บทความวิจัย

ปัจจัยที่ส่งผลกระทบต่อการเปลี่ยนรูปแบบการเดินทางไปสู่ระบบรถไฟฟ้าชานเมือง: กรณีศึกษาพื้นที่ศาลายา ประเทศไทย

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รับเมื่อ 18 กุมภาพันธ์ 2564 แก้ไขเมื่อ 20 พฤษภาคม 2564 ตอบรับเมื่อ 25 พฤษภาคม 2564 เผยแพร่ออนไลน์ 4 สิงหาคม 2565

บทคัดย่อ

งานวิจัยนี้เป็นการศึกษาพฤติกรรมการเลือกรูปแบบการเดินทางของผู้เดินทางระหว่างศาลายาและกรุงเทพมหานคร โดยได้พัฒนาแบบจำลองการเลือกจากทฤษฎีอรรถประโยชน์แบบสุ่ม เพื่อประเมินผลกระทบของปัจจัยต่างๆ ที่มีต่อการตัดสินใจของผู้เดินทาง การออกแบบแบบสอบถามใช้วิธีสถานการณ์สมมติเพื่อสร้างรูปแบบปัจจัยการบริการที่มีศักยภาพในการดึงดูดผู้เดินทางให้มาใช้รถไฟสายสีแดงอ่อนในอนาคต การศึกษาได้สร้างและปรับเทียบแบบจำลองโลจิตพหุนามสองรูปแบบโดยแยกตามข้อมูลการครอบครองรถยนต์ กลุ่มตัวอย่างในการสำรวจเป็นผู้ตอบแบบสอบถามจำนวน 444 คน จากพื้นที่ศึกษา แบบจำลองที่ปรับเทียบแล้วมีความถูกต้อง และสามารถพยากรณ์สัดส่วนการใช้รถไฟในอนาคต มูลค่าของเวลาการเดินทางสำหรับผู้ที่เป็นเจ้าของรถยนต์ส่วนตัวมีค่าเท่ากับ 69.24 บาทต่อชั่วโมง ซึ่งต่ำกว่ามูลค่าเวลาของเวลาการเดินทางของผู้ที่ไม่มีรถยนต์ส่วนตัวซึ่งเท่ากับ 113.02 บาทต่อชั่วโมง มูลค่าของเวลาเดินทางนี้อาจเป็นผลมาจากปัจจัยด้านเศรษฐกิจสังคมและด้านการเดินทางอื่นๆ เช่น รายได้ อาชีพ เวลาเดินทาง และวัตถุประสงค์การเดินทาง ความยืดหยุ่นอุปสงค์ทางตรงแสดงให้เห็นว่า เวลาในการเดินทางนี้มีผลต่อการเลือกรูปแบบการเดินทางมากกว่าค่าใช้จ่ายในการเดินทาง อย่างไรก็ตาม เวลาในการเดินทางจะมีผลกระทบน้อยลงเมื่อมีการครอบครองรถยนต์มากขึ้น การศึกษานี้พบว่า อิทธิพลของเวลาในการเดินทางนี้จะลดลงเมื่อผู้เดินทางเป็นเจ้าของรถยนต์ การครอบครองรถยนต์นี้เป็นอุปสรรคในการเปลี่ยนไปใช้รูปแบบการเดินทางอื่นที่มีอยู่ คาดการณ์ว่าถ้ารถไฟสายสีแดงอ่อนใช้เวลา 55 นาที และคิดค่าโดยสาร 60 บาท ในการเดินทางระหว่างศาลายาและกรุงเทพฯ จะมีส่วนแบ่งตลาดถึง 41.5% ผลของการศึกษานี้ทำให้สามารถกำหนดนโยบายการดำเนินงานสำหรับรถไฟฟ้าสายสีแดงอ่อนเพื่อให้มีสัดส่วนผู้ใช้มากขึ้น และส่งเสริมรูปแบบการเดินทางที่ยั่งยืน

คำสำคัญ: แบบจำลองโลจิตพหุนาม สถานการณ์สมมติ รถไฟฟ้าชานเมือง การเลือกรูปแบบการเดินทาง ความยืดหยุ่นของอุปสงค์

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Research Article

Factors Influencing Modal Shift to the Commuter Rail System: A Case Study of Salaya, Thailand

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Abstract

This research addresses the mode choice behavior for commuters traveling between Salaya and Bangkok. The choice model was developed based on utility theory to evaluate the effects of attributes on commuters' decisions. To design the questionnaire survey, Stated Preference approach was practiced by creating hypothetical scenarios of attributes for potential commuters of the future SRT Light Red line. Two multinomial logit models were created and calibrated based on individuals' private car ownership status. Altogether, 444 participants completed the questionnaire from the study area. Calibrated models were accurate and were able to forecast the future rail mode share. The value of travel time of private car owners was 69.24 THB/hour, compared with 113.02 THB/hour for those without private cars. This might have been attributed to other socioeconomic and trip characteristics such as income, profession, time of day, and trip purpose, which should be further investigated. Direct demand elasticity revealed that travel time was more influential in mode choice than travel cost for the overall population. However, sensitivity of travel time was found to decrease with an increase in ownership of private cars. Moreover, an increase in car ownership was found to be a barrier to shift to other available modes. It was expected that if the Light Red Line's traveling time took 55 minute with the fare of 60 baht between Salaya and Bangkok, the company would reach 41.5% market share. The outcomes allowed the company to develop operational policies for the Light Red line to enhance its mode share and promote sustainable commuting options.

