Authors Petro Horbachev, Olena Tokmylenko, Olga Svichinska

Title Development of discrete choice models for public transit route system

Track General Papers

Director Mark Wardman

Abstract The public transportation system in Ukraine is characterized by the existence of the highly developed route network that serves most of trips taken by residents and visitors. An effective planning of the public transit system operation becomes an important purpose to provide a high quality service to all these users. It becomes even more important considering the fact that the level of service in Ukraine is quite different from the typical level of service in developed countries: bus schedules are often violated, there is no public access to schedule information and there is a pour operational control for bus bunching. As a result public transit users are not aware of transit arrival time.

Research on the behavior of public transit user presented in this paper is significantly different from the general random choice method, which is used in the Discrete Choice Models. Taking into account the headway-based service, the decision about the route choice is usually made directly at the stop point. There is a relatively small set of measurable variables of the alternative available for route choice. At the same time, each variable can be specified as a random or deterministic one. It allows defining the concrete sense of random part of utility and determining its distribution via theoretical and experimental methods. There are three categories of travel cost that are considered by the user for the route choice:

- Deterministic (travel cost, number of transfers, in-vehicle travel time, level of service, etc.).
- Random (on-stop waiting time).
- Unspecified (perceptional non-measurable factors).

So, the question of this research is how to determine the probability of the route choice when the decision significantly dependent on passenger’s on-stop waiting time, which is random by its nature.

A mathematical model that describes the utility function of the route and a new approach to estimate utility function coefficients was developed. A relative shift is included into the waiting time distribution to obtain empirically observed probabilities. Such shift describes a relative utility of particular choice for a nest of alternatives. For each nest, the Fredholm equation system is solved according to shift parameters. Solutions for each respondent are processed based on the Gauss method to receive a regression utility as a function of the route parameters.

Experiments were carried out in Kharkiv, the second biggest city of Ukraine, with population above 1.5 million people. 866 commuters were surveyed for five days. From the forms returned 307 forms were selected as acceptable for a further research. Surveys were considered acceptable if five-day questionnaires were filled in correctly and at least two or more alternatives of the routes has been used.

It was found that at the headway-based service a user waiting time for a vehicle operating on one route is distributed by the gamma distribution with parameters of scale and form that are linearly dependent on the headway schedule on the route. An initial waiting time distribution with the equal route utility is shown in Fig.1.

In the next stage, values of the deterministic utility of route alternatives were calculated using the approximate method on the basis of equation system for each nest. The objective solution function is the minimum magnitude of the vector disparity of empirical and calculated values. A corresponding distribution of the waiting time taking into account the utility of routes is shown in Fig. 2.

