Bus quality improvements and local commuter mode share

Justin Tyndall

Sauder School of Business, University of British Columbia, 2053 Main Mall, Vancouver, BC V6T 1Z2, Canada

A B S T R A C T

The choice to use bus transit over a rival mode of transportation is a consequence of many variables. The importance of bus service quality on mode share is often considered but rarely measured explicitly. This study presents a novel temporal data set of geolocated buses from New York City. The merger of locational vehicle data with public schedule data allows for the estimation of bus dependability across neighbourhoods. This study uses plausibly exogenous spatial variation in the introduction New York City's Select Bus Service program to explore the relationship between the policy intervention, bus service quality and changes in commuter mode share. A propensity score matching procedure compares bus reliability and mode share in tracts that received Select Bus Service to a control group. A sizeable treatment effect is found. The policy intervention significantly increased service frequency and improved bus arrival reliability. Additionally, bus mode share amongst commuters in treatment neighbourhoods increased substantially. Select Bus Service was responsible for an increase in local bus mode share of 1.9 percentage points, with bus mode share in the median tract rising from 9.6% to 11.5%. Female commuters are found to be more responsive to the service improvements than males.

1. Introduction

Implicit in the decision to take a bus is the choice to accept the possibility of delay or uncertainty in journey duration. Frequent stops and the necessity to navigate urban traffic cause bus transit to be particularly susceptible to delays (Lin et al., 2008). The importance of providing reliable bus service in supporting bus patronage is well accepted in the theoretical literature (Bates et al., 2001). Rider surveys also support the hypothesis that bus reliability is important to patrons (Diab and El-Geneidy, 2012; Eboli and Mazzulla, 2007; Kou et al., 2017).

Many cities have enacted programs to improve the quality of bus service (Currie and Wallis, 2008). The recent introduction of the *Select Bus Service* (SBS) initiative in New York City (NYC) will be used as a source of quasi-random variation in local service quality. A unique opportunity for identification provides causal estimates of the effect of bus quality improvement on neighbourhood commuter behaviour. Results of a statistical matching procedure demonstrate that the policy intervention led to significantly improved adherence to scheduled arrival times and a reduction in arrival volatility. Results also show that tracts which received SBS treatment experienced an increase in commuter bus mode share of 1.9 percentage points, with bus mode share in the median tract rising from 9.6% to 11.5%. These estimates may hold lessons for similar initiatives elsewhere.

Analysis will rely on detailed automatic vehicle location (AVL) data collected from GPS enabled NYC buses. AVL systems communicate the location of vehicles in real time. Several previous studies have suggested methods for transforming AVL data into dependability metrics (Bullock et al., 2005; Chen et al., 2009; Diab and El-Geneidy, 2012; Mazloumi et al., 2009; Uno et al., 2009). This study will estimate bus dependability statistics directly by combining a large AVL data set with publicly available schedule information.

The paper will proceed as follows. Section 2 reviews relevant literature. Section 3 presents data sources. Section 4 provides details on NYC's SBS program. Section 5 introduces the propensity score matching identification strategy. Section 6 presents results and Section 7 concludes.

2. Related literature

There exists a wealth of research on the theory of optimal trip scheduling in an environment with uncertainty. Small (1982) provided the orthodox formulation of the problem. Noland and Small (1995) expanded the model and argued that uncertainty in arrival time can carry large negative utility costs for commuters. A recent and detailed literature review of work estimating the value of travel time reliability in general can be found in Carrion and Levinson (2012). The current section will limit its focus to works specific to the effect of bus quality on mode choice or works with relevance to AVL data applications.

The impact of bus service quality on mode choice has received empirical attention primarily in the analysis of stated preference (SP) survey data (Bates et al., 2001; Diab and El-Geneidy, 2012; Kou et al., 2017; Prashker, 1979). Prashker (1979) was an early investigation into the attitudes of transit riders regarding service dependability. Results from a Chicago based survey showed that high variability in the arrival time of transit vehicles represented a strong source of disutility for urban travellers.

