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Factors associated with disability paratransit's travel time reliability

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ABSTRACT

This paper identifies some of the characteristics of trips and pick-up and drop-off locations that are associated with paratransit's travel time reliability. Following convention, reliability has been defined as the inverse of variability. Four measures of travel time variability have been used to examine reliability: Standard Deviation, Percent Variation, Misery Index, and Buffer Index. Regression models have been used to estimate these four variables with trip data from Access Link, the paratransit service provided by NJ TRANSIT pursuant to the Americans with Disabilities Act (ADA). A number of characteristics of the pick-up and drop-off locations as well as selected characteristics of the trips were used as independent variables of the models. The statistical significance of the independent variables varied depending on which measure of reliability was estimated, but a few variables were consistently associated with reliability in all four models. These variables were trip distance, booking type, winter season, density of motor vehicle crashes in pick-up and drop-off locations, and whether pick-ups occurred in suburban bus corridors or urban core areas. Because of the significance of the variables on motor vehicle crash density in pick-up and drop-off locations, an additional regression model was used to examine the effect of crash incidents on trip duration by considering drop-offs that occurred in locations immediately after a crash. The model showed that trips take 4 to 5% longer when crashes occur in locations prior to a drop off. Planning implications of the findings are discussed.

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1. Introduction

Reliability is the inverse of variability. When travel time for a given roadway segment or trip duration between an origin–destination pair varies widely, travel time reliability is low. On the other hand, when trips between an origin–destination pair always take similar time, reliability is high. Travel time variability is a greater concern for travelers than recurring roadway congestion because it is typically unexpected and unpredictable (Carrion and Levinson, 2012). Such unpredictability can be caused by a number of factors, including motor vehicle crashes and weather elements. With the growing recognition that travel time variability is a more serious concern for travelers than delay caused by everyday congestion, recent studies have suggested a greater emphasis on increasing reliability than addressing recurring delay for transportation planning purposes (Cambridge Systematics et al., 2010; Kimley-Horn and Associates, 2011). A number of studies in the general context of transportation have examined the value of reliability for travelers (Noland and Polak, 2002; Brownstone and Small, 2005; Lyman and Bertini, 2008; Li et al., 2010; Sweet and Chen, 2011). While these studies focused on all trips or trips for specific purposes, Kittleson and Associates (2013) compared the value of reliability for different trip purposes and concluded that the value of reliability is high when trips are made for medical and personal service appointments, to pick-up or drop-off children, or to travel to work; whereas its value is low when trips are made to shopping or social activities.

Travel time reliability is more important for travelers with disabilities who use paratransit service provided in accordance with the Americans with Disabilities Act (ADA) than the general population because they often make those trips for medical appointments and they are less likely to have other means of transportation. Wallace (1997) found that elderly and disabled persons depend on paratransit mostly for medical appointments and they are highly concerned about travel time reliability of the services. According to a recent study (Deka, 2014a), almost half of the special transit service trips by persons with disabilities in the US are made for healthcare appointments. It is also evident from the study that poorer persons with disabilities are more dependent on public transit compared to similar persons from higher-income households.

Due to the importance of travel time reliability of disability paratransit to its users, this study seeks to identify the characteristics of the pick-up and drop-off locations as well as other trip characteristics that are associated with paratransit's travel time variability using statistical models with data from New Jersey. Although several past studies addressed reliability issues related to paratransit (e.g., Wilds and Talley, 1984; Lewis et al., 1998; Fu, 2002; Khattak and Yim, 2004; and

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Metaxatos and Pagano, 2004), they did not examine the effects of location characteristics on paratransit's travel time reliability. By examining the effects of the characteristics of locations served by disability paratransit, this study adds to the existing knowledge base on paratransit's reliability. It hypothesizes that, in addition to factors such as time of day and weather conditions, the characteristics of the locations where pick-ups and drop-offs occur also influence paratransit's travel time variability.

The study area for this research is an 18-county region of New Jersey where Access Link paratransit service is provided by NJ TRANSIT. Access Link is a service provided to persons with disabilities pursuant to the Americans with Disabilities Act (ADA) of 1990. Data on Access Link trips and motor vehicle crashes were analyzed in conjunction with data from the American Community Survey (ACS) and the Longitudinal Employer–Household Dynamics (LEHD) of the US Census Bureau. The analysis was conducted for the entire study area as well as for the six Access Link regions.

The analysis focuses on four measures of travel time variability, namely, Standard Deviation, Percent Variation, Buffer Index, and Misery Index. It includes basic statistical tests and regression models. The first major analytical component of the paper includes regression models on the four measures of travel time variability using characteristics of pick-up and drop-off locations and other trip characteristics as independent variables. Based on the results of the four models on travel time variability, a second set of regression models was used to examine the effect of motor vehicle crashes in the drop-off location on trip duration.

