COMMUTER ARRIVAL TIME VALUE FUNCTION IN URBAN RAIL TRANSIT

Yan Cheng, Corresponding Author
Key Laboratory of Road and Traffic Engineering of Ministry of Education, Tongji University
4800 Cao'an Road, Jiading District, Shanghai, P.R. China, Post Code 201804
Tel: (86)021-69583757; Email: patty_1234@126.com

Xiafei Ye
Key Laboratory of Road and Traffic Engineering of Ministry of Education, Tongji University
4800 Cao'an Road, Jiading District, Shanghai, P.R. China, Post Code 201804
Tel: (86)021-69589875 Fax: (86)021-69583712; Email: yxf@tongji.edu.cn

Zhi Wang
Key Laboratory of Road and Traffic Engineering of Ministry of Education, Tongji University
4800 Cao'an Road, Jiading District, Shanghai, P.R. China, Post Code 201804
Tel: (86)021-69585031; Email: zhiwang@tongji.edu.cn

Word Count: 4,492 words text + 7 tables/figures x 250 words (each) = 6,242 words

Number of References 27
Number of Figures 3
Number of Tables 4

Submission Date: 7/31/2017

ABSTRACT

The passenger distribution of urban mass transit network is influenced by two kinds of choice, route choice and departure time choice. However, the latter choice has been ignored for a long time. For commuters with specified destination arrival time, the departure time choice is actually a trade-off between the perceived crowdedness and arrival time value. To obtain a better understanding of the influencing factors and mechanism of commuter arrival time value, the paper tries to introduce the value function of prospect theory. Several reference point alternatives are discussed and parameters are estimated with the empirical data from Shanghai, China. Results show that commuters show asymmetrical response to gains and losses, being more sensitive to the latter one, which is consistent with prospect theory. The time when a commuter starts to consider departing later and work/school start time are two reference points of arrival time value function in urban mass transit, and commuters are reluctant to switch their departure time even when they arrive at reference points. The optimal simplified value function fits the data well and hits as much as 86.45% of the sample.

Keywords: Urban Rail Transit, Departure Time Choice, Arrival Time Value, Prospect Theory, Value Function, Reference Point

INTRODUCTION

Thanks to its speediness, punctuality and large capacity, urban rail transit is becoming the backbone of many cities' transportation. Especially during morning and evening peak, it undertakes a large number of middle- and long- distance trips of commuters. However, overcrowding has become the common problem for these cities at the same time. For example, the proportion of crowded sections within Shanghai Metro Network in China during peak hour is 15.19%, and the most crowded section's demand-capacity ratio is as high as 1.67. To alleviate this situation, efforts should not only be put to enhance capacity from the supply side. From the demand side, dynamic passenger distribution needs to be clearer. The passenger flow of each section within the network is accumulated by the passengers departing at various moments with diverse routes. So the passenger distribution is influenced by two kinds of choice, route choice and departure time choice. However, commuter departure time choice has been ignored by most of previous studies (*1-3*) or assumed to be given (*4-6*).

Departure time choice was focused in road traffic since the 1980s. Its core issue is to establish the relation between the time uncertainty caused by congestion and commuter arrival time value, both in econometric modeling (*7-10*) and dynamic user equilibrium analysis fields (*11-13*). But in urban rail transit, with the increase of passengers, the travel time of trains doesn't change. Instead, it leads to the aggravation of in-vehicle crowdedness and the extension of time for passengers to board and alight. Thus, what affects commuter departure time choice in urban rail transit is no longer time uncertainty. It is the additional psychological pressure caused by in-vehicle crowdedness that really works. The other essential factor in the choice of departure time is arrival time value, which is also known as schedule delay penalty. With switching departure time, passengers will experience different in-vehicle crowdedness and arrival times. The departure time choice of commuters with a definite work start time is actually a trade-off between the perceived crowdedness and arrival time value.

