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# Does service reliability determine transit patronage? Insights from the Los Angeles Metro bus system

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ABSTRACT

We explore whether improving service reliability can be effective in increasing transit patronage. Survey data shows that reliability is highly valued by passengers, because unreliability results in unpredictable wait times, missed transfer connections, and penalties associated with arriving at the destination earlier or later than desired. Consequently, transit planners have devoted significant effort towards measuring unreliability, exploring factors that cause unreliability, and developing strategies to increase reliability. However, we still know very little about how service reliability influences demand – i.e. whether reliability can be used as a tool to increase patronage.

We use data from the Los Angeles Metro bus transit system to analyze the variation in boardings across lines and find service reliability to be a significant determinant of patronage. The reliability effect appears to be stronger in the weekday peak relative to the off-peak. Our results suggest that better schedule adherence can potentially promote patronage of fixed-route fixed-schedule transit systems. Reliability improvements may lead to productivity gains for transit agencies.



## 1. Introduction

The US public transit industry has experienced substantial growth in funding support over the past several decades. For example, between 1992 and 2012, total annual government spending on transit increased from $22 billion to $58 billion, an annual average inflation-adjusted growth rate of about 2.5%.[1] Continued funding from federal, state and local governments have helped expand service areas, improve service quality and upgrade fleets, in addition to maintaining core infrastructures and sustaining operations.

However, patronage growth has not kept pace with capital investments and rising operating costs, and transit's share of the US travel market continues to be small. Between 2002 and 2011, while total revenue miles of service increased by 14.2%, total subsidy per trip increased by 17.4% (NTD 2012) – indicating declining productivity. Moreover, less than 2% of all trips within the US are made via transit (Santos et al., 2011), and our analysis of 2001 and 2009 NHTS[2] data shows that transit has even been losing share in some of its largest urban markets (e.g. New York, Washington D.C., San Francisco, and Pittsburg) over the past decade.

Given these trends, it is important to consider how US public transit systems might attract more patrons and increase productivity. A recent analysis of US public transit policy suggests that strategies for increasing transit's market share must include investment in the dimensions of service quality that travelers value most (Giuliano, 2011). Using empirical evidence from Los Angeles, we explore whether investing in reliability can be effective. A reliable service is broadly defined as one which consistently operates according to its schedule or plan.

We start from the premise that reliable service is critical for transit travel based on findings from many previous studies, and analyze the reliability–patronage relationship by observing the variation in weekday boardings across lines within a particular network. Our analysis is expected to inform transit managers about the efficacy of reliability investments as a patronage promotion strategy.

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[1] US National Transit Database figures, available at http://www.ntdprogram.gov/ntdprogram/data.htm (accessed on 8/11/2014).

[2] National Household Travel Surveys (refer http://nhts.ornl.gov/; accessed on 8/11/2014).

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Our study of the Los Angeles Metro[3] (Metro) bus system reveals a significant positive association between a line's service reliability and its patronage. The reliability effect appears to be stronger during weekday peak periods relative to off-peak periods. This implies that, all else equal, more reliable lines attract comparatively greater numbers of peak-period riders across their service corridors. Based on the reliability measure ("on-time performance" or OTP)[4] used in this study, we conclude that better schedule adherence, or increase in the frequency of on-time departures from time points (i.e. between 1 min early and 5 min late with respect to schedule per Metro's convention), can positively influence patronage of fixed-route fixed-schedule bus transit service. Investing in reliability can therefore be a useful strategy, particularly in cities like Los Angeles with an extensive transit network coverage and potentially high latent demand.

The remainder of this paper is organized as follows: Section 2 presents fundamental concepts relevant in the context of this study; Section 3 explains the research methodology; Section 4 summarizes empirical models and presents observations; Section 5 includes a discussion of findings; and Section 6 presents conclusions and policy implications.

## 2. Transit service reliability: theory and practice

### 2.1. The demand for travel time reliability

The classic behavioral model expresses travel choice as a utility maximization problem (e.g. de Donnea, 1972; Domencich and McFadden, 1975). Alternatives modes, routes or trips are selected based on their attributes (time and money costs, service quality, etc.). Travel is a disutility; it is a cost incurred in order to conduct a given activity. Thus, all else equal, travelers seek to minimize travel costs (Jiang and Morikawa, 2004). Reduced travel time provides opportunities for engaging in other productive purposes, such as work for earning income, or spending time with friends.

