Modal Choice after Opening New Railway in Bangkok - Case of Dark Red Line –

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Abstract

Although urban road traffic studies have been conducted extensively in Bangkok, the survey of demand elasticity for service levels such as travel time, fare, and frequency of the urban rail transit has not been insufficiently carried out and understood. Thus, it is impossible to estimate the number of railway passengers accurately and set the service levels for the urban railways currently being developed. Therefore, it is strongly required to clarify the influence of service levels on railway demand. For that purpose, we conducted a stated preference survey along the Dark Red Line (DRL) that is scheduled to open later this year. We estimated a discrete modal choice model and examined the choice preference concerning fare, travel time, and frequency. The survey was conducted in the vicinity of DRL stations, namely Rangsit and Thammasat University stations. Among the 243 samples collected, 174 are valid and completed. A multinomial logit (MNL) model was estimated where the likelihood-ratio and hit-ratio are satisfied. The results revealed that shorter travel time and more comfortable access transportation are significantly preferable. On the other hand, variation in fare level did not have a significant effect on mode choice.

Keywords: Multinomial Logit Model, Dark Red Line (DRL), Service Level, Urban Railway

1. Introduction

Many cities in developing countries face severe traffic problems due to traffic congestion resulting in significant delays, substantial economic losses, and environmental degradation [1-2]. These problems are caused by unorganized urban growth, high levels of suburbanization, rapid motorization, and low quality of public transportation [3-5]. Therefore, the improvement of public transport is expected to alleviate these problems; however, it is not easy. In Bangkok, the development of an urban railway system started in 1999. Due to urbanization and rapidly increasing urban population, a master plan for urban railway network has been proposed and revised from time to time. Then, a draft revision of the M-MAP (Mass Rapid transit Master Plan in the Bangkok Metropolitan Region) was proposed in 2019; [6]. To efficiently update the master plan, it is necessary to discuss the service level of the urban railway system based on elasticity for the railway service such as fare, travel time, frequency, etc.

However, so far, the railway system's service elasticities have never been measured in the travel survey in Bangkok. This is because the share of urban rail transport in Bangkok is significantly lower than in other modes [6]. As a result, it was difficult to estimate the impact of railway service levels in the demand forecasting process. This makes it very difficult to accurately assess the diversion of demand from the other modes of transport to the railway.

The objective of this study is to examine the impacts of service level for the preference of urban railway by estimating a multinomial logit (MNL) model that includes service level of urban railway based on stated preference (SP) survey data. The case study is the Dark Red Line (DRL), which is being developed in Bangkok according to its 'M-MAP' railway master plan, and the first phase is expected to open in 2021. The train will be running in the north-south direction, namely between Bang Sue and Rangsit areas. It is likely that commuters and students in north districts, including Thammasat University, will be using.

The remainder of the paper is organized as follows. The literature review will be presented in Section 2. The SP survey and MNL model will be described in Section 3. The estimation results will be presented in Section 4 with some discussion and application. The elasticity of service level will be presented in Section 5. Finally, Section 6 concludes the paper.

2. Discrete Choice Analysis in Public Transportation Studies

Many studies discussed the understanding of the traveler's attitude and preference based on the SP survey. The impacts of new public transportation systems in Southeast Asian Cities were estimated by developing discrete choice models, e.g., Binary logit, Multinomial logit and, Nested Logit model, based on the collected survey data from conducting an SP survey; [7-11]. In particular, some of the studies tried to understand each parameter's influence, such as travel time, travel cost, etc., on commuting trips; [12-16]. Moreover, some studies analyzed the elasticity of travel time and travel costs concerning various policies, such as reducing travel time and determining a fare structure for the new transit system; [17-19]. Furthermore, some studies evaluated scenarios: promotion of usage of new public transit such as Park & Ride, determination of parking fee for passenger car or motorcycle. These studies calculated the change in a modal split when increasing or decreasing the travel time and travel cost. They conducted a preliminary survey on the rail and other modal choice behavior in Bangkok to forecast the railway demand; [6,20-22].