Over the past decades, research efforts in urban rail transit have gradually placed emphasis on departure time choice behavior of passengers for overcrowding reduction. Tian and Huang (*14*) regarded that crowding cost and early arrival penalty are compared by passengers when they choose trains. However, this study only gave a conceptual description about early arrival penalty, without a certain function. Both early arrival and late arrival penalties are considered in the model proposed by Tian et al. (*15*). Schedule delay penalties are expressed as linear functions and assumed to be proportional to the difference between actual arrival time and work start time. The linear function form was also used in the subway commuter departure time choice model proposed by Wu and Huang (*16*). Nevertheless, the values of parameters in actual network haven't been estimated by any one of them. Harada et al. (*17*), Iwakura and Harada (*18*) developed a departure time choice model for commuter trips in Tokyo metropolitan area. The utility function of Logit model took the time earlier than work start time as one variable. Estimation result showed its parameter is negative. Ieda et al. (*19*) proposed that commuter arrival time choice behavior is affected by late arrival penalty. It is assumed to be a non-linear function of the difference between the actual arrival time and work start time. Late arrival penalty increases with the difference, while the rate of its growth decreases gradually. Soyama et al. (*20*) divided the value of arrival time into two parts, deviation penalty and late arrival penalty. The former one is assumed to be a quadratic function of the difference between the actual arrival time and the preferred arrival time, while the latter one is a quadratic function of the difference between the actual arrival time and work start time.

In the researches mentioned above, most of them assumed that arrival time value is a linear function of the difference between commuter actual time and their work start time. Only a little study considered the preferred arrival time as a reference point, but the function form was still predetermined. Although these works provide valuable insights into commuter departure time choice, they do not identify the commuter's asymmetrical response to gains and losses arising from his/her actual arrival time relative to reference points they may have. And the determination of reference point still needs more discussion.

Prospect theory was proposed by Kahneman and Tversky (*21*) in 1979 based on the assumption that people are "bounded rational" (*22*) instead of "complete rational", owning to their limited cognitive ability, inferential capability and information acquisition. According to the theory, a commuter is assumed to maintain the same choice as long as his/her actual schedule delay is contained in the indifference band. Otherwise, the commuter will adjust the departure time through some procedures. Moreover, the commuter reacts asymmetrically to gains and losses. The commuter exhibits risk aversion for gains and risk seeking for losses. Thus, the value function is normally concave for gains, commonly convex for losses. The theory has been already introduced to commuter departure time choice in road traffic. The study by Chang and Mahmassani (*23*) has confirmed that the indifference band of tolerable schedule delay is the most important criterion governing the day-to-day responses of commuters to congestion. Jou and Kitamura (*24*) developed a four-segmented value functions with the earliest arrival time, the preferred arrival time, and the work start time for a given commuter as reference points. Using the maximum likelihood method. Jou et al. (*25*) estimated the value model with the survey data of auto commuter departure time decision. Limited to the tool, the value function is simplified to a linear form. Results indicated that the commuter behavior is consistent with the theoretical postulates of prospect theory. However, it cannot examine the concavity and convexity of the function. Senbil and Kitamura (*26*) proposed two decision frames that comply with the prospect theoretic propositions. The empirical results suggest that prospect theory is applicable in commuter departure time choice. The value function is convex for losses and concave for gains.

Although the mechanisms of commuter departure time choice in road traffic and urban rail transit are similar, the trade-off element is totally different, which is time uncertainty in road traffic but in-vehicle crowdedness in urban rail transit. Since there is no related research on commuter arrival time value function in urban rail transit, this paper aims at examining the applicability of the value function of prospect theory to the commuter departure time decision-making and discussing the decision frame and reference points of value functions with empirical data.

The remainder of the study is organized as follows. Section 2 briefly introduces the characteristics of value function of prospect theory and proposed a decision frame as well as several alternative reference points. Section 3 analyzes the survey data of Shanghai Metro commuters. The relations among alternative reference points are also discussed in this part. Section 4 estimates the models with different reference points and examines whether the arrival time value functions are in accordance with prospect theory. Section 5 provides conclusions.

METHODOLOGY

The value function of prospect theory is used to evaluate each possible result, reflecting the subjective value of different results. It is assumed to be a random function due to the cognitive limitation of commuters. The properties of the value function are summarized as follows:

1. Defined on the deviation from the reference point;
2. Generally concave for gains and convex for losses;
3. Steeper for losses than for gains.

