Transportation Research Part A 45 (2011) 880–895

Contents lists available at ScienceDirect

Transportation Research Part A

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

Latent temporal preferences: An application to airline travel

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ARTICLE INFO

Keywords:
Airline demand
Time of day demand
Schedule delay
Discrete choice
Latent variables
Finite mixture models

ABSTRACT

An essential element of demand modeling in the airline industry is the representation of time of day demand—the demand for a given itinerary as a function of its departure or arrival times. It is an important datum that drives successful scheduling and fleet decisions. There are two key components to this problem: the distribution of the time of day demand and how preferred travel time influences itinerary choice. This paper focuses on estimating the time of day distribution. Our objective is to estimate it in a manner that is not confounded with air travel supply; is a function of the characteristics of the traveler, the trip, and the market; and accounts for potential measurement errors in self-reported travel time preferences. We employ a stated preference dataset collected by intercepting people who were booking continental US trips via an internet booking service. Respondents reported preferred travel times as well as choices from a hypothetical set of itineraries. We parameterize the time of day distribution as a mixture of normal distributions (due to the strong peaking nature of travel time preferences) and allow the mixing function to vary by individual characteristics and trip attributes. We estimate the time of day distribution and the itinerary choice model jointly in a manner that accounts for measurement error in the self-reported travel time preferences. We find that the mixture of normal distributions fits the time of day distribution well and is behaviorally intuitive. The strongest covariates of travel time preferences are party size and time zone change. The methodology employed to treat self-reported travel time preferences as potentially having error contributes to the broader transportation time of day demand literature, which either assumes that the desired travel times are known with certainty or that they are unknown. We find that the error in self-reported travel time preferences is statistically significant and impacts the inferred time of day demand distribution.

1. Introduction

While long a stalwart component of airline schedule and fleet planning, time of day demand is thus far a poorly described phenomenon in the airline industry. Yet, it is critical to understand the passenger choices that drive successful scheduling and fleet decisions; for example, when to schedule a departure in a low frequency market, how to spread flights over the day in a high frequency market, or the impact on market share when a new technology is introduced.

There are two essential components to understanding time of day demand. The first is the choice of itinerary, conditional on the desired travel time. This aspect has received relatively more attention in the literature, and is generally captured by

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0965-8564/$ - see front matter
doi:10.1016/j.tra.2011.04.010

introducing a schedule delay variable in the utility function. The second component is the preferred time of day distribution, which has received considerably less attention, and estimating this distribution is the focus of this paper.

The next section presents background information, which is followed by a literature review and discussion of the contributions of this paper. The proposed modeling framework is then described in detail and an empirical application is presented.

1.1. Background

Common experience suggests that the departure (or arrival) times of alternative flights are important in determining the choice of flights, along with other attributes such as travel time and fare. In terms of utility, we can assert that there is a value associated with the timing of an airline schedule, in the sense that some flights that depart at certain times may be more or less preferred than others. The Boeing Decision Window Model (Boeing, 1996) asserts, for example, that flights that depart within a given window of time are acceptable and have no disutility, while those that do not are unacceptable, that is, have infinite disutility.

It is typical to reflect the attractiveness of certain flights based on time of day using a schedule delay variable, which is a measure of the difference between desired and scheduled departure times. To gain some intuition on the form in which the schedule delay function could take, consider Fig. 1. The horizontal axis is the time of day, and the vertical axis is disutility. Two flights are shown, one in the morning departing at time t_1 and one in the evening departing at t_2. The desired departure time for the passenger is towards noon, and indicated by τ. The curve represents the disutility of departing at a time different than the desired one, which gets larger as one moves away from the desired departure time and may be asymmetric (in the figure, departing late is more costly than departing early). The function is then parameterized via the functions for earlier than desired and later than desired departure times noted as $GE()$ and $GL()$, respectively. $GE()$ and $GL()$ are functions of the desired time τ, and the scheduled time t_i. In addition, there may be a band near the desired departure time where the traveler is indifferent, which is denoted as the window between a and b in the figure. The problem then reduces to determining an appropriate functional form for $GE()$ and $GL()$ and estimating the parameters using travel data.

Fig. 1 assumes that the desired departure time (τ) is known. Such information is sometimes collected in passenger surveys and therefore can be incorporated in itinerary choice models, conditional on desired departure times. However, if such models are to be used for airline scheduling, a model of preferred time of day is required. Fig. 2 shows what a distribution for preferred time of day might look like. This figure suggests strong morning and evening peaks, although the distribution would be expected to vary based on traveler, trip, and market characteristics. Such distributions are the focus of this paper, and we estimate jointly the time of day distribution and the itinerary choice model with schedule delay. The next section will review the literature on these topics.

1.2. Literature

Temporal dimensions of travel have been a focus in the transportation literature since the 1960s (and probably earlier). Vickrey (1969) introduced the concept that congested conditions in urban settings lead to travelers making tradeoffs be-

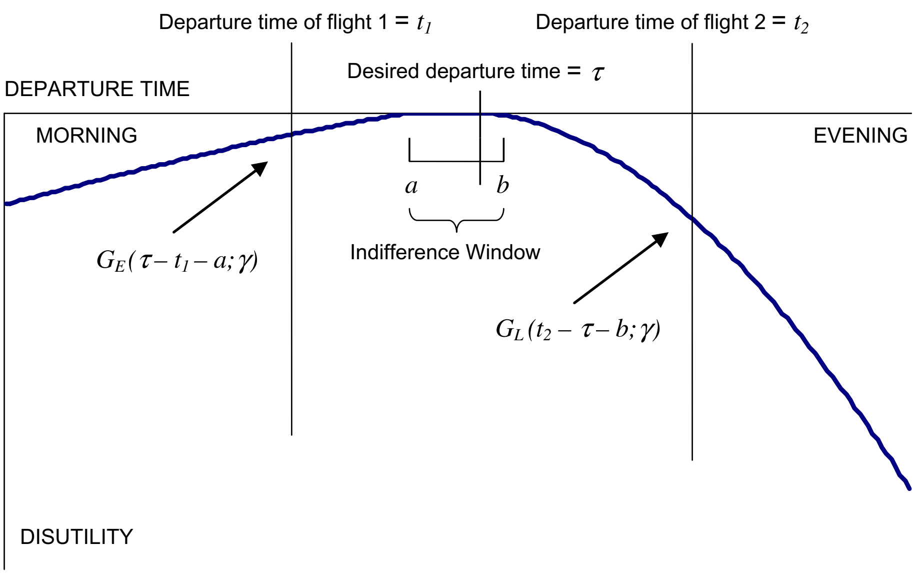

Fig. 1. Hypothetical schedule delay curve.