It should be noted that the demand forecast in those studies was done by a comprehensive model where the impact of significant factors such as waiting time and transfer time was not addressed. These studies employed a discrete choice model to examine people's attitudes and preferences to use public transport and measured the effectiveness of policies. However, it was not relevant to understand the service level and its elasticity of the new public transportation (e.g., urban railway and Bus Rapid Transit, etc.). Therefore, the present study focuses on understanding people's preferences and behavior concerning changing the service level. A multinomial logit model is estimated based on the SP survey data. Besides, the elasticity of railway preference to changing service levels such as travel time, travel cost, waiting time, etc. will be presented.

3. The Case Study

3.1 SRT Dark Red Line (DRL)

Residents in the Rangsit area, including students and commuters in Thammasat University district, are having difficulty traveling from/to the city center due to traffic congestion and delay, as shown in Table 1; [23-27]. They are traveling by passenger cars, buses, or van up to Victory Monument station or Mo chit station. They have to transfer into the other modes: BTS Sukhumvit Line, MRT Blue Line, and local buses to reach their destination, illustrated in Figure. 1. According to the M-MAP railway master plan, the Dark Red Line (DRL) has been proposed, currently under construction and scheduled to open in 2021 from Bang Sue to Rangsit, and extended its service to Thammasart University in 2022. The railway is an elevated structure built on the premises of the State Railway of Thailand. Moreover, it is being considered to extend about 51 km to the north of Thammasart University. DRL will hopefully not only help daily commuters or students to access from/to the city center of Bangkok but also allow travelers to connect to the Don Mueang International Airport. In this study, the attributes of the presently available travel mode choices between Asok and Thammasat University and between Asok and Rangsit are shown in Table 1. DRL is expected to save travel time, waiting time, and travel costs.

Table 1 Attributes of the present travel modes

(Source: BTS HP, MRT HP, Transit Bangkok HP)

	Mode	Travel Time (min)	Travel Cost (THB)	Waiting and Trasfer Time (min)
Asok-Thammasat				
	Car	80	170	0
Transfer at Victory Monument	Bus+BTS	97	65	16
	Van+BTS	63	88	11
Transfer at Mo Chit	Bus+Bus	94	69	15
	Van+BTS	56	82	10
	Bus+MRT	89	60	18
	Van+MRT	51	73	13
Asok-Rangsit				
	Car	68	150	0
Transfer at Victory Monument	Bus+BTS	75	55	16
	Van+BTS	48	80	11
Transfer at Mo Chit	Bus+BTS	72	59	15
	Van+BTS	49	74	10
	Bus+MRT	67	50	18
	Van+MRT	44	65	13

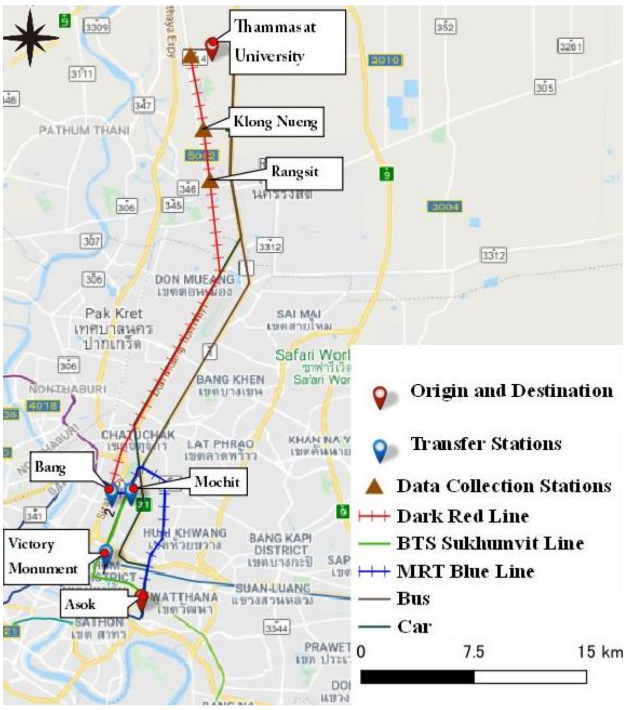

Fig.1 The Study Area

3.2 Questionnaire Design

This study employed a Stated Preference (SP) survey to consider the attribute of DRL that influences the commuter's modal choice decision. The characteristics of each mode include:

