Literature Review
MACS 30200, Dr. Evans
Bobae Kang

1 Literature Review

In the following, I first discuss the last mile problem in the traditional transportation literature and how recent studies on the bike share relate to the last mile problem in public transit. Then I explore the bike share literature and its limitations with respect to quantitatively evaluating bike share as a solution to the last mile problem.

1.1 Last mile problem

Advocates of public transportation struggle with the last mile problem, which states that passengers rarely opt for public transit systems that leave them a mile from their destination without any convenient connecting options. Alternatively, the first mile problem expresses a similar situation in which passengers have difficulties in getting to a transit system from their point of departure. Although most studies tend to focus on the last mile problem, some use these two terms in tandem as in "first and last mile problem" (Griffin and Sener, 2016).

The term last mile originates in the telecommunications and other related industries, where it is used to refer to the final connectivity leg of the telecommunication networks that delivers services to the end users (Wikipedia, 2016). In communication networks, the last mile is typically the main source of limitation on the bandwidth of data that can be delivered to the customers. Moreover, though necessary to connect individual users to the backbone lines of communication networks, the "last mile" constitutes the most challenging part of the system to maintain and upgrade because it interfaces with a variety of end-user equipment.

This expression has since been appropriated by the transportation literature to address a similar phenomenon in the filed of public transit. In the transportation literature, the last mile similarly limits the accessibility of the public transit network to passengers. Transportation scholars and policy makers have yet to find any one-size-fits-all solution to the last mile problem because of the diversity of passenger needs and the resulting high cost of providing passengers with personalized connecting service to the main transit network.

In the transportation literature, the last mile problem is often examined in terms of passengers' transportation mode choice (Tilahuna et al., 2016; Zellner et al., 2016). Here, mode choice refers to what mode of transportation a passenger chooses for each trip. This notion of mode choice comes from the standard "four-step" approach to modeling demand for and performance of a transportation system, which consists of the following components: trip generation, trip distribution, mode choice, and route choice (McNally, 2007).

More formally, researchers typically examine transportation mode choice using discrete choice models, in which passengers choose among multiple alternatives. Commonly used models are various forms of logit and probit models that assumes passengers would choose a mode of transportation maximising their utility. Under this framework, the last mile problem can be formulated as a feature or a combination of features that negatively contributes to passenger utility which consequently decreases the probability that each passenger will choose the public transit system. Therefore, any "solution" to the last mile problem must sufficiently reduce the negative impact of such negative features of the public transportation system, so that any passenger is more likely to choose the public mode of transportation over other alternatives.

Researchers have proposed various solutions to the last mile problem in public transit, including local shuttle bus systems (Xie et al., 2011), automated vehicles (Yap et al., 2016), and land-use improvement (Zellner et al., 2016). Thus far, the most popular solution among researchers appears to be public bike share systems (DeMaio, 2009; Fishman et al., 2013; Faghih-Imani and Eluru, 2015; Griffin and Sener, 2016; Liu et al., 2012). All solutions seek to make public transit more available to a diversity of passengers, thereby maximizing both utility of passengers and the economic and environmental benefits of the increased use of public transit.

1.2 Bike share

There have been at least three generations of bike share system since its beginning in the 1960s (DeMaio, 2009; Shaheen et al., 2010). First-generation programs simply provided with ordinary bicycles for public use. Without any means or structure to ensure people's responsible use, first-generation public bikes were often stolen and vandalized. As a result, White Bike Plan in Amsterdam, Netherlands, which began in July 1965, was brought to its end soon after its launch. Second-generation bike share programs, born in Denmark in the early 1990s, introduced the use of docking stations and coin-deposit system. Arguably the most famous of the second-generation programs is Copenhagen City Bikes, the world's first large-scale organized bike share program that launched in 1995 with 1,000 bicycles. Despite the improvements, however, the second-generation programs were still susceptible to theft due to the inevitable anonymity of their users.

Third-generation bike share programs are characterized by the use of information technology to track bikes and collect user information. The incorporation of information technology has helped third-generation programs to effectively prevent bike theft, which constituted a major concern of the previous generations of bike share, as riders no longer remain anonymous. Another innovative components of the third-generation models include paid membership system and "smart technology" used for bike check-in and checkout (Shaheen et al., 2010). With these new innovative features, the third-generation model has spread worldwide and the number of cities and municipalities offering bike share programs has increased to over 800 currently (Fishman, 2016).

The soaring popularity of bike share has attracted scholarly attention to the subject. Fishman et al. (2013) and Fishman (2016), together, provide an overview of the relevant literature since the early 2010s. The scope of research ranges from user preferences (Shaheen et al., 2013; Fishman et al., 2014) to characteristics of actual usage (Buck et al., 2013; Fishman et al., 2014) to safety concerns (Fishman et al., 2012) to impacts and policy implications (Fishman et al., 2014) to practical issues such as mandatory helmet uses (Fishman, 2012) and rebalancing (?Fishman et al., 2014). As noted by Fishman et al. (2013), however, many previous studies become quickly outdated due to the rapid growth in the industry.

