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Bootstrap confidence intervals for effects of electronic peak load pricing on public transport demand

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Abstract

In the public transport system of the city of Münster / Germany electronic ticketing has been introduced. Subsequently flexible electronic fares in public transport have been established in order to conduct peak load pricing. The pricing scheme for the new annual season ticket named FlexAbo consists of a low basic fare per month, an incremental fare per day with trips during the defined peak time limited by a maximum monthly fare.

Before launching the FlexAbo a large scale stated choice survey among annual season ticket holders was conducted. They were asked to assume the FlexAbo would replace their tickets. Within the experimental choice context the incremental fare and the maximum fare per month varied according to an orthogonal design. Holders of the seasonal ticket MSAbo and the job ticket were asked whether they would still ride during peak times, delay peak-trips to off-peak times, go by car instead, ride by bicycle or even walk. The shares of shifted peak-trips were forecasted applying a discrete choice model.

The results of shifted peak-trips are presented as well as their associated bootstrap confidence intervals. Percentile and bias corrected confidence intervals are compared. Additionally, all results are provided in dependency of different sample sizes. It is shown that even for small shifted shares notable differences between the two techniques for constructing confidence intervals only occur in combination with small sample sizes. Further, the width of the confidence intervals substantially decreases with sample size.

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Keywords: public transport, electronic ticketing, peak load pricing, bootstrap confidence interval, discrete choice

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1. Introduction

There is a widespread use of electronic tickets in public transport. These tickets allow for more complex, flexible peak load pricing solutions. Therefore, forecasting of the effects of peak load pricing, namely shifting peak trips to off-peak times and shifting peak trips to other modes of transport, is necessary. Since it is difficult to estimate choice models based on revealed preference data surveys often rely on stated preference data. But there is little evidence on the accuracy of such models.

This paper provides some results on the accuracy of a large scale stated choice study conducted on behalf of the transport division of the Stadtwerke Münster GmbH (Germany) in order to model the effects of a peak load pricing scheme. The main research question is whether the confidence intervals of the estimated shares of shifted trips will substantially decrease with increasing sample size. To this end the paper is organised as follows. Chapter 2 provides some information on the political context of electronic ticketing with special reference to the city of Münster. In chapter 3 the choice experiment and the estimated utility functions for two groups, the holders of a job ticket and the holders of the usual season pass, are presented. Chapter 4 gives an overview on the bootstrap method in order to obtain confidence intervals. In chapter 5, firstly, the significances of utility coefficients for different sample sizes are presented. Secondly, the choice probabilities and their bootstrap confidence intervals are provided for the different sample sizes. Percentile as well as bias corrected, accelerated confidence intervals are compared. The paper ends with a conclusion.

2. Policy context

2.1. Electronic ticketing in public transport

Paper-less, electronic tickets are well known in public transport. Usually chip cards or smartphones (via apps or NFC) carry the passengers' data. There are three main systems how the passengers have to read in their electronic tickets: Check-In/Check-Out, Check-In/Be-Out, and Be-In/Be-Out. The latter is not yet implemented in public transport but field tests are ongoing (e.g. (((eSim 2020). There are efforts to extend the functionality of electronic tickets. Public transport users shall be able to pay the fare of different transport operators (interoperable function), to buy a ticket for different modes of transport (intermodal function) and to use the electronic ticket for other services (e.g. cinemas, museums, libraries). Furthermore, electronic tickets can be used as an instrument for customer relationship management. (Mezghani, 2008; VDV eTicket Service, 2016)

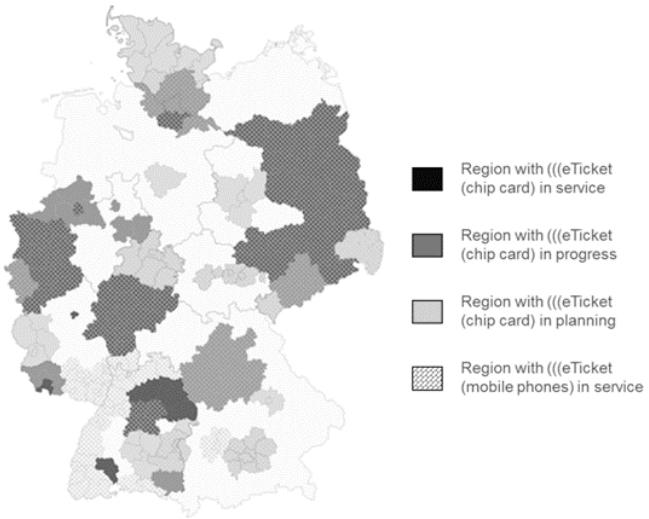

Fig. 1: The extension of eTickets in Germany, 2015 (Source: VDV eTicket Service GmvH & Co. KG).