Property 1 shows that the value function focuses on the magnitude of change from reference points, so the selection of reference points is critical. On the other hand, the mathematical form of the value function should comply with Properties 2 and 3.

Reference Points

In the value function, the reference points are divided into two categories, zero-value position and extreme-value position. A commuter experiences the maximum gain when his/her arrival time is in the extreme-value position, the corresponding moment of which is defined as the preferred arrival time (t_P). A commuter is assumed to maintain the same choice as long as his/her actual schedule delay is contained in the indifference band according to prospect theory. The demarcation points of the indifference band are defined as zero-value positions. When a commuter arrives at these moments, there is neither gain nor loss. The lower limit position is called the demarcation point of too-early arrival (t_E), when the upper limit position is called the demarcation point of too-late arrival (t_L). Most of studies regard the acceptable earliest arrival time (t_{e1}) as t_E and work start time (t_w) as t_L (*24-26*) . In view of that more commuters are allowed to be later than work start time, the acceptable latest arrival time (t_{l1}) is introduced as an alternative to t_L. Based on the concept of indifference points, this paper adds the time when a commuter starts to consider departing later (t_{e2}) and the time when a commuter starts to consider departing earlier (t_{l2}) as alternatives to t_E and t_L, respectively.

The Proposed Decision Frame

This decision frame has been developed by Jou and Kitamura (*24*). The demarcation points of too-early and too-late arrival are reference points, and the preferred arrival time is a “pseudo” reference point. A gain occurs when the commuter arrival time is within the range of two reference points (segments II and III), similarly, a loss occurs when the commuter experiences an arrival time which is beyond this range (segments I and IV). When a commuter arrives at reference points, then the net value is zero. When his/her actual arrival time is the preferred arrival time, the value reaches the maximum (Figure 1).

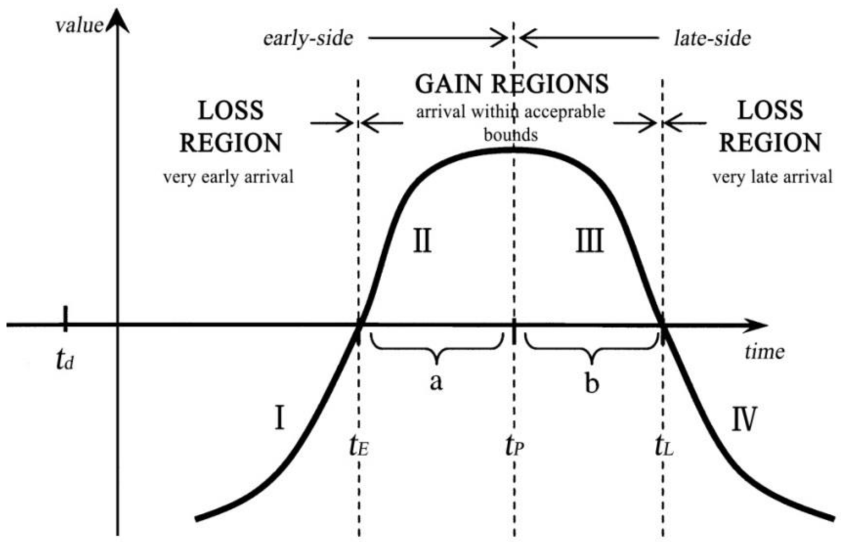


FIGURE 1 Arrival time value function.

An arrival is defined as an early-side arrival if $t_a < t_P$; and is defined as a late-side arrival if $t_a > t_P$. The reference point for an early-side arrival is t_E, and for a late-side arrival is t_L. The segmented value function can be written as

$$V(t_a)=\begin{cases}\beta_1(t_E-t_a)^{\alpha_1}+\varepsilon_e^L & (t_d < t_a \le t_E)\\ \beta_2(t_a-t_E)^{\alpha_2}+\varepsilon_e^G & (t_E < t_a \le t_P)\\ \beta_3(t_L-t_a)^{\alpha_3}+\varepsilon_l^G & (t_P < t_a < t_L)\\ \beta_4(t_a-t_L)^{\alpha_4}+\varepsilon_l^L & (t_a \ge t_L)\end{cases} \quad (1)$$