The remainder of the paper is divided into six sections. Section 2 provides a description of the Access Link service and discusses the importance of comprehending the effects of location characteristics on travel time reliability. Section 3 provides a description of the travel time variability measures in the general context of transportation. Section 4 describes the data used for analysis. Section 5 provides empirical results showing how the four measures of travel time variability are associated with the characteristics of pick-up and drop-off locations and other trip characteristics. To supplement the findings of the models in Section 5, results from a model on the association between trip duration and the characteristics of the drop-off locations are presented in Section 6. Section 7 is the concluding section where the research findings are summarized and their implications for transportation planning are discussed.

2. Description of the Access Link service

Access Link is the paratransit service provided by NJ TRANSIT in local bus corridors to customers who have difficulty in using fixed-route transit due to disabilities. The service is provided in 18 of 21 New Jersey counties. The Access Link service area is divided into six regions and service is provided in all regions by private contractors. The service is available to eligible persons with disabilities in all locations within areas designated as urban core and within 3/4 mile buffers along local bus routes in other areas. The 3/4 mile buffers are typically in suburban areas, whereas the urban core areas are in highly urban places with ubiquitous local bus routes. Service is provided within the urban core areas even in the small pockets that are not necessarily within 3/4 miles of local bus routes. Additional information about the characteristics of the Access Link service can be found in Deka (2014b).

Fig. 1 shows the regional boundaries of the six Access Link regions, the boundaries of the designated urban core areas, and the bus routes along which service is provided within 3/4 mile buffers. In addition, the figure shows the density of motor vehicle crashes in the study area at the census tract level. The relevance of crash locations is discussed in the subsequent sections of the paper.

Access Link vehicle runs, consisting of a number of pick-ups and drop-offs between a vehicle's departure from a garage or facility and its return to the facility, are determined in advance by an in-house computer system on the basis of the locations of scheduled pick-ups and drop-offs. As a result, unpredictable events such as customer no-shows and roadway congestion due to motor vehicle crashes near pick-up or drop off locations can have a considerable effect on actual pick-ups and drop-offs for an entire vehicle run. Being a transit agency, NJ TRANSIT has no control over roadway motor vehicle crashes that cause congestion and affect paratransit trips. Furthermore, until recently, geocoded data on motor vehicle crashes were not available even if the agency wanted to take into account the frequency of crashes in different locations for trip-scheduling purposes. This research is the first effort to examine how crashes affect reliability of Access Link trips.

3. Measures of reliability in transportation

In the general context of highway performance, a number of reliability measures have been discussed in past studies (Cambridge Systematics et al., 2008; Martchouk, 2010; Cambridge Systematics et al., 2010; Kimley-Horn and Associates, 2011; Kittleson and Associates, 2013; Cambridge Systematics, 2013). They include Standard Deviation, Percent Variation, Travel Time Window, Misery Index, Buffer Index, Travel Time Index, and Planning Time Index. These measures are often described in the literature in terms of travel time (minutes) for a highway segment of a given length (miles). Standard Deviation is a measure defined in minutes. When travel time on a highway segment varies widely, Standard Deviation is high and reliability is low. On the other hand, when all trips on the highway segment take more or less the same time, Standard Deviation is low and reliability is high. By adding and subtracting the Standard Deviation to the mean trip time ($\overline{X}$), one can obtain the Travel Time Window, which is defined as a range of minutes. Percent Variation is a measure of variability obtained by multiplying the coefficient of variation by 100. This unitless measure is high when the Standard Deviation is high and low when the mean is high. Standard Deviation and Travel Time Window are likely to be more meaningful to travelers than Percent Variation because travelers are concerned about minutes delayed instead of unitless measures. On the other hand, Percent Variation may be more meaningful to transportation agencies because its unitlessness allows comparison across different components of a transportation network or system.

Standard Deviation, Travel Time Window, and Percent Variation place equal emphasis on trips involving different amounts of travel time. In contrast, Buffer Index and Misery Index place a greater emphasis on trips involving extreme travel time. The premise in using these two measures instead of Standard Deviation or Percent Variation is that it is the trips that take an inordinately long time compared to the mean time are important to travelers, whereas trips that take slightly longer than the mean trip time are of no significance. In the case of Buffer Index, the concern is the difference between the mean travel time for all trips and the 95th percentile trip time, whereas in the case of Misery Index, the concern is the difference between the mean travel time for all trips and the mean travel time for the 20% trips that take the longest time. In both cases, the greater the difference between the mean travel time and the trips involving extreme travel time, the lower is the travel time reliability.

Another measure of reliability is Travel Time Index, which is defined as the ratio of actual travel time to the free-flow travel time between an origin–destination pair. Yet another reliability measure is the Planning Time Index, defined as the ratio of the 95th percentile travel time to the free-flow travel time. Since these two measures require estimates of free-flow travel time, they are mainly applicable to roadway segments or simple roadway networks. For that reason, this study focuses on only Standard Deviation, Percent Variation, Travel Time Window,

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