Keywords: Multinomial Logit, Stated Preference, Commuter Rail, Mode Choice, Demand Elasticity

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1. Introduction

Traffic congestion in Bangkok has been significant for more than five decades. In 1971, a German agency conducted a Bangkok traffic study and suggested that Bangkok was in urgent need of a well-organized mass transit system together with an urban study plan [1]. Decades later, the city was renowned as one of the most congested and air-polluted cities in the world [2], [3]. Eventually, the city's first rail transit network began operation in 1999. Since then, the government has simultaneously prioritized rail transit network expansion to encourage metro usage [4]. However, in 2016, Bangkok moved up from 30th to 12th most congested city in the world [5]. This implied some mismatches between commuters' preferences of transportation and the existing metro service characteristics which prevented the shift from automobile to metro.

Several studies have been centered on the feasibility of the metro project and predictions for potential travel demand. Little is known about the perceptions of actual commuters towards the willingness to shift to the Light Red line (LRL). More specifically, studies depicting understanding of the influential role of service attributes on commuters based on automobile ownership status on mode choices are rare in the study area.

This study relies on choice theory to gain better understanding about the influences of service characteristics on commuters' decisions to shift from existing modes to the LRL based on their car ownership status. Owning private cars has been defined as the main factor determining mode choice decisions, fossilizing travelling behavior of commuters using private cars, and has been blamed as a main cause of traffic congestion in Bangkok [6], [7].

The LRL was specifically selected for passenger mode choice analysis as it was planned to link inner Bangkok to Salaya area. It would become the newest transport alternative between the two areas by 2022. Previous studies suggested that the service characteristics of the metro could greatly contribute to modal shift [8–10]. Therefore, current commuters' perceptions on potential service characteristics should be thoroughly observed and considered. Ultimately, it could tailor service planning and policy of the Light Red line (LRL) in the right direction.

2. Material and Methods

2.1 Research design

Quantitative data collection was conducted on-site and online. This English-Thai questionnaire survey included three sections. The first section was labeled Stated Preference mode choice survey. The second section included inquiries regarding socio economic status and the third section comprised trip characteristics.

Before its actual use, the questionnaires were revised and validated by university experts on choice modelling for rail transportation studies to ensure its reliability and validity [11], [12].

2.1.1 Attribute selection

The travel alternatives contained various "attributes", or service characterstics that the alternatives offered. The research focused on four general modes available to the whole sample group of this study. These included Private Car (PC), Public Bus (PB), taxi (TX) and Light Red line (LRL) (Future Alternative). It should be noted that the conventional train was excluded from the set of alternatives in this study as it was expected to be replaced by the LRL [13]. Attribute selection was based on various choice modal studies of intercity, metro and commuter rail transit.

Total travel time in this study was used to explain travel time from origin to destination by corresponding modes. The total travel cost for LRL and public bus referred to the cost of a ticket per head for a single trip from origin to destination. The total travel cost for private car and taxi referred to the cost of gasoline, and the fare charged by a taxi for a single trip from origin to destination, respectively. The study assumed that the average access and egress cost and time for each mode are perceived by the respondents and would later be reflected by Alternative Specific Constants (ASC) in the utility functions. Further disintegration of travel time and cost under access and egress for public mode was not done in this study to make the choice task simple for respondents. Frequency is the attribute provided by public mode i.e. LRL and public bus whereas transfer is only for LRL. Commuters were also asked about their car ownership status on the Revealed Preference survey. This data was collected to classify commuters based on their car ownership status. The study hypothesized travel time, travel cost and frequency as a generic variable and transfer in LRL as mode specific.

All attributes provided by alternatives were assigned with 3 levels, except transfer. Level 2 represented the base level or the attribute level provided by alternative in present scenario. The time and cost varied up and down by 25% in levels 1 and 3 whereas the frequency fluctuated by 50% from the current scenario. Transfer was represented by a nominal variable where 1 indicates a transfer and 0 no transfer. Current levels of attributes, i.e., Level 2 for existing alternatives were estimated from information obtained from various studies and websites. The base levels of LRL service were estimated with reference to the service attributes provided by the Airport Rail Link because of their similar operational characteristics and operator.

Table 1 Summary of alternatives, attributes and their levels used for stated preference survey.

	Travel Mode			
	LRL	Private Car	Public Bus	Taxi
Total Travel Time (Mins.)	45, 55, 65	60, 75, 90	80, 100, 130	60, 75, 90
Total Travel Cost (THB)	45, 60, 75	65, 85, 105	15, 25, 35	180, 250, 320
Frequency (Every 'x' Mins.)	5, 10, 15	-	5, 15, 25	-
Transfer	0, 1	-		-

2.1.2 Orthogonal Experimental Design

Hypothetical scenarios were created in the questionnaire. Individuals were subjected to scenarios with various levels of drafted attributes offered by alternatives from which they were to choose one with the highest level of satisfaction [14]–[16]. Two or three levels were assigned to attributes which could illustrate a feasible commuting choice on future days as shown in Table 1. The principle of orthogonal design was used to construct statistically efficient fractional factorial design and avoid multