Dynamic Discrete Choice Model for Railway Ticket Cancellation and Exchange Behavior

Pratt Hetrakul, Cinzia Cirillo
University of Maryland
Fabian Bastin
University of Montreal

Short ABSTRACT

The increasing use of internet as a major ticket distribution channel has resulted in passenger becoming more strategic to fare policy. This potentially induces passengers to book the ticket well in advance in order to obtain a lower fare ticket, and later adjust their ticket when they are sure about trip scheduling. Therefore, when modeling this behavior, it is important to account for the characteristic of the passenger that optimally makes decision over time based on trip schedule and fare uncertainty. In this paper, we propose an inter-temporal choice model of ticket cancellation and exchange for railway passengers assuming that customers are forward looking agents. A dynamic discrete choice model (DDCM) is applied to predict the timing in which ticket exchange or cancellation occurs in response to fare and trip schedule uncertainty. The application is based on data extracted from the online sale of high speed railway tickets.

Extended Abstract

1. Introduction and literature review

Ticket cancellation and exchange behavior has significant impact on the revenue management (RM) system. In flexible refund markets, passengers are inclined to book their ticket in advance in order to obtain lower fares, and to exchange/cancel the tickets when changes in their schedule intervene. Moreover, the use of internet as a major ticket distribution channel has affected the behavior of customers who have now better access to fare information, and are becoming more strategic in their choices. Reliable predictions in cancellation and exchange decisions enable analysts to derive more efficient overbooking and refund/exchange policies. Existing literature on choice modeling for revenue management (RM) has mostly ignored temporal effects in individual decision making. Although static models enable analysts to address the dependence of demand on the set of products offered by the provider, they are unable to model forward looking agents, who would typically wait and see before making the final decision. There is an emerging research effort toward dynamic frameworks that account for inter-temporal behavior in choice modeling. Existing research on inter-temporal price variation that considers forward-looking consumers includes Stokey (1979), Landsberger and Meilijson (1985), and Besanko and Winston (1990). A number of studies on demand uncertainty have focused on supply chain management approach. To our knowledge, Spinler et al. 2002, 2003 are among the first in the operations management literature that incorporate consumer's uncertainty in valuations into revenue management, and the first paper that studies partially refundable fares. Others who study uncertain valuations for traditional revenue management problems are Levin et al. (2009), Yu et al. (2008), and Koenigsberg et al. (2006). There is also an emerging literature that deals with strategic consumers who develop expectations on future prices and product availability based on the observed history of prices and availabilities (e.g. Besanko and Winston 1990, Gallego et al., 2009, Liu and van Ryzin, 2005, Aviv and Pazgal, 2008). In the context of ticket cancellation and exchange model, a number of papers have been published in the past decade. For example Garrow and Koppleman (2004) focuses on airline cancellation and exchange behavior based on disaggregate passenger data.

2. Methods and Data

In this paper, the railway operator in consideration offers fully refundable fare and provides flexibility in ticket exchange which makes ticket cancellation and exchange decision to be very crucial to their RM system. It gives incentive to passengers to purchase ticket early and adjust their ticket later when they are more certain about trip schedules. We consider a railway revenue management problem in which we explicitly model a passenger trip adjustment choice using a dynamic discrete choice model (DDCM), which specifies the probability of exchanging ticket as a function of the set of available exchange tickets. In this setting, choice includes keep, cancel and departure time specific exchange decisions.

The data set used for the analysis has been extracted from intercity railway ticket reservation data registered in March 2009. This data set contains 155,175 individual transaction records in terms of ticket purchase, cancellation, and exchange over time prior to departure.

3. Problem Formulation

We consider a passenger set $\mathfrak{T} = \{1, \dots, M\}$ where each passenger $i \in \mathfrak{T}$ can be in one of the two possible states $s_{it} = \{0,1\}$ in time period $t \in \{0,1, \dots, T\}$. Passenger is considered to be in the decision process when $s_{it} = 0$ and out of the decision process when $s_{it} = 1$. In each time period t, passenger i in state $s_{it} = 0$ has two options:

1. To make change to the ticket (either exchange or cancel).
2. To keep the original ticket and obtain a one-period payoff U_{ikt}.

The two-step decision process is that, at each time period, the passenger decides whether to keep, cancel or change the ticket for a new departure time. The optimal time period in which passenger decide to change the ticket is denoted by τ, where the passenger chooses the ticket change alternative j_t^* that maximizes the utility from $\mathfrak{J}$. The passenger decision is the optimal stopping problem at time t:

$$D\left(u_{i1t}, \dots, u_{iJt}, U_{ikt}, t\right) = \max_{\tau} \left\{ \sum_{k=t}^{\tau-1} U_{ikt} + E\left[\max_{j \in \mathfrak{J}} u_{ij\tau} \right] \right\}$$

4. Results from ticket reservation data

Preliminary results show that the DDCM slightly under-predicts cancellation; its performance is inferior to MNL for the first time period and equivalent to MNL for the last time period. In terms of exchange, DDCM slightly under-predicts the total number of exchange except for the first and last time periods which have relatively high exchange rates. The prediction of keep obtained from DDCM is reasonably close to the observed values while the MNL significantly under predicts the keep decision as a consequence of over prediction in exchange. Figure 1 briefly summarizes the results obtained when calculating the probability of the “keep” decision over different time periods (days) with both static and dynamic models.

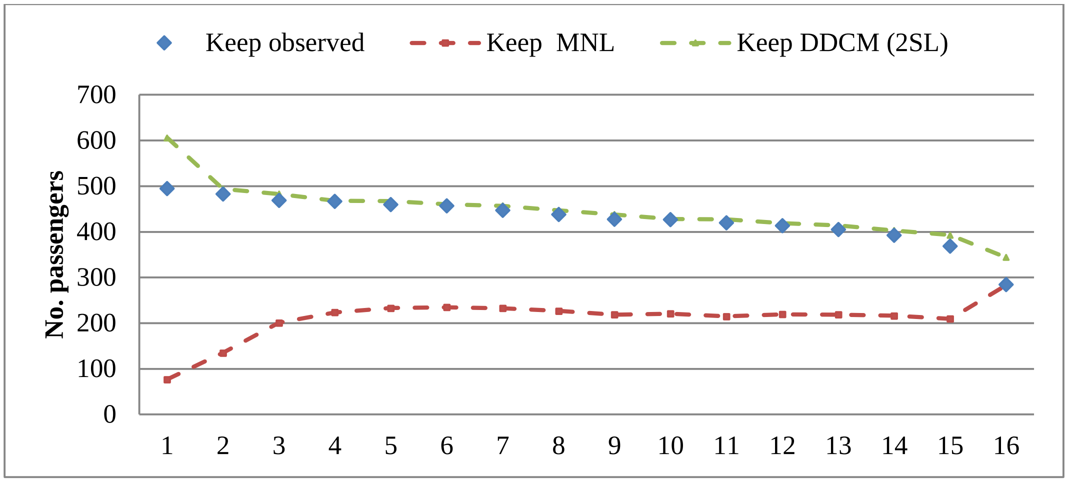

Figure 1 - Validation of Keep Decision: Actual Data

To conclude, in the context of ticket exchange and cancellation, the proposed DDCM is superior to static approaches. Although applied in the context of RM, the method proposed here is general and can be transferred to other problems in transportation demand analysis (car ownership, route choice, activity scheduling, and freight transactions).