deng et al., 2015; Zhan and Ukkusuri, 2015).

Given the recent growth of BSS around the world, the research on BSS has increased in the past few years. BSS studies employed survey data and BSS operation data in order to better understand users' travel behavior and choice process, as well as BSS usage and demand (for a review of recent literature on BSS, please see Fishman, 2016). Several studies investigated the relationship between BSS usage and demand with bicycling infrastructure, land use and built environment, public transportation infrastructure, temporal and meteorological attributes (Rixey, 2013; Faghih-Imani et al., 2014; Gebhart and Noland, 2014; Faghih-Imani and Eluru, 2015; Wang et al., 2015; Faghih-Imani and Eluru, 2016a, 2016b). Further, another subset of studies concentrated on operational issues of BSS including identifying problematic stations, efficiency of operator rebalancing program, and proposing new methods for optimizing bicycle rebalancing operations and repositioning trucks' routing schemes (Vogel and Mattfeld, 2011; Nair et al., 2013; Raviv et al., 2013; Fricker and Gast, 2014; Pfrommer et al., 2014).