Journal of Transport Geography 60 (2017) 11–20

Contents lists available at ScienceDirect

Journal of Transport Geography

journal homepage: www.elsevier.com/locate/jtrangeo

Examining changes in travel patterns among lower wealth households after BRT investment in Bogotá, Colombia☆

Tabitha S. Combs

Department of Environmental Management, Faculty of Environment, Society, and Design, PO Box 85084, Lincoln University, Lincoln 7647, Christchurch, New Zealand

ARTICLE INFO

Article history:
Received 27 August 2015
Received in revised form 20 September 2016
Accepted 13 February 2017
Available online 21 February 2017

Keywords:
Bus rapid transit
Low income households
Mobility
Travel purpose diversity
Bogotá

ABSTRACT

Bogotá, Colombia's TransMilenio Bus Rapid Transit (BRT) system has garnered praise for its beneficial effects on transit ridership, congestion, and air quality, yet there has been little research into the system's impacts on individuals and households, particularly on the city's lower wealth households. These households tend to be located in peripheral neighborhoods and access the BRT system largely via its sprawling network of feeder buses, rather than directly accessing the more central trunk lines. This paper examines the relationship between BRT access—especially feeder-based BRT access—and the degree to which the city's lower wealth households are able meet needs for mobility and out-of-home activity participation by analyzing changes in self-reported travel patterns among lower wealth households from before to after introduction of the BRT system. A secondary aim of this paper is to propose and test the variable 'travel purpose diversity' as an indicator of the degree to which households are able to meet their needs for out-of-home activity participation. Further work is needed to improve measurement of mobility in order to assess the household-level impacts of transit investments, particularly on lower wealth households. The results provide preliminary support for the validity of this indicator. Overall, findings suggest that the introduction of the BRT has not had a substantial or significant impact on the ability of Bogotá's lower wealth households to meet daily mobility needs. The paper presents some possible interpretations of these findings and offers suggestions for additional research to help improve our understanding of the impacts of Bogotá's transit investment.

1. Introduction and motivation

Bogotá, Colombia's TransMilenio BRT system has been widely recognized for its positive impacts on transit use, congestion, safety, and air quality. The system was introduced in late 2000 as a means to address a long-term mobility crisis, and quickly began making an impact. In the first three years of operation, TransMilenio was credited with a 32% decrease in commute times, a 40% reduction in air pollution, and an 88% drop in traffic-related deaths along the BRT corridors. By 2005, the system was carrying nearly one fourth of Bogotá's travel demand (roughly 1.25 million daily boardings[1]) on a network that included 84 km of dedicated busways and a feeder system covering 541 km^2 of peripheral neighborhoods (Muñoz-Raskin, 2010).

However, recent research suggests that access to the BRT is associated with an unexpected increase in motor vehicle ownership in the city's lower wealth neighborhoods (Combs and Rodríguez, 2014). One possible explanation for this result is that the reorganization of Bogotá's traditional transit services into the BRT led to a reduction in effective transit service levels among the city's lower wealth households, increasing the pressures faced by those households to become motorized. The present study examines this hypothesis by analyzing changes in mobility patterns among Bogotá's lower wealth households from before to after TransMilenio's introduction.

Why such a massive investment in public transport would be associated with an *increase* in automobile ownership rates is unclear. However, early research on the impacts of TransMilenio's first phase suggest that travel times for trips originating on the system's sprawling network of feeder buses—which primarily serve low wealth neighborhoods at the city's periphery—increased by an average of 2 min per trip from before to after BRT investment (Lleras, 2003). Additionally, Bocarejo and Oviedo report finding a gap between the actual travel patterns and desired mobility in Bogotá's most impoverished neighborhoods, where residents spend 40% more time and 38% more money traveling to and from work than they would like to spend (Bocarejo and Oviedo, 2012). If the rise in auto ownership is signaling a widening of this gap between actual and desired mobility patterns, then it calls into question the system's long run viability as a just, sustainable transport system.

As of mid-2016, there were slightly >200 BRT systems either in operation or under construction around the world, many based on the TransMilenio model (BRT Centre of Excellence et al., 2016). Accordingly,

☆ Preliminary field work for this research was supported in part by a grant from the Institute of Latin American Studies at the University of North Carolina.

E-mail address: tabitha.combs@lincoln.ac.nz.

[1] The most recent figures available report daily boardings of ~2.2 million (BRT Centre of Excellence et al., 2016)

http://dx.doi.org/10.1016/j.jtrangeo.2017.02.004
0966-6923/

understanding the potential impacts of such investments on the ability of low wealth households to meet their mobility needs is of global importance, and is the primary research objective of this paper.

1.1. Importance of understanding travel patterns of low wealth households

Low wealth households are particularly likely to have limited access to opportunities, as they are often forced into residential locations that are distant from employment opportunities, with land use patterns that provide few opportunities for activity participation within the neighborhood. These challenges are often exacerbated by mismatches between travel needs and available transit service, and high costs of transit and motorized travel (Giuliano, 2005; Srinivasan and Rogers, 2005). Due to the barriers and high costs of travel, many lower wealth households around the world limit or even forego certain types of travel altogether, substantially reducing their access to educational and employment opportunities, health care, and social networks, resulting in an overall lower quality of life and diminished ability to escape poverty (Kolodinsky et al., 2013; Lucas, 2012; Motte-Baumvol and Nassi, 2012; Stanley et al., 2011).

