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Improving bus service reliability: The Singapore experience

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ABSTRACT

In February 2014, Singapore embarked on a 2-year trial of a Bus Service Reliability Framework (BSRF) to improve en-route bus regularity and reduce instances of bus bunching and prolonged waiting times. Based on London's Quality Incentive Contract, the Singapore model also imposes penalties or provides incentives to operators for increases/reductions of Excess Wait Time (EWT) beyond a certain route-specific baseline.

Drawing on insights derived from research on performance-based contracts, this paper describes some key considerations surrounding this particular innovation in Singapore's overall bus regulatory framework. We also discuss an important advancement in our understanding of how bus users value reliability improvements through estimates obtained from stated preference data. At the same time, early indications from the trial have been encouraging.

1. Introduction

For many public transport users, service reliability is a key attribute of the travel experience. The importance of reliability is amply demonstrated by the multitude of papers concluding that variability in travel time impacts well-being more negatively than the actual journey time itself (see review by Carrion & Levinson, 2012). With regards to the bus in particular, an unreliable bus service, characterised by unequal headways or bus bunching for high frequency services, can lead to longer waiting time and travel time for bus passengers. Moreover, in cases where passenger loading on a particular bus route is already high, unequal arrival times can mean severe crowding on the first bus that arrives after a long headway. The generally unpleasant in-vehicle experience adds another layer of frustration to passengers who have already endured a longer than expected wait, if they are not denied boarding in the first place. Unreliability begets further unreliability as dwell times increase at bus stops to cater for the higher passenger movements on and off the bus.

This paper describes Singapore's experience with improving bus service reliability. Section 2 provides a review of reliability measures and how reliability is achieved in various jurisdictions worldwide. Section 3 briefly describes Singapore's bus industry before discussing Singapore's trial of its Bus Service Reliability Framework (BSRF). Section 4 is largely an empirical section which discusses commuter awareness of the BSRF, stated preference strategies to measure improvement in reliability and crowding, and outcomes to date. Section 5 concludes.

2. Literature review

2.1. Overview of reliability measures used worldwide

Recognising the centrality of this aspect of service quality in passenger experience, industry regulators around the world have introduced various service reliability frameworks in their performance monitoring regimes. TriMet in Portland, Oregon, uses the Bus Dispatching System (BDS) to monitor public transport reliability (Feng & Figliozzi, 2012). The BDS combines Automatic

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Vehicle Location and Automatic Passenger Counters data to provide detailed information on bus service performance. The two performance measures are headway deviation and actual headway spatial distribution. Headway deviation looks at the difference between actual headway and scheduled headway. Actual headway spatial distribution depicts the proportion of actual headways deviating from scheduled headway against different stops along the route. Spikes and dips on the distribution would suggest congestion or chokepoints that require improvements. Strathman et al. (2000) report that the BDS has decreased bus service running time by 3 percent after implementation.

In Shanghai and Jiangyin City, a normalised average headway index is used to determine the actual headway deviation from the scheduled headway (Guo, Luo, Lin, & Feng, 2011). An index below 100% indicates that the bus is earlier than scheduled, while an index above 100% indicates that the bus is behind schedule (Eq. (1)).

$$\overline{H_i} = \frac{\sum_2^n H_{\delta i}/H_\delta}{n-1} \times 100\% \qquad (1)$$

where: $\overline{H_i}$ = average headway of normalised i-th bus stop;
H_δ = the departure interval at departure station of two specific adjacent bus deployments;
$H_{\delta i}$ = headway of the two specific adjacent bus deployments at i-th bus stop;
n = number of bus deployments.

In Changzhou's Bus Rapid Transit, four measures are used as indicators of reliability (Huo, Zhao, Li, & Hu, 2014). One statistic used is the coefficient of variation of headway, which is the standard deviation of headway divided by its mean. It indicates service reliability from the operator's perspective. On the other hand, potential waiting time, equivalent waiting time and reliability buffer time indicate service reliability from the users' perspective. Potential waiting time refers to the difference between 95th percentile waiting time and mean waiting time. Equivalent waiting time is the weighted sum of mean and potential waiting time. Reliability buffer time is the extra time that commuters need to provision beyond typical journey time to ensure on time arrival at destination with 95% probability.

In Chicago, the Automatic Vehicle Location data is used to determine running time adherence and headway regularity (Lin, Wang, & Barnum, 2008). Running time adherence measures the average difference between actual and scheduled run times, while headway regularity measures the average difference between actual and scheduled headways. A high metric value for these two indicators will indicate irregular bus services and poor reliability (Eq. (2)).

In Sydney, Transport for New South Wales uses Key Performance Indicators to monitor bus services performance. It measures punctuality of buses at the commencement of trip, mid-point of trip and at the last transit stop, requiring at least 95% of the trips to be between 2 min early and 6 min late.

Transport for London (TfL) characterises London bus services depending on whether they are high or low frequency. The reliability of high frequency services, defined as those with headways of less than 15 min, is assessed based on average excess wait time (EWT) experienced by commuters. Unreliable bus services, as evidenced by irregular spacing of buses, will result in high EWT. On the other hand, low frequency services are assessed on percentage of buses departing on time according to bus schedules.

2.2. *Achieving reliability through performance based contracts*

How to meaningfully measure bus service reliability is one, but certainly not the only consideration that regulators need to address. Another important question involves mechanism design—how one might achieve even better bus service reliability performance. Fortunately, on this latter issue, the existing literature offers substantial guidance, particularly through the use of performance-based contracts (PBCs). Based on the extensive research, PBCs are now used across manufacturing and service industries, in public and private domains (Selviaridis & Wynstra, 2014).

In the realm of bus service provision in particular, Hensher and Houghton (2002) proposed a system that takes into account various external costs such as costs of congestion, among many others, with social surplus maximisation as the underlying motivation in order to ensure that bus operators deliver the optimal service level that is consistent with the needs of stakeholders, especially the government. Working along similar lines, Hensher and Stanley (2003) highlighted the importance of PBCs as a crucial factor that aligns commercial objectives with social objectives by rewarding operators for achieving a minimum service level (MSL) and for an increase in ridership. Selviaridis and Wynstra (2014) also highlighted a form of PBCs where negative or positive incentives are given although there can also be ‘dead zones’ for acceptable performance levels for which there is neither penalty nor extra rewards.

A notable example of an implementation of PBCs in the provision of public bus service is the Hordaland framework (Larsen, 2001). In the Hordaland framework, social benefits such as reduced waiting time, reduced number of transfers and transfers of riders from car to public transport are internalised into the operators' remuneration contracts based on revenue kilometres and passengers. The framework attempts to induce operators to deliver the socially optimal level of services through performance-based subsidies as part of the total payment per passenger received by operators (Hensher & Stanley, 2003).

Numerous studies have also shown that reliability remains a crucial component of bus service quality. dell'Olio, Ibeas and Cecín (2010) found that bus reliability is one of the most important attri-

$$\begin{aligned} \textit{Running Time Adherence} &= \frac{\sum_m \left| \dfrac{\textit{Actual Run Time} - \textit{Scheduled Run Time}}{\textit{Scheduled Run Time}} \right|}{m} \times 100\% \\ \textit{Headway Regularity} &= \frac{\sum_n \left| \dfrac{\textit{Actual Headway} - \textit{Scheduled Headway}}{\textit{Scheduled Headway}} \right|}{n} \times 100\% \end{aligned} \qquad (2)$$

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