1. Travel Time, travel cost of a passenger car to reach the Asok
2. Travel Time, travel cost, waiting time of bus and bus transfer at Victory monument, and Mochit to reach the Asok
3. Travel Time, travel cost, waiting time of Van and Van transfer at Victory monument and Mochit to arrive the Asok
4. Travel Time, travel cost, waiting time of the train, and train transfer at Victory monument and Mochit to reach the Asok

In addition to the SP questions, we also asked for the other information, such as available alternative modes, the reason for choosing the mode, fare information, and personal information. These additional data were useful in the analysis of SP data and explanation of the behavioral responses.

3.3 Stated Preference (SP) Survey

The SP survey was conducted during December 2019 and January 2020 on a weekday by interviewing respondents at three locations around the two envisaged stations (Klong Nueng Station and Rangsit Station) and Thammasat University. The positions are shown in Fig. 1. We selected and conducted this area and weekday to examine the preference of commuters or students. The respondents were asked to choose among four alternative modes: Bus, Van, Passenger Car, and Train. In this study, we assumed there is no modal change between the first and second modes. Therefore, the travel choices are the passenger car, Bus-Bus, Van-Van, and Train-Train in the SP experiment. Among the 250 samples, 174 samples of them are valid. Fig. 2 shows the survey result of the Revealed Preference part. From this result, half of the respondents chose train (MRT Blue Line) as a primary mode of commuting and going to school.

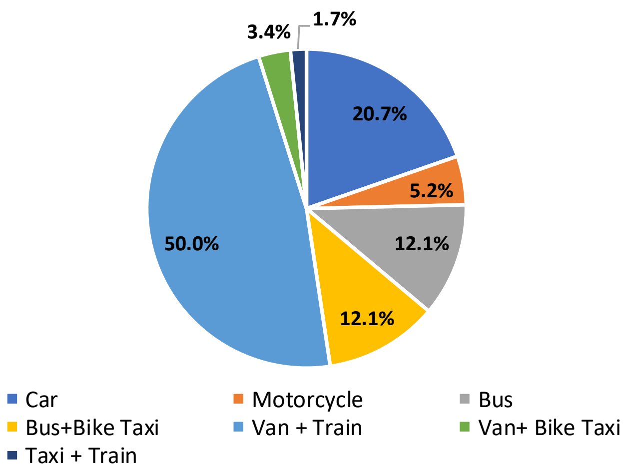

Fig.2 Modal Split from the Revealed Preference Survey

Table 2 presents the distribution of individual and household monthly income, Occupation, Age, Gender for each traveler group. Most of the passenger car users have a high salary. Moreover, 80% of the respondents are either students or company officers reflected by their trip purposes of commuting or going to study place.

Table 2 Characteristics of the Respondents

Characteristics	User Group			
Monthly Individual Income (Unit: THB)	Bus	Van	Passenger Car	Train
10000 or less	0.0%	0.0%	1.7%	32.8%
10001-20000	2.9%	0.6%	5.2%	27.6%
20001-30000	1.1%	0.0%	4.6%	13.2%
30001-40000	0.0%	0.0%	8.6%	1.7%
Occupation				
Student	0.0%	0.0%	5.2%	43.1%
Company	1.7%	0.0%	5.7%	23.6%
Freelance	0.6%	0.6%	0.0%	2.3%
Government	1.7%	0.0%	4.0%	6.3%
Retail business Owners	0.0%	0.0%	5.2%	0.0%
Age(Unit: Years old)				
19-29	2.3%	0.6%	6.9%	59.2%
30-39	1.2%	0.0%	10.3%	14.4%
40-49	0.6%	0.0%	1.7%	1.2%
50-59	0.0%	0.0%	1.2%	0.6%
Sex				
female	2.3%	0.6%	5.2%	35.1%
male	1.7%	0.0%	14.9%	40.2%