Faghih-Imani and Eluru (2015) identifies two broad perspectives based on which the quantitative studies on bike share are conducted: first, a systems perspective, and second, a user perspective. The former refers to a set of studies that investigate into the determinants of bike share usage, which is generally characterized by arrivals and departures. Such studies evaluated the significance of bike share infrastructure (e.g., the number, location and capacity of docking stations), environment (e.g., the presence of businesses, public transit stations, and schools), weather (e.g., temperature and precipitation), and other temporal characteristics (e.g., time of day, day of week, and season of the year) in terms of bike share usage. The latter is exemplified by another set of studies focused on how the behavior of users may change in response to bike share programs. These studies examine the impact of different user types (e.g., socio-demographic characteristics, convenience of access, and purpose of usage) as well as policy changes (e.g. opening of new stations, and encouragement of usage) on bike share usage.

Meanwhile, researchers also took note of the potential contribution of bike share with respect to the last-mile problem in public transportation. DeMaio (2004) is one of the early studies that highlighted the positive impact of bike share programs on improving the last mile and first mile connections to other modes of transportation. Although DeMaio (2004) does not use the term "last mile", the paper speculates that bike share programs, or public bikes in its original expression, "may increase trips on other modes of public transportation, as they expand the reach of trains and buses."

In the following years, more studies argued for the contribution of bikes share problems to addressing the last mile problem, providing some empirical evidence. For example, DeMaio (2009) cites two surveys conducted by the City of Paris on the users of its bike share program, called Vélib'; put together, these surveys suggest a growth in the number of bike share riders who use the service to reach or return from the public modes of transportation.[1] Fishman et al. (2013) introduce more evidence from other cities, including Dublin, Ireland, London, UK, and Washington, D.C., that bike share programs may serve as a solution to the last mile problem.[2]

As noted by Faghih-Imani and Eluru (2015), not many studies have attempted quantitative evaluation of the actual bike share uses and the integration between bike share and other, traditional modes of public transportation. Instead, researchers often resorted to various survey methods. More recently, however, this trend has changed as bike share programs began to make their trip data publicly accessible. Faghih-Imani et al. (2014) examines trip data of BIXI, the first major bike share program in Montreal, Canada, to identify factors contributing to the increased usage of bike share in the area on the bike station level. Ma et al. (2015) investigates another case of bike share program, namely, Capital Bikeshare (CaBi) in Washington, D.C. Griffin and Sener (2016) develops a multi-method approach that combines "descriptive statistics, plan evaluation techniques, and semi-structured interviews of bike share system planners" for two bike share programs in Chicago, Illinois (Divvy) and Austin, Texas (B-cycle). Finally, Faghih-Imani and Eluru (2015) attempts to adapt the random utility maximization approach used in the transportation literature to the trip-level bike share data.

Although these studies all account for the impact of public transportation on bike share trips and the bike share users' choice of destination, only Griffin and Sener (2016) explicitly focuses on bike share programs' potential impact on facilitating transit trips. In other studies, the existing public transit system constitutes simply another feature that might affect each bike trip. However, the method Griffin and Sener (2016) uses to analyze bike share data involves hardly more than a mere comparison between the number of bike share embarks within 400 meters from a rail station and that of all other trips, thus failing to offer any statistically rigorous

[1] "In 2008, 21 percent of survey respondents used Vélib to reach the subway, train, or bus, and 25 percent used Vélib on the return trip from other transit modes. In 2009, 28 percent used Vélib to begin and to end their multi-leg transit trip" (DeMaio, 2009, p. 45).

[2] Empirical studies on bike share also note that different types of bike share riders have different trip purposes. In fact, only a small portion of bike share riders appear to use the services mainly to support their public transport uses.

analysis of the data.

More importantly, none of the four studies cited above provides a convincing reason for their choices of proximity standard, which marks the maximum distance for the existing public transit stations to influence bike trips. In Griffin and Sener (2016), for example, the choice of 400 meters for the proximity standard is simply drawn from a maximum distance suggested by operators for spacing between bike share stations (p. 11), and is not empirically supported. Ma et al. (2015) uses a quarter mile (or approximately 400 meters) as the proximity standard, again, without explaining why. Faghih-Imani and Eluru (2015) construct spatial variables based on the 300-meter buffer, arguing that it is "to be an appropriate walking distance, considering the distances between Divvy stations." Lastly, Faghih-Imani et al. (2014) suggests a 250-meter buffer as "an appropriate walking distance considering the distances between BIXI stations," but provides no further rationale.