where t_d =departure time; t_a =actual arrival time; t_P =preferred arrival time; t_E = the demarcation time of too-early arrival, with the acceptable earliest arrival time (t_{e1}) and the time when a commuter starts to consider departing later (t_{e2}) as alternatives; t_L = the demarcation time of too-late arrival, with work start time(t_w), the acceptable latest arrival time (t_{l1}) and the time when a commuter starts to consider departing earlier (t_{l2}) as alternatives. The subscripts *e* and *l* represent early-side and late-side, respectively, and the superscripts *G* and *L* represent gain (*V*>0) and loss (*V*≤0), respectively. The error terms are assumed to be normally distributed with zero means and heteroskedastic variances. Parameters $\beta_i (i=1,2,3,4)$ are weights which represent the importance of gains or losses to that commuter. β_2 and β_3 should take on positive values, and β_1 and β_4 should take on negative values. Parameters $\alpha_i (i=1,2,3,4)$ represent the rate of change in gain or loss to that commuter. If the value function is symmetrical, it implies that a=b and t_P is the midpoint of t_E and t_L.Then the value function can be simplified into two regions. At this time, $\beta_1=\beta_4$, α_1

$=\alpha_4$,and similarly, $\beta_2=\beta_3$, $\alpha_2=\alpha_3$. Otherwise, each parameter needs to be estimated respectively.

Estimation

The parameters are estimated by applying the binary probit model (*27*). The probability of switching departure time is expressed as a function of arrival time value. An important assumption of this paper is that a commuter is reluctant to switch his/her departure time, so the utility of the binary probit model not only includes arrival time value, but also includes a reluctance factor.

A commuter will maintain his/her departure time when the utility is greater than zero, and the commuter will switch the departure time when the utility is negative. So the probability of these choices can be written in equation (2) and (3)

$$p(NS)=p(d=1)=p(U(t_a)>0) \tag{2}$$

$$p(S)=p(d=0)=p(U(t_a)<0) \tag{3}$$

where $p(NS)$ =probability of not switching departure time; $p(S)$ = probability of switching departure time; $d=1$if the commuter maintain his/her departure time, and $d=0$,otherwise. The utility of the probit function is given in equation (4)

$$U(t_a)=\begin{cases}\gamma_1+\beta_1(t_E-t_a)^{\alpha_1}+\varepsilon_e^L & (t_d<t_a\le t_E)\\ \gamma_1+\beta_2(t_a-t_E)^{\alpha_2}+\varepsilon_e^G & (t_E<t_a\le t_P)\\ \gamma_2+\beta_3(t_L-t_a)^{\alpha_3}+\varepsilon_l^G & (t_P<t_a<t_L)\\ \gamma_2+\beta_4(t_a-t_L)^{\alpha_4}+\varepsilon_l^L & (t_a\ge t_L)\end{cases} \tag{4}$$

where γ_1 =reluctance factor for early-side arrival; γ_2 = reluctance factor for late-side arrival.

DATA ANALYSIS

Data Source

A survey was conducted to collect data on urban mass transit commuters' departure time choice for morning commutes from June 27th to July 18th, 2017 in Shanghai, China. 1400 questionnaire was mailed to commuters randomly, and 596 of them are valid (valid rate =42.8%). 470 commuters traveled by metro to go to work or school in the first trip on the latest weekday. The survey consists of four parts:

1. socioeconomic properties, including gender, age and job;
2. travel information, including the frequency and time period of travel by metro in one week, the aim of the first trip taking metro on the latest weekday;
3. departure time choice information, including specified destination arrival time(work/school start time), the acceptable earliest and latest arrival time, preferred arrival time and the time when he/she starts to consider departing later or earlier;
4. intention for departure time switching, including the actual arrival time of the latest weekday and whether he/she would switch the departure time next weekday.

Socioeconomic and Travel Characteristics

The socioeconomic and travel characteristics of the sample are summarized in Table 1. Most of respondents are female (56.38%), and are aged between 18 and 40 years old (88.51%). 91.91% of commuters in the sample travel by metro more than 3 times in one week, which proving that they are familiar to Shanghai Metro network. Their aims of the first metro trip on the latest weekday are mostly going to work (97.66%).