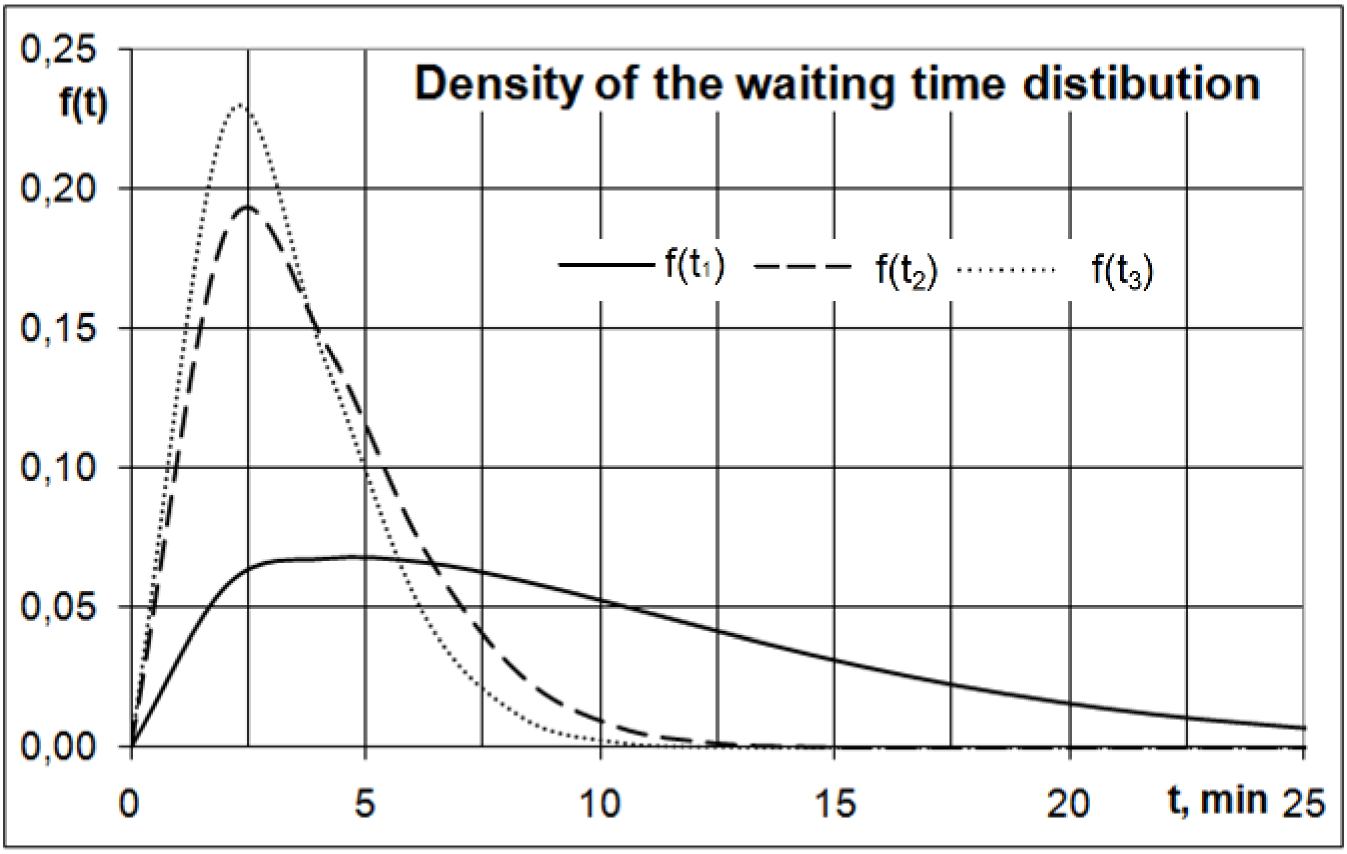

Fig. 1. A waiting time distribution of the alternative routes

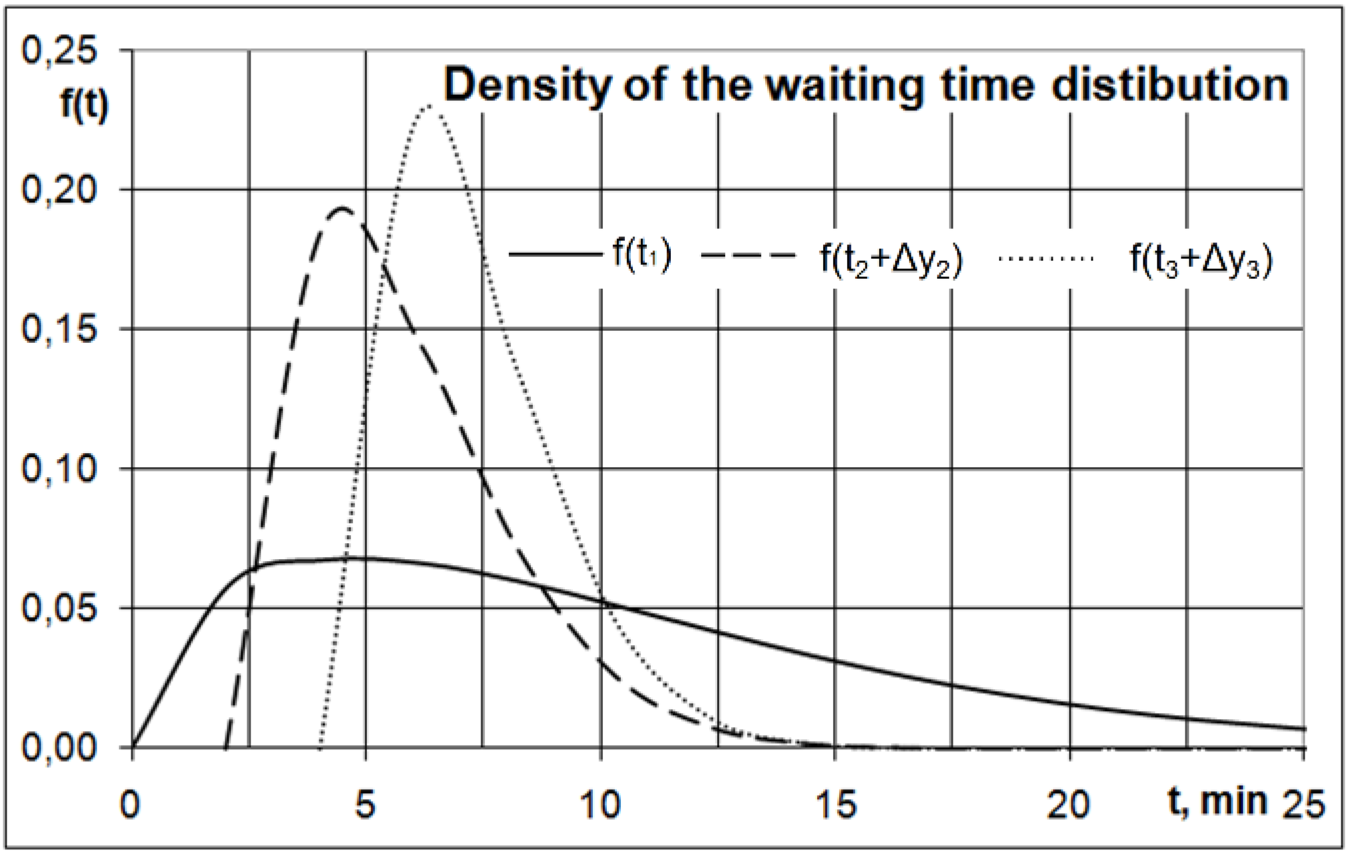

Fig. 2. A waiting time distribution of alternative routes taking into account the route utility

Processing data for survey sample allows obtaining the trip utility model as follows

$$y = 103.25 - 1.029 \cdot t - 9.227 \cdot \gamma - 83.544 \cdot C - 11.430 \cdot T$$

where *t* is the in-vehicle time for travelling from home to work, in minutes; *γ* is the load factor at the moment of boarding; *C* is the travel cost, in $; *T* is a number of transfers on the way to work, in units.

Table 1. Regression analysis of the route attractiveness model

Factor	Value
Multiple Correlation Coefficient (R)	0.903
R square	0.816
Adjusted R square	0.814
Standard error	9.159
Number of alternatives	692

Factors of the model and deterministic utility of the routes show a high correlation. The influence of unspecified factors proved to be less than 20% that evidence in favor of proposed model.

Table 2. Characteristic of regression coefficients

Factor in Regression	Coefficients	Standard error	t-value	P – value
Y-intercept	103.25	4.47	9.68	7.4E-21
Travel time	-1.03	0.09	-12.71	2.2E-33
Load factor	-9.23	3.07	-3.01	0.02706
Travel cost	-83.44	12.20	-4.75	2.5E-06
Number of Transfers	-11.43	2.33	-4.91	1.1E-06

As seen from Table 2, the all regression coefficients are turned out to be significant for the model and decrease utility of the trip, which corresponds to the generally accepted ideas about the nature of utility. It gives sufficient grounds to use the route utility model to forecast choice probabilities in urban transportation modeling.
The obtained patterns of the waiting time distribution for the headway-based service with the random departure time allowed receiving a specific meaning to the random variable in the expression for the trip utility and solving the problem of correlation between route alternatives on the basis of integral equations.
The results have proven that proposed model allows simulating transit users' choice for the diverse set of alternatives that are typical for transit users who travel from different places in different directions. This makes it possible to suppose this approach is more general than the one used in Discrete Choice Models.