ARTICLE IN PRESS

Case Studies on Transport Policy xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Case Studies on Transport Policy

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

Assessing interchange effects in public transport: A case study of South East Queensland, Australia

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ARTICLE INFO

Keywords:
Transfer fare policy
Smart card data
Travel behaviour
Transfer behaviour
Network effects

ABSTRACT

Interchange or transfers for passengers in large multimodal public transport networks are more or less inevitable. In South East Queensland (SEQ), Australia, there is a zone based fare system in place which does not penalize transfers within the same zone but does charge a full fare for an inter-zone transfer in a single journey. This research investigates the interchange effects from an analysis of passengers' travel patterns using the smart card data from the automated fare collection system in place in SEQ. Latent class nested logit models are estimated with social demographic characteristics to measure transfer behaviour, and are used to investigate the opportunity for better interchange policies to increase the network effect. The results identified passengers' heterogeneous preferences towards travel alternatives with markedly different market segments. The empirical results identified passengers categorised into four segments of employees, students, wealthier people and seniors. The findings suggest that public transport network effects are most important to the employee segment with student and senior segments being more likely to choose direct alternatives over alternatives involving interchange. In order to enhance the public transport network effects, two transfer policies are simulated and all segments show increase of the transfer behaviour but with different alternative shares.

1. Introduction

Transfers in large multimodal public transport networks are almost inevitable (Vuchic, 2006). One or more transfers are made for trips in many of the major cities around the world: 30% of trips in London, 80% in New York, 70% in Munich, 40% in Paris and 50% in Melbourne (NYMTC, 1998; Transport for London, 2001; GUIDE, 2000; Currie and Loader, 2010; Guo and Wilson, 2011). However, public transport users often link transfers with inconvenience. Inconvenient interchanges can disrupt passengers' travel giving a negative travel experience and reduce public transport's competitiveness as compared to the car which provides a door-to-door service (Guo and Wilson, 2011). For example, passengers, particularly commuters and business users, would prefer to select fast and direct routes for their journeys (Conquest Research, 1997; Hine and Scott, 2000). An assessment of public transport transfer options and suggestions for the improvement of interchange within large multimodal networks can not only improve the quality of public transport but will enlarge its network effects.

Transfers are a fundamental issue in large multimodal systems, but are largely overlooked in public transport planning (Guo and Wilson, 2011). Often, a zonal based fare system is introduced to mitigate the impact on the user of having to interchange but little research has been made of how passengers behave in respect of intra-zonal versus inter-zonal transfers within an urban area, where these transfers are treated differently by the fare system. This paper addresses this under developed research area to examine the current transfer behaviour and the impact of the fare system on transfer behaviour using South East Queensland (SEQ), Australia, as the case study. A zone based fare system is adopted in SEQ such that there is no penalty for a transfer within the same zone, but a full fee is charged for an inter-zone transfer within a single journey with no separate transfer policy to encourage or integrate inter/intra-mode transfers in the zone based system. In many countries, a transfer discount policy has been shown to have positive effects on increasing public transport usage. For example, in Taiwan, a different ticketing regime is in place. A discount of NT$8 (approximately US$0.25 which is equal to 50% discount on the transfer trip) is provided to each bus transit user transferring to or from the Taipei metro. This transfer discount has significantly raised commuters' use of both the metro and the bus systems. A motivation of this paper is to understand transfer behaviour with a view to examining whether a

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https://doi.org/10.1016/j.cstp.2018.01.005
Received 26 September 2016; Received in revised form 17 November 2017; Accepted 14 January 2018

Please cite this article as: Yen, B.T.H., Case Studies on Transport Policy (2018), https://doi.org/10.1016/j.cstp.2018.01.005

specific transfer policy could increase public transport usage in SEQ.

The paper is structured as follows. The next section provides the literature context to transfer behaviour and this is followed by a description of the SEQ transport study area together with a summary of the current fare system. The methodology and data used in the paper are then described. The penultimate section provides the results together with interpretation. The paper concludes with a discussion and suggestions for further research.