TABLE 1 Commuters' Socioeconomic and Travel Characteristics

Variable		Number of cases	Proportion(%)
Gender	Male	205	43.62
	Female	265	56.38
Age	< 18	7	1.49
	18 -40	416	88.51
	41-60	46	9.79
	> 61	1	0.21
The frequency of travelling by	1-2	38	8.09
metro in one week	⩾3	432	91.91
The time period of travelling by	Only weekdays	124	26.38
metro in one week	Weekdays and weekends	346	73.62
The aim of the first metro trip on	Go to work	459	97.66
the latest weekday	Go to School	11	2.34

Departure Time Choice

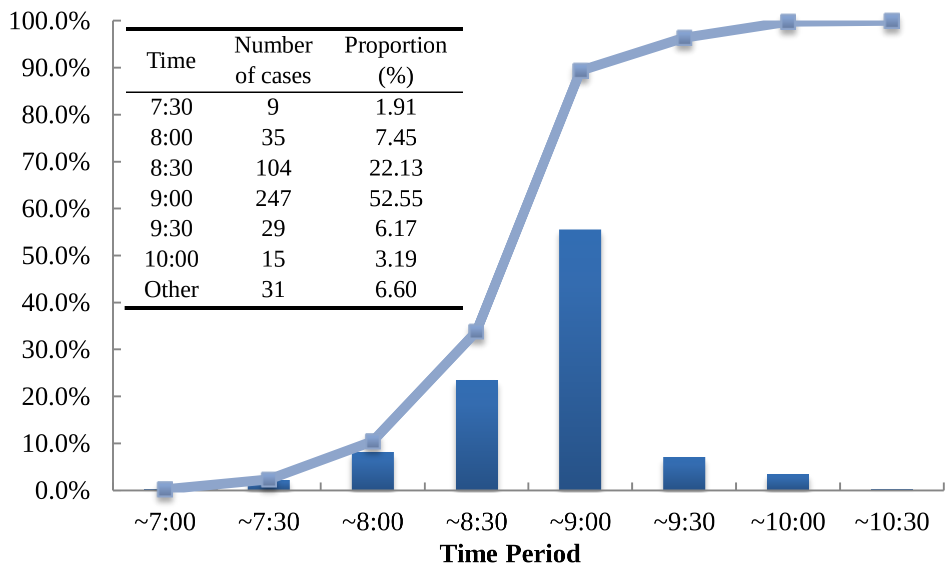


FIGURE 2 The distribution of commuters' work/school start time.

As shown in Figure 2, 94.09% of respondents indicate their work/school start time is during 7:30-9:30am. Most of commuters start work or school at 9:00am (55.55%), followed by 8:30am (22.13%). Since commuters' first trips on weekdays are during morning peak period, 6:00am is taken as the origin moment. Other moments are represented by relative time according to this origin moment in Table 2.

TABLE 2 Key Points of Commuters' Departure Time Choice

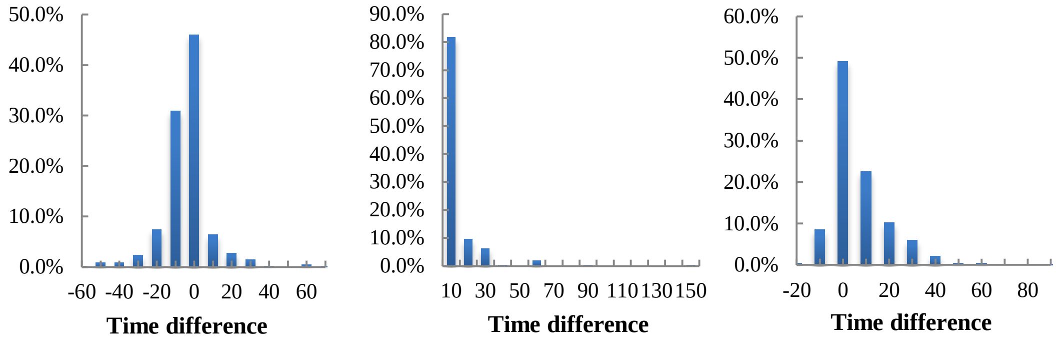
	Mean	Minimum	Maximum	Std. deviation
Work/school start time (t_w)	169.38	60.00	270.00	28.70
The acceptable earliest arrival time (t_{e1})	145.47	30.00	235.00	32.75
The acceptable latest arrival time (t_{l1})	177.75	60.00	330.00	32.87
Preferred arrival time (t_P)	159.16	55.00	240.00	29.80
The time when a commuter starts to consider departing later(t_{e2})	139.86	30.00	230.00	32.26
The time when a commuter starts to consider departing earlier(t_{l2})	173.73	70.00	280.00	32.18
The deviation relative to work/school start time				
$t_w - t_{e1}$	23.91	5.00	150.00	15.18
$t_{l1} - t_w$	8.37	0.00	150.00	13.31
$t_w - t_P$	10.22	0.00	50.00	6.39
$t_w - t_{e2}$	29.53	5.00	120.00	14.42
$t_{l2} - t_w$	4.34	-20.00	90.00	12.88