4. Multinomial Logit Model

The multinomial logit (MNL) model is commonly employed in the analysis of choice behavior. It is based on the Random Utility Theory; [22]. It expresses each mode probability (*P*) that an individual *i* selects a specific alternative *j* as a function of the utilities among *M* alternatives available in the choice set, as expressed in Equation (1);

$$P_{ij} = \frac{e^{V_{ij}}}{\sum_{m=1}^{M} e^{V_{ij}}} \quad (1)$$

The deterministic part of the utility (*V*) of an alternative *j* is related to relevant attributes (X_{ij}) which represent the alternative and individual variables (travel time, travel cost) as defined in Equation (2);

$$V_{ij} = \sum_{k=1}^{K} \beta_{jk} X_{ijk} \quad (2)$$

The parameters (B_{ijk}) in Equation (2) can be estimated by the maximum likelihood method. Each estimated parameter may be interpreted as an estimate of the weight of the corresponding attribute *k* n the utility function *Vj* of alternative *j*.

4.1 Utility Functions

In this analysis, four alternatives for transport mode are motorcycle, van, passenger car and, bus. The utility functions of van and bus consist of an alternative specific constant (ASC), travel time, travel cost, and transit & waiting time. Note that passenger car's utility does not include transportation and waiting time, while the train's utility consists only of travel time, travel cost, and waiting and transit time. They are expressed mathematically, as shown in Eq. (3) to (5), respectively.

$$V_{Passenger\ Car} = ASC_{Passenger\ Car} + \beta_c(Travel\ Cost) + \beta_t(Travel\ Time) \quad (3)$$

$$V_{Van,Bus} = ASC_{Passenger\ Car} + \beta_c(Travel\ Cost) + \beta_t(Travel\ Time) + \beta_{wt}(Waiting\ and\ Transit\ Time) \quad (4)$$

$$V_{Train} = \beta_c(Travel\ Cost) + \beta_t(Travel\ Time) + \beta_{wt}(Waiting\ and\ Transit\ Time) \quad (5)$$

The ASC terms represent the effect that is not related to the other attributes; however, they have a contribution to the indirect utility amount. In this case, the sign for ASC is expected to be negative because people are likely to prefer the train, which provides the best services. Travel cost is in Baht where travel time and waiting time are in minutes.

4.2 Estimation and Validation

The estimated parameters are evaluated by considering the corresponding t-value under 90% and 95% confidence levels. For the overall goodness of fit, likelihood-ratio is presented to assess the power of the model with estimated coefficients concerning the null model (where all coefficients are zero). For validation, a hit-ratio is performed to determine how accurate the model can predict the choice. In this study, we estimated the parameters by using Programming language "R."

4.3 The Results

In this paper, the two MNL models are presented. Model 1 exhibits the estimated coefficients for travel time, travel cost (fare), and the corresponding ASCs. Model 2 additionally includes the waiting and transfer time. The estimation results are shown in Table 3, where the coefficients with the corresponding t-value are shown. In Model 1, the ASCs of Bus and Car are not statistically significant. The ASC of Passenger car only has a positive sign, indicating that in general, the passenger car is preferable than rail.

Rail, in contrast, the ASCs of Van and Bus have negative signs, suggesting that they are inferior to Car and Rail. The travel time is found to be statistically significant in both models. Furthermore, in Model 2, the ASC of Bus and the Waiting and Transfer time are not statistically significant. This result indicates that transit time and waiting time do not influence the choice of travel mode. One of the possible explanations is that rail passengers have perceived the waiting and transfer time in the total trip time. In terms of the goodness of fit, Model 1 and Model 2 are nearly similar, by considering hit-ratio and likelihood-ratio. However, the significant power of the coefficients of Model 2 is more reliable than Mode 1. Therefore, Model 2 will be used for further analysis of elasticity in the next section.

