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## Dynamic Route Choice Based on Prospect Theory

Wei Zhang<sup>\*</sup>, Ruichun He

*School of Traffic and Transportation, Lanzhou Jiaotong University, 88 West Anning Road, Lanzhou 730070, P.R. China*

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### Abstract

Traveller route choice behaviour is influenced by many uncertain factors, which include both outer stochastic factors from road network and inner factors from traveller psychology. Traveller route choice behaviour is dynamic in practical travel process, namely traveller can change route on the way. Considered the characteristics of bounded rationality in human decision making process and change of route choice on the way, a dynamic route choice model is established based on prospect theory, and the method of dynamic route choice which is more suitable to human thinking habits and actual travel characteristics is proposed in this paper. The method allows the traveller to adjust the route according to road situation at any time. Decision making process reflects that the influence of traveller reference point on the decision result. Reference point changes with the situation of road sections passed. The examples are given to verify the validity and explain application of the method. The result shows that traveller can change route on the way when he meet congestion on the section passed, and if traveller's psychological expected time can not be met, he will choose risky route, by which the probability of congestion is higher. The method describes traveller route choice behaviour process better and reflects the true situation of road network. It is beneficial to predict traveller behaviours and changes of traffic network situation, and have certain guiding significance for traffic network planning and traffic intelligent control.

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*Keywords:* prospect theory; dynamic route choice; change on the way; reference point; bounded rational

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### 1. Introduction

The problem of traveller's route choice is always the focus in the field of traffic research. The reliability of the research result has direct influence on traffic network planning and traffic intelligent control. Traditionally the

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<sup>\*</sup> Corresponding author. Tel: +86-(0)931-7654-991.

E-mail address: [zhangwei@mail.lzjtu.cn](mailto:zhangwei@mail.lzjtu.cn).

researches of traveller route choice problem are based on the expected utility theory (Gao et al., 2010). Traveller's complete rationality is a prerequisite for the utility theory (De et al., 2011). However people often reflect less than fully rational behaviours in actual route choice decision due to interference of individual psychological factors. In recent years, some scholars introduce prospect theory into the research of route choice behaviour to overcome the prerequisite shortcoming of the utility theory, in which decision makers must be completely rational. De et al. (2011) presents a comparative analysis from the points of view of theory and application of the expected utility theory, prospect theory, and regret theory; Zhao and Zhang (2007) formulated a theoretical model for traveller's route choice behaviour within a day; Zhang et al. (2013) established a stochastic dynamic user optimal (SDUO) traffic assignment model based on prospect theory. Liu et al. (2010) built model of traveller's perceived utility under the condition of the route utility continuous random distribution based on prospect theory. Xia et al. (2012) studied reference point setting and influence of departure time on route choice under the condition of reference point unchanged. Wu and Yang (2013) proposed a traveller decision method in uncertain traffic environment. Jou and Chen (2013) applied cumulative prospect theory into studying of freeway drivers' route choice behaviours. The above studies only consider travellers' route decision before departure, and the problem of adjusting route on the way is not involved after departure.

It is possible that travellers change route on the way according to road condition. The route choice behaviours run through the whole travel process. So this paper builds a dynamic route choice model allowing traveller to change route on the way based on prospect theory.

## 2. Prospect Theory

Psychologist Kahneman proposed a new theory—prospect theory that apply psychology research into economics field, and made outstanding contribution for human judgment and decision under the uncertain condition. So he won the 2002 annual Nobel Prize in economics. Prospect theory opens up a new studying field of decision making under the uncertain condition. Prospect theory holds that people's behaviours, revealing non-rational psychological factors, are predictable (Bromiley, 2010).

Prospect theory finds out the behaviour mode that is not realized in rational decision research, and obtains four basic conclusions: (1) most people show risk aversion when they are faced with gain (fixed effect); (2) most people show risk preferences (reflection effect); (3) most people usually judge gain and loss according to reference point (reference dependent); (4) most people are more sensitive to loss than gain (loss effect). These conclusions are reflected in people's life, and people tend to follow the above rules in the face of decision making.

The utility function and the subjective probability function in classic utility theory are replaced with the value function and the decision weight function respectively. The value function related to reference point reflects decision-maker subjective feelings towards objective value. The decision weight function, representing people's subjective evaluation towards objective probability, reflects the influence of probability on prospect value. Prospect theory can reasonably explain practical phenomenon (see, e.g. Hjorth and Fosgerau, 2012) and reflect real scene. Characteristics of prospect theory are also concerned (see, e.g. Zeisberger et al., 2012). Prospect theory currently is applied into the fields of economy, accounting and market decision behaviour researches (see, e.g. Li et al., 2012).

## 3. Description of Dynamic Route Choice Problem Based on Prospect Theory

Symbols related to the problem of dynamic route choice based on prospect are given below:

- $L_i = \{l_{i1}, l_{i2}, \dots, l_{in}\}$ : feasible route set when traveller at intersection  $i$ , in which  $l_{ij}$  is route  $j$  in the set  $L_i$ ,  $j = 1, 2, 3 \dots n$ ;
- $l_{ij} = \{d_{ij1}, d_{ij2}, \dots, d_{ijz}\}$ : road sections set of route  $l_{ij}$ , that is, route  $l_{ij}$  is composed of road sections sequence  $d_{ij1}, d_{ij2}, \dots, d_{ijz}$ , in which  $d_{ijq}$  is road section  $q$  of route  $l_{ij}$ ,  $q = 1, 2, 3 \dots z$ ;

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