Bates et al. (2001) provided a vital synthesis of theory relating to the importance of reliability in mode choice. Bates et al. (2001) expressed scepticism regarding the validity of SP analyses due to issues such as sensitivity to the wording of questions and findings of implausibly high implied valuations of reliability. Bates et al. (2001) posited that survey respondents may overstate the disutility they receive from transit unreliability as a way to express frustration and "protest" low quality service. In relation to barriers to conducting revealed preference investigations Bates et al. (2001) noted, "there are serious problems of finding real choice situations with sufficient variation to allow statistically reliable estimates.".

A starting point to conducting revealed preference analysis of the effect of bus quality on ridership can be through the comparison of locations that received improved bus service to locations that did not see an improvement in service. Kain and Liu (1999) used variation through time and across cities in bus service levels and fares to argue that the rise in bus ridership in San Diego and Houston observed in the 1980s and 1990s was explainable primarily through improved service levels. Currie and Delbosc (2011) analysed detailed bus service and ridership data from Australia. The study compared conventional bus routes, superior quality Bus Rapid Transit (BRT) routes, and so-called "smart-routes," which featured only a subset of the quality improvements of the BRT system. The heterogeneity in service quality across locations facilitated a disaggregation of the relative importance of various components of bus quality on ridership. Consistent with prior research, Currie and Delbosc (2011) found service frequency and reliability to be drivers of high ridership. In particular, the presence of dedicated bus lanes were found to increase ridership. The current study will similarly use variation in the timing and location of service improvements to identify effects.

Kou et al. (2017) conducted a detailed SP study to estimate the determinants of bus mode choice in Beijing. Kou et al. (2017) found reliability differences to be a relatively more important factor in mode choice than observed differences in average travel time. Kou et al. (2017) noted the valuation of reliability is heterogeneous across socio-economic groups, with high income earners having a stronger preference for reliability, and therefore being more likely to avoid the uncertainty associated with bus travel.

Bhat and Sardesai (2006) investigated mode choice in Austin, Texas and found large valuations for reliability, particularly for those with rigid work schedules. Analysis relied on data from an online survey. Eboli and Mazzulla (2007) employed a combination of stated and revealed preference data collected from university students in Italy to estimate a structural model of characteristics that affect rider satisfaction with bus service. Model results suggested that the design of the bus network and service reliability were central to influencing user satisfaction. Characteristics associated with rider comfort and the physical upkeep of vehicles and stops were found to be significant but less important. Eboli and Mazzulla (2011) presented further evidence regarding passenger perceptions of service quality, conducting a SP analysis of commuter bus riders in Italy. Results confirmed the primacy of route design and reliability to user satisfaction.

An international summary of bus improvement initiatives is provided by Currie and Wallis (2008). The authors present evidence that past initiatives to expand the frequency, reliability or spatial coverage of bus service have resulted in increases to bus patronage in the range of 10–20%. Interventions focused on improvements to the cleanliness and comfort of vehicles and bus stops were shown to result in smaller patronage gains. A main result of the current study is that SBS caused a 20% rise in local commuter bus mode share. The current paper differs from past estimates due to its focus on commuters, the particular causal identification strategy employed and the unique characteristics of SBS. Though not directly comparable to estimates found in Currie and Wallis (2008), the estimated magnitude is generally consistent.

There is a substantial methodological literature regarding the use of AVL bus data to estimate service dependability (Bullock et al., 2005; Camus et al., 2005; Chen et al., 2009; Diab and El-Geneidy, 2012; Mazloumi et al., 2009; Uno et al., 2009). The current paper attempts to operationalize AVL data to generate meaningful estimates of bus frequency and dependability. As AVL technology becomes more common, and if data collection becomes more prevalent, the application of AVL data to answer transit demand questions appears promising. This study represents a step towards embedding AVL data into mode share estimation.

Bertini and El-Geneidy (2004) served as a precursor to AVL applications by employing detailed bus dispatch data to estimate the factors determining bus route trip time. Chen et al. (2009) contributed an array of AVL compatible dependability metrics, including a bus stop level metric capturing the probability of a bus arrival exceeding a lateness threshold relative to the typical headway. El-Geneidy et al. (2011) provided an attempt to apply AVL data to the estimation of bus reliability. The study employed AVL data from a single bus route in suburban Minneapolis to estimate a detailed model of bus travel time and reliability. Among practical recommendations to improve bus service was the consolidation of bus stops. Bus stop consolidation is one feature of the SBS system.