Table 3 Estimation Results

	Model1	Model2
Variables	Coefficient(t-value)	Coefficient(t-value)
ASC_Bus	-0.653(-0.786)	1.327(1.521)
ASC_Van	-3.986(-3.839)*	-2.416(-3.507)**
ASC_Car	0.346(0.682)	1.484(1.832)*
Travel Cost	-0.004(-1.924)*	-0.042(-2.242)**
Travel Time	-0.034(-2.989)**	-0.061(-4.722)**
Waiting, Transfer Time		0.005(0.141)
Number of Observations	174	174
Likehood-Ratio	0.505	0.485
Hit-Ratio	75.30%	65.50%

* Significant at.10 and ** at .05 levels

5. The elasticity of the Dark Red Line

The multinomial logit (MNL) model presented in the previous section is employed to understand the effectiveness of service levels (travel time and travel cost) on the proportion of train users when DRL opens. The elasticity to train's travel time and the fare is shown in Fig. 3 (travel time) and Fig. 4 (fare), respectively. It shows the percentage of train users at each range of travel time and fare. To compare with the travel cost with the current situation, If DRL fare is at the same level of travel cost (70- 90 THB) in the current situation, DRL will be possibly used by many commuters and students (87.3 to 98.1 percent). This trend is similar for travel time. Moreover, in Figure 3 and Figure 4, the travel time reduction has more pronounced effects than the train fare having on the number of train users.

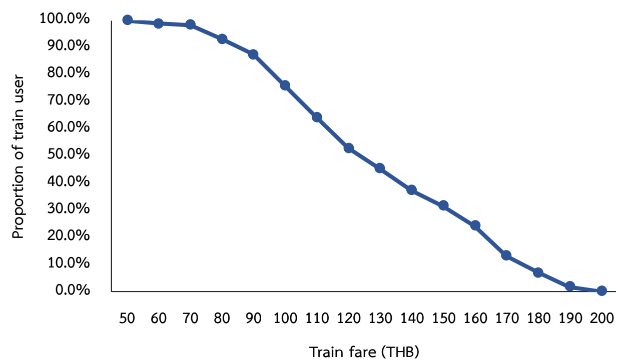

Fig. 3 Choice Probability of Train Under Various of Train Fares

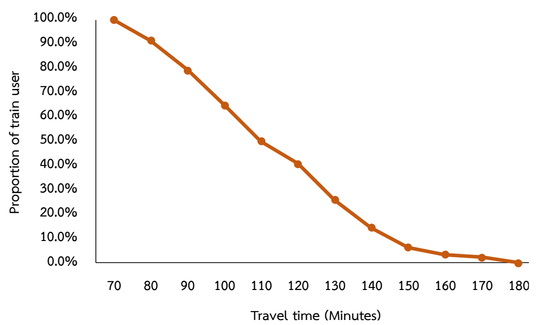

Fig. 4 Choice Probability of Train Under Various Train Travel Times

6. Conclusions

This paper has presented an analysis to examine respondents' preference towards DRL in Bangkok based on the stated preference (SP) survey. Two Multinomial Logit (MNL) model were presented. It is found that travel time is a more critical factor than travel cost for the modal choice of commuting or going to school. Moreover, the elasticity analysis of DRL has shown that at the same service level as the current situation, there is a possibility that people will choose the train to commute and go to study places. It was revealed that railways' service level (travel time and fare) has a significant influence on demand. Besides, travel time was shown to be a more influential factor than travel costs. However, this study has considered each mode's service level in a representative manner where access to each transport model is not explicitly represented, i.e., access to station or bus stops. This point is left for further studies.

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