2. The literature context

The assessment of interchange can be considered from the operator or the passenger perspective. There are various studies on public transport transfer from an operator's perspective, including scale economics in urban bus (Mohring, 1972; Tirachini, 2014), inter-modal transfer facility design (Horowitz and Thompson, 1995; Smart et al., 2009; Hoeven et al., 2014; Harmer et al., 2014), location for transfers (Clever, 1997; Vassalo et al., 2012), unreliability (Abkowitz et al., 1987; Carey, 1994; Rietveld et al., 2001), network accessibility (Hine and Scott, 2000; Shafahi and Khani, 2010; Currie and Loader, 2010), and public transport coverage (Murray, 2001). This literature is extensive but has in common the tendency to treat passengers as if they are a homogeneous segment without consideration of the passengers' trip characteristics in evaluating transfer effects. The trip characteristics (e.g. travel time, travel cost, transfer waiting and walking time, transfer information, fare, safety and comfort, etc.) are identified as the most significant factors for passengers in selecting travel with transfer or not (Atkins, 1990; Callaghan and Vincent, 2007; Iseki and Taylor, 2009; Chowdhury and Ceder, 2013; Chowdhury et al., 2015) and hence, it would appear sensible to take these into account when examining interchange behaviour. The travel behaviour literature has tended only to focus on the impact of some aspects of the trip on users, such as the impact of transfer penalties on the value of time in travel (Iseki and Taylor, 2009; Guo and Wilson, 2011; Chowdhury et al., 2015). In addition, Iseki and Taylor (2009) included a transfer penalty as part of the traveller's total generalized cost of travel by classifying the most important users' factors, including transfer costs, time scheduling and transfer facility attributes (i.e. access; connection and reliability; information; amenities; and security and safety). Guo and Wilson (2011) extended this by including transfer costs based on both the operator's service supply and the customers' perceptions. Chowdhury and Ceder (2013) conducted a survey to understand passengers' perceptions on defined planned/unplanned transfer that consisted of five attributes (network integration, integrated time-transfer, integrated physical connection of transfers, information integration, and fare and ticketing integration). They found that public transport users' willingness to use transfer routes increases if attributes of the connections are closely aligned to being planned especially for the planned transfer. In a number of studies, travel time has been found to be more significant than waiting and walking time in transfer, particularly for commuters (Vande Walle and Steenberghen, 2006; Xumei et al., 2011). This is enhanced by the results of Chowdhury et al. (2015) who in New Zealand, explored commuters' perception of transfer using the two trip attributes of travel time and cost. They found that for more 'comfortable' interchanges, users' valued these as a 25% reduction in travel time and a 10% reduction in travel cost. Other studies have shown that transfer waiting time is valued more highly than transfer walking time (Vande Walle and Steenberghen, 2006; Iseki and Taylor, 2009). The evidence is therefore mixed on transfer valuations.

Much research has been done in the field of travel behaviour, often using traditional travel surveys to capture current and potential change in travel behaviour (for example, Meyer, 1999; Garling et al., 2002; Hensher and Puckett, 2007). However, the major challenge for travel surveys is the validity of the survey (does the survey itself change travellers' behaviour?, how do we account for differing response rates?, does different coding affect the results?) The nature of the questionnaire has been shown to make a large difference and there is always the challenging issue of whether or not participants are self-selected in the recruitment process with the consequential introduction of bias (Stopher et al., 2007). Therefore, this study utilizes an alternative data source (public transport smart cards records) to precisely capture passengers' travel patterns. Many recent studies have used smart card data to evaluate public transport behaviour and has been shown to be a reliable source (Blythe, 2004; Bagchi and White, 2005; Trepanier and Morency, 2010), travel behaviour (Bagchi and White, 2004; Seaborn et al., 2009; Munizaga et al., 2010), operational performance (Morency et al., 2007), and fare policies (Pelletier et al., 2011). Smart cards typically provide more limited data than a questionnaire, for example, it is rare to find information on trip purpose (Bagchi and White, 2004), but smart card data have the advantage of providing continuous trip data covering longer time periods and thus, providing the opportunity of evaluating transfer effects with accuracy.

Research has shown that travel behaviour is affected by a combination of instrumental, situational and personal factors and that these will differ for distinct groups of people (Anable, 2005). In order to account for the heterogeneous preferences of users, market segmentation should be introduced into travel behaviour analysis (Hair et al., 1998; Wedel and Kamakura, 1998; Anable, 2005; Wen et al., 2012). The major purpose of market segmentation is to group different 'types' of people who share well defined characteristics into a manageable number of groups for analysis. In the previous research, different segment-specific parameters have been used, including trip purpose (Tsamboulas et al., 1992), a lifestyle variable (e.g. investment in car mobility) (Bekhor and Elgar, 2007), socio-economic variables (e.g. household income, type of accommodation, dependency factor, and occupation level of commuters) (Rastogi and Rao, 2009; Wen and Lai, 2010; Wen et al., 2012).

This paper will contribute to the literature in two ways. Firstly, the public transport smart card transaction data in this paper serves as revealed preference data, and has been adopted to objectively capture passengers' travel patterns. Secondly, a market segmentation concept has been introduced to measure the heterogeneous preferences of users (in this paper, public transport passengers). The results of this paper also suggest that the undertaking of a future case study would provide important further information into transfer behaviour which is especially important for large multi-modal systems with zonal based fare systems. In summary, the contribution comes from the way in which this paper uses the objective measure of transaction data, as identified by the automated smart card fare collection in SEQ to explore the transfer effects. This is demonstrated from the passengers' travel patterns with a market segmentation scheme that incorporates parameters to differentiate between distinct groups of users. Thus, allows the estimation of transfer effects for passengers and the subsequent use of these estimation results to investigate fare policy around transfer effects by simulating potential alternative interchange fare policies.

3. The SEQ transport system

As this paper considers the transfer behaviour of public transport users in SEQ, this section presents a brief outline of the current public transport modes. The SEQ region of Australia, which includes Brisbane, the Sunshine Coast and the Gold Coast, has merged into a 200 km long city (Spearritt, 2009). SEQ's public transport system is made up of a network of trains, trams, buses and ferries. Fig. 1 shows the public transport service network in SEQ as of January 2015.

3.1. Train

SEQ's rail network of over 200 km connects to the Sunshine Coast and Gold Coast to Brisbane. Operated by a division of the Queensland Government, the CityRail network has relatively low ridership if considered on a world scale. The CityRail network has 11 lines and 214,