In fact, if we are to examine how bike share programs may serve as connecting options to public transit networks, neither 250 meter nor 300 meter nor a quarter of mile may be an adequate standard. In downtown Chicago, for example, we may find a dozen bus or rail stops within the 300-meter range from a single Divvy station. In addition, the same 300-meter range will include many other docking stations as well. Worse still, a great majority of all Divvy stations in downtown Chicago will have at least one public transit station in its "proximity," making it difficult to properly measure the effect of access to public transit network on bike trips in the area. Therefore, we need a better measure to evaluate whether and if so, to what extent bike share may serve as a solution to last mile problem in public transportation.

References

Buck, Darren, Ralph Buehler, Patricia Happ, Bradley Rawls, Payton Chung, and Natalie Borecki, "Are bikeshare users different from regular cyclists?," *Transportation Research Record: Journal of the Transportation Research Board*, 2013, *2387* (1), 112–119.

DeMaio, Paul, "Will smart bikes succeed as public transportation in the United States?," *Journal of Public Transportation*, 2004, *7* (2), 1–15.

_ , "Bike-sharing: History, impacts, models of provision, and future," *Journal of Public Transportation*, 2009, *12* (4), 41–56.

Faghih-Imani, Ahmadreza and Naveen Eluru, "Analysing bicycle-sharing system user destination choice preferences: Chicagos Divvy system," *Journal of Transport Geography*, 2015, *44*, 53–64.

_ , _ , Ahmed M. El-Geneidy, Michael Rabbat, and Usama Haq, "How land-use and urban form impact bicycle flows: evidence from the bicycle-sharing system (BIXI) in Montreal," *Journal of Transport Geography*, 2014, *41*, 306–314.

Fishman, Elliot, "Fixing Australian bike share goes beyond helmet laws," 2012. https://theconversation.edu.au/fixing-australian-bike-share-goes-beyond-helmet-laws-10229.

_ , "Bikeshare: A review of recent literature," *Transport Reviews: A Transnational Transdisciplinary Journal*, 2016, *36* (1).

_ , Simon Washington, and Narelle Haworth, "Understanding the fear of bicycle riding in Australia," *Journal of the Australasian College of Road Safety*, 2012, *23* (3), 19–27.

_ , _ , and _ , "Bike share: A synthesis of the literature," *Transport Reviews: A Transnational Transdisciplinary Journal*, 2013, *33* (2).

_ , _ , and _ , "Bike share's impact on car use: Evidence from the United States, Great Britain, and Australia," *Transportation Research Part D: Transport Environment*, 2014, *31* (7).

Griffin, Greg Phillip and Ipek Nese Sener, "Planning for bike share connectivity to rail transit," *Journal of Public Transportation*, 2016, *19* (2).

Liu, Zhili, Xudong Jia, and Wen Cheng, "Solving the last mile problem: Ensuring the success of public bicycle system in Beijing," *Procedia - Social and Behavioral Sciences*, 2012, *43*, 73–78.

Ma, Ting, Chao Liu, and Sevgi Erdoğan, "Bicycle Sharing and Transit: Does Capital Bikeshare Affect Metrorail Ridership in Washington, D.C.?," *Transportation Research Record: Journal of the Transportation Research Board*, 2015, *2534*, 1–9.

McNally, Michael G., "The four step model," in David. A. Hensher and Kenneth Button, eds., *Handbook of Transportation Modeling*, 2 ed., Amsterdam, Netherlands: Pergamon, 2007, chapter 3, pp. 35–52.

Shaheen, Susan, Adam Cohen, and Elliot Martin, "Public bikesharing in North America: Early operator understanding and emerging trends," *Transportation Research Record: Journal of the Transportation Research Board*, 2013, *2387*, 8392.

_ **, Stacy Guzman, and Hua Zhang**, "Bikesharing in Europe, the Americas, and Asia," *Transportation Research Record: Journal of the Transportation Research Board*, 2010, *2143*, 159–167.

Tilahuna, Nebiyou, Piyushimita (Vonu) Thakuriahb, Moyin Lia, and Yaye Keitaa, "Transit use and the work commute: Analyzing the role of last mile issues," *Journal of Transport Geography*, 2016, *54*, 359–368.

Wikipedia, "Last mile," 2016. Retrieved 22 April, 2017.

Xie, Chao, Huili Gong, and Fahui Wang, "A solution for the last mile problem of the Beijing rapid transit network: Local shuttle bus system," in "Geoinformatics, 2010 18th International Conference on" IEEE Beijing, China 2011, pp. 18–20.

Yap, Menno D., Gonalo Correia, and Bart van Arem, "Preferences of travellers for using automated vehicles as last mile public transport of multimodal train trips," *Transportation Research Part A: Policy and Practice*, 2016, *94*, 1–16.

Zellner, Moira, Dean Massey, Yoram Shiftan, Jonathan Levine, and Maria Josefa Arquero, "Overcoming the last-mile problem with transportation and land-use improvements: An agent-based approach," *International Journal of Transportation*, 2016, *4* (1), 1–26.