Recent research suggests that Bogotá's low wealth households complete just 1.5 daily trips per capita, costing upwards of 20% of household income (Bocarejo and Oviedo, 2012). Similarly low trip rates have been noted in other South American cities. For example, households in the favelas of Rio de Janeiro complete 1.7 daily trips per capita (Koch, 2012), and Medellín's low wealth households complete just 1.4 trips per capita per day. Because they do tend to travel so little, some have theorized that lower-income households place higher value on additional travel than do higher-wealth households: Stanley et al. (2011) found that willingness to pay for an additional trip was negatively correlated with income, and that low-income travelers were willing to pay significantly more, in absolute terms, than higher-income travelers, to complete one additional trip.

The combination of limited access to opportunities and higher generalized costs of mobility means lower-wealth households are less likely to feel their available travel options enable them to meet their needs for mobility, and more likely to feel greater travel-related pressure to motorize than higher-wealth households, even though they can less afford the expense of vehicle ownership. When lower-wealth households do transition into vehicle ownership, they are forced to make trade-offs, spending less on essential maintenance and leisure travel (Giuliano, 2005).

Alleviation of the inequitable mobility burden of lower-wealth households is frequently given as a reason for transit investment (Jaramillo et al., 2012; Sanchez et al., 2004). However, transit investments often are charged with the competing objectives of (a) reducing congestion by luring in higher-wealth, choice riders, and (b) enhancing social equity by improving access and affordability for lower-wealth, captive riders (Walker, 2008). This conflict is particularly troublesome in developing cities, where private provision of public transport is commonplace, and farebox revenues are expected to cover operating and sometimes even capital costs. Nonetheless, planners and policymakers in many developing cities list improved equity as a fundamental goal of and rationale for public transit investment (Bocarejo and Oviedo, 2012; Jaramillo et al., 2012; Muñoz-Raskin, 2010)

1.2. Measuring mobility

To date, our understanding of the mobility impacts of transit interventions, particularly in low-mobility contexts, has been limited by a lack of valid, readily available indicators of unmet travel needs. Thus, a secondary objective of this paper is to introduce and test a potential indicator, travel purpose diversity, meant to reflect the degree to which households are able to meet their mobility needs. In the context of a developing city, with low but rising levels of car ownership, transit-based interventions that improve mobility will theoretically enable households with access to the system to fulfill a greater diversity of travel purposes than those without access to the system, all else equal. Sections 2.2 and 2.3 provide further detail on the development and theoretical supports for travel purpose diversity as a metric of mobility.

1.3. Importance of BRTs' complementary feeder systems

BRT's global popularity has surged over the past decades, with >200 systems in operation or under construction (BRT Centre of Excellence et al., 2016). Accordingly, the past few years have also seen growth in research on the impacts of BRT investments. However, most of that research focuses on BRT systems' main trunk lines: the physically separated, dedicated rights-of-way that allow BRT its much-lauded speeds and capacities (Combs, 2013). Many BRT investments also involve the introduction of large complementary feeder networks, which bring passengers from peripheral neighborhoods into the main trunk system. The current study is unique in that it focuses explicitly on the impacts of the introduction of feeder services in addition to trunk lines.

Three factors motivate this focus. First, feeder networks have been critical to the success of many mass transit systems including TransMilenio. Particularly in large developing cities, which, like Bogotá, are often characterized by rapid expansion of lower wealth settlements at the periphery, feeders are able to reach a much larger share of transit dependent households than the more central trunk lines (Cervero, 2013a,b; Hidalgo et al., 2013). In 2005, near the end of TransMilenio's second phase, only 25% of Bogotá's lower wealth households were located within walking distance (1 km) of a trunk stop, but over half of lower wealth households were within walking distance of at least one feeder stop. Unsurprisingly, feeder services play an important role in generating overall system ridership: approximately half of all trips on Bogotá's TransMilenio BRT involved at least one leg on a feeder route as of 2005 (Hidalgo et al., 2013).

Second, BRT investment in developing cities typically involves restructuring pre-existing transit routes, which have often evolved over time in concert with mobility patterns of transit users (Cervero, 2013a; Hidalgo and Graftieaux, 2008). Consequences of this change may include dramatic shifts in the nature of transit supply in some neighborhoods. There is evidence that such a shift may have had deleterious impacts in some of Bogotá's feeder-served neighborhoods: upon the completion TransMilenio's first phase in 2003, transit travel times for trips originating in feeder-served neighborhoods increased by an average of 2 min per trip after the BRT investment, even while travel times dropped for transit trips originating in areas served by the main BRT trunk lines dropped (Lleras, 2003).

Finally, I focus specifically on the complementary feeder system of Bogotá's TransMilenio BRT to help clarify the unexpected relationship previously found between feeder access and rising rates of automobile ownership among lower wealth households (Combs and Rodríguez, 2014). The previous study found that while automobile ownership rates dropped from before to after BRT implementation for higher-wealth households along the main BRT trunk lines, they rose significantly for the city's lower-wealth feeder-served households.

2. Theoretical framework

A large body of research examines the links between travel behavior and transit access. In US and European contexts, researchers have consistently found that increasing access to transit is associated with decreased automobile trip generation and VMT (Brown and Werner, 2008; Ewing and Cervero, 2010), and increased transit trip generation (Ewing and Cervero, 2010; Greenwald, 2006; Hess, 2009; Olaru et al., 2011), increased transit and nonmotorized mode shares (Crowley et al., 2009; Ewing and Cervero, 2010; Olaru et al., 2011; Shay and Khattak, 2007; Targa and Clifton, 2005), and increased tour complexity (de Abreu e Silva et al., 2014).