Variability in travel time, for example due to non-recurrent congestion, imposes additional cost and increases disutility. Travel time variability increases the risk of missing connections or being late. Travelers must build in additional time in order to assure a time definite arrival, or accept the risk of being late. The greater the penalty for being late, the more extra time the traveler is likely to budget to avoid the penalty. For repeated trips (for example the journey to work), the traveler will arrive early most of the time, incurring an extra time cost every day. Travelers' knowledge or perception regarding the probability of variations influences decisions regarding the time of travel, destination choice, mode choice, and whether to travel at all (Fosgerau and Engelson, 2011). User benefits brought about by transportation investments not only include travel time savings, but a reduction in travel time variability (Asensio and Matas, 2008).

There is empirical evidence that risk-averse individuals try to avoid unpredictability associated with travel. Many studies, largely focusing on the automobile mode, have analyzed how the demand for travel time reliability governs trip scheduling (e.g. Small, 1982), route choice (e.g. Noland et al., 1998; Lam and Small, 2001; Liu et al., 2004; Small et al., 2005; Asensio and Matas, 2008; Tilahun and Levinson, 2010), and mode choice (e.g. Nam et al., 2005; Bhat and Sardesai, 2006; Sweet and Chen, 2011) decisions.

However, the nature of the relationship between transit service reliability (independently, or relative to other modes) and transit mode choice has been less studied and remains unclear.

### 2.2. Importance of transit service reliability

While waiting for transit is a major cost (e.g. Wardman, 2001, 2004), longer-than-expected (and unpredictable) wait times due to service unreliability can impose massive penalties on riders who generally travel via chains, making one or more transfers (Rietveld et al., 2001). Greater service unreliability (experienced or observed over time) can therefore lead to attrition of risk-averse riders and discourage choice riders from entering the transit market (Perk et al., 2008). Transit dependents may adjust routes and travel times to minimize expected risk or to avoid budgeting for risk.

Studies analyzing transit passengers' attitudes and preferences consistently show that unreliability, generally defined as how well the service adheres to the expected schedule or plan, ranks among the top inconvenience costs associated with transit travel. Studies by Wachs (1976), Glascock (1997), Hensher et al. (2003), Tyrinopoulos and Antoniou (2008), Cantwell et al. (2009), Eboli and Mazzulla (2009), Iseki and Taylor (2010), Eboli and Mazzulla (2010), dell'Olio et al. (2010), Nurul Habib et al. (2011), and de Oña et al. (2013) are illustrative. Empirical research estimating the value of reliability, mostly using stated preference approaches, also shows the importance of punctuality or schedule adherence to transit users (see Bates et al., 2001; Hollander, 2006).

Given the importance of service reliability, many researchers have proposed various measures of service reliability (e.g. Polus, 1978; Nakanishi, 1997; Camus et al., 2005; Lin et al., 2008; Chen et al., 2009), analyzed factors that cause unreliability (e.g. Sterman and Schofer, 1976; Abkowitz and Engelstein, 1983; Strathman and Hopper, 1993; Strathman et al., 1999; Yetiskul and Senbil, 2012), and recommended methods to improve reliability (El-Geneidy et al., 2006, 2009, 2011; Xuan et al., 2011).

### 2.3. Transit on-time performance (OTP)

Based on an understanding of how passengers perceive fixed-route fixed-schedule transit service to be reliable, researchers have proposed several measures of (un)reliability. In general, measures seek to capture the (in)ability of a transit system to successfully complete scheduled trips, adhere to schedules (reach the route-end and/or serve en-route time points around scheduled times), maintain regular headways (across different segments of a route), and perform steady runs (consistently maintain expected travel times across different segments of a route).[5] In sum, unreliability is measured in terms of the variability in various dimensions of system performance, observed over some period of time (El-Geneidy et al., 2011).

The US Federal Transit Administration (FTA) recognizes reliability as a key dimension of transit quality of service (see the "Transit Capacity and Quality of Service Manual"[6]; Kittelson & Associates, Inc. et al. , 2013). It proposes several measures based on the source of unreliability, magnitude of impact, and purpose of measurement.

For example, reliability impacts of major system breakdowns that cause service disruptions are captured through measures such as: (a) percent of scheduled trips that were cancelled, (b) percent of scheduled time operations were down, or (c) average distance traveled between mechanical breakdowns. Impacts of common service variations, generally considering successfully completed

[3] The Los Angeles County Metropolitan Transportation Authority.

[4] Within the U.S. public transit industry, OTP relates to the proportion of total trips that served time points within an acceptable tolerance range (typically between 1 min early and 5 min late) around the schedule time.

[5] Refer Chen et al. (2009) for an exhaustive review.

[6] The third edition is available online at http://www.trb.org/main/blurbs/169437.aspx (accessed on 8/11/2014).