* min

The average work/school start time of the sample is 169.38min (8:49am), with a standard deviation of 28.70min. The average acceptable earliest arrival time is 23.91min earlier than work/school start time, while the average preferred arrival time is 10.22min earlier than work/school start time. 285 respondents (60.64%) are allowed to be late for work, and the average acceptable latest arrival time is 8.37min later than work/school start time. So tardiness should be considered in the modelling of departure time choice modeling as well as arrival time value function. The average time when a commuter starts to consider departing later is earlier than the average acceptable earliest arrival time. 88.51% of respondents start to consider departing later only when time is not later than their acceptable earliest time. On the other hand, 370 respondents (78.72%) start to consider departing earlier when time is still earlier than their acceptable latest arrival time, which means that most of commuters tend to be more cautious when they are likely to be late.

Reference Points Analysis

For the demarcation point of too-early arrival (t_E), the difference of two alternatives is shown in Figure 3(a). The difference of 92.13% respondents is within -20 to 20. For the demarcation point of too-late arrival (t_P), the difference of the other two alternatives relative to work/school start time is shown in Figure 3(b) (c). The difference between the acceptable latest time and work/school start time of 91.28% respondents is within 0 to 20, while the difference between the time when a commuter starts to consider departing earlier and work/school start time of 93.19% respondents is within -20 to 20.



(a) $t_{e1} - t_{e2}$ (b) $t_{l1} - t_w$ (c) $t_{l2} - t_w$

FIGURE 3 The difference distributions between reference point alternatives.

TABLE 3 The Distribution of Commuters' Actual Arrival Times

t_E	**Region Ⅰ** $t_d < t_a \le t_E$	**Region Ⅱ** $t_E < t_a \le t_P$	t_L	**Region Ⅲ** $t_P < t_a < t_L$	**Region Ⅳ** $t_a \ge t_L$
t_{e1}	82 (17.45%)	210 (44.68%)	t_w	100 (21.28%)	78 (16.60%)
t_{e2}	33 (7.02%)	259 (55.11%)	t_{l1}	138 (29.36%)	40 (8.51%)
			t_{l2}	133 (28.30%)	45 (9.57%)

For 90.64% of commuters, the absolute difference between actual arrival time and preferred arrival time is no more than 20min. Most of commuters (45.53%) arrive before their preferred arrival time, while 37.87% of commuters' actual arrival time is later. The rest of commuters' arrival time is just their preferred arrival time (16.60%). Table 3 reveals that no matter which alternative is selected as a reference point, and most of commuters (65.96%-83.40%) have a gain because their actual arrival time is within region II and III. Commuters with actual arrival time in region II are more than those with arrival time in region III. The ratio of these two parts is from 1.52 to 2.59.

Because the majority of commuters have a gain, so they are less likely to switch their departure times. 391 respondents indicate that they would keep the same departure time in the next weekday (83.19%). Only 79 respondents choose to switch their departure time (16.81%), which is much less than the number of commuters experiencing a loss in arrival time value except when $t_E = t_{e2}$ and $t_L = t_{l1}$ or t_{l2}. This situation supports the existence of reluctance to switch departure time.

MODEL ESTIMATION RESULTS

To eliminate the impact of outliers, a box diagram of the difference between actual arrival time and preferred arrival time is depicted. 428 respondents are left with a difference less than 25min. There are 12 utility functions to be estimated, the main differences among which are whether the value function included is symmetrical and reference point combinations. Because the functions are non-linear segmented functions, if a logarithmic transformation is adopted, the assumption of normally-distributed error terms is broken, and then the estimation method is no longer valid. Therefore, the functions are simplified to a linear form by setting α_1, α_2, α_3 and α_4 equal to 1.

TABLE 4 Estimation Result of Value Function

	Reference points t_E	Reference points t_L	Hit rate (%)	DuMouchel index*	Significance	Region	Parameter	Value	t-stat	Region Hit rate (%)
							γ_1, γ_2	0.979	8.257	
A	t_{e1}	t_w	85.83	0.6789	0.000	Gain	β_2, β_3	0.028	2.161	88.27
						Loss	β_1, β_4	-0.079	-2.976	73.33
							γ_1, γ_2	0.941	7.515	
B	t_{e2}	t_w	86.45	0.6794	0.000	Gain	β_2, β_3	0.023	2.387	87.82
						Loss	β_1, β_4	-0.083	-3.209	73.68

*DuMouchel index =exp(LogLikelihood/*N*). Higher index value indicates better fit to the data.

A segmented function is identified as passing t-test only when the parameters of each part pass t-test. Unfortunately, none of asymmetrical functions passes t-test. Table 4 shows the estimation result of two symmetrical functions. The reluctance factor is significant in all functions, so the assumption of its existence is acceptable. That is to say, when a commuter arrives at his/her perceived reference points, the commuter would not switch the departure time next time. Their actual indifference points is earlier than t_E and later than t_L. The time difference between actual indifference points and reference points is equal to the ratio of γ_1, γ_2 and β_1, β_4, which is 12.39min in Function A and 11.34min in Function B. Function B shows better fit to the data both in gain and loss regions, and its DuMouchel index is higher. Its hit rate reaches 86.45%, and fits better in gain region. This function's reference points are the time when a commuter starts to consider departing later and work/school start time. The parameter β_2 and β_3 are positive, while β_1 and β_4 are negative. Moreover, the absolute values of β_1 and β_4 are larger than β_2 and β_3, which means commuters are more sensitive to losses than gains. Both the signs and the relation of parameters are consistent with prospect theory.

CONCLUSIONS

The paper discusses the applicability of the value function of prospect theory in urban mass transit commuter departure time choice. The proposed decision frame consists of two region, gain and loss. Each region contains two sides, early-side and late-side. On this basis, several alternatives of reference points are analyzed. The empirical study of commuters from Shanghai, China shows that most of passengers' arrival time is in gain region. Commuters are more cautious when they tend to face late-side losses than early-side losses.

The existence of reluctance factor is assumed in this paper, which means the utility of switching departure time model not only consists of arrival time value. Estimation results show that this assumption is acceptable. And arrival time value functions are consistent with prospect theory. Commuters are more sensitive to losses than gains. Within all the models passing t-test, the optimal one has a hit rate of 86.45%, with a better hit rate in gain region than in loss region.

REFERENCES

1. X. Wu and C. Liu. Traffic Equilibrium Assignment Model Specially for Urban Railway Network. *Journal of Tongji University (Natural Science)*, No. 09, 2004, pp. 1158-1162.
2. J. Liu. Transfer-based Urban Rail Transit Flow Distribution Modeling and Empirical Study, Beijing Jiaotong University, 2012.
3. Y. Huang. Research on Urban Rail Transit Passenger Flow Assignment Model and Algorithm, Beijing Jiaotong University, 2010.
4. Poon, M. H., S. C. Wong and C. O. Tong. A dynamic schedule-based model for congested transit networks. *Transportation Research Part B: Methodological*, Vol.38, No.4, 2004, pp. 343-368.
5. X. Liu. Research on the Dynamic Flow Assignment Model Based on Train Schedule for Urban Subway Network, Chang'an University, 2013.
6. D. Yang. Research on Schedule-based Rail Transit Passenger Flow Assignment, Beijing Jiaotong University, 2013.
7. Abkowitz, M. D. The impact of service reliability on work travel behavior, Massachusetts Institute of Technology. Cambridge, 1979.
8. Hendrickson, C. and G. Kocur. Schedule Delay and Departure Time Decisions in a Deterministic Model. *Transportation Science*, Vol.15, No.1, 1981, pp. 62-77.
9. Small, K. A. The Scheduling of Consumer Activities: Work Trips. *The American Economic Review*, Vol.72, No.3, 1982, pp. 467-479.
10. Hendrickson, C. and E. Plank. The flexibility of departure times for work trips. *Transportation Research Part A: General*, Vol.18, No.1, 1984, pp. 25-36.
11. De Palma, A., M. Ben-Akiva, C. Lefevre and N. Litinas. Stochastic Equilibrium Model of Peak Period Traffic Congestion. *Transportation Science*, Vol.17, No.4, 1983, pp. 430-453.
12. Mahmassani, H. and R. Herman. Dynamic User Equilibrium Departure Time and Route Choice on Idealized Traffic Arterials. *Transportation Science*, Vol.18, No.4, 1984, pp. 362-384.
13. Mahmassani, H. S. and G. Chang. Experiments with departure time choice dynamics of urban commuters. *Transportation Research Part B: Methodological*, Vol.20, No.4, 1986, pp. 297-320.
14. Q. Tian and H. Huang. An Equilibrium Ride Model for Subway Passengers with Arrival Early Penalty. *Journal of Transportation systems Engineering and Information Technology*, No. 04, 2004, pp. 108-112.
15. Tian, Q., H. Huang and H. Yang. Equilibrium properties of the morning peak-period commuting in a many-to-one mass transit system. *Transportation Research Part B: Methodological*, Vol.41, No.6, 2007, pp. 616-631.
16. W. Wu and H. Huang. Model of Subway Commuters' Departure Time Choice with In-Carriage Congestion and Arrival Early/Late Penalty. No. 01, 2009, pp. 128-132.
17. C. Harada, S. Iwakura and S. Morichi. Analysis and Modeling of Commuters' Departure Time in Urban Railway Network. *Proceedings of infrastructure*

planning, Vol. 26, No.2002.

18. S. Iwakura and C. Harada. A Model System of Departure Time Choice for Commuter Trips by Metropolitan Railway. *Transport policy studies' review*, Vol. 8, No. 3, 2005, pp. 4-15.
19. H. Ieda, K. Tsuchiya, L. B. Phan and T. Okamura. Development of the commuter demand concertration model based on a time-space network scheme. *Journal of Japan Society of Civil Engineers*, No. 702, 2002, pp. 65-79.
20. Y. Soyama, Y. Kaneko and H. Kato. Departure Time Choice under the Condition of Daily Service Delay in Urban Railway. *Proceedings of infrastructure planning*, Vol. 41, 2010.
21. Kahneman, D. and A. Tversky. Prospect Theory: An Analysis of Decision under Risk. *Econometrica*, Vol.47, No.2, 1979, pp. 263-291.
22. Simon, H. A. A Behavioral Model of Rational Choice. *The Quarterly Journal of Economics*, Vol.69, No.1, 1955, pp. 99-118.
23. Chang, G. and H. S. Mahmassani. The Dynamics of Commuting Decision Behaviour In Urban Transportation Networks. Travel Behavior Research. 5th International Conference on Travel Behavior. *Publication of: Gower Publishing Company Limited*, 1989.
24. Jou, R. and K. Ryuichi. Commuter Departure Time Choice: A Reference Point Approach. Bari, 2002.
25. Jou, R., R. Kitamura, M. Weng and C. Chen. Dynamic commuter departure time choice under uncertainty. *Transportation Research Part A: Policy and Practice*, Vol.42, No.5, 2008, pp. 774-783.
26. Senbil, M. and R. Kitamura. Reference Points in Commuter Departure Time Choice: A Prospect Theoretic Test of Alternative Decision Frames. *Journal of Intelligent Transportation Systems*, Vol.8, No.1, 2004, pp. 19-31.
27. Ben-Akiva, M. E. and S. R. Lerman.*Discrete choice analysis: theory and application to travel demand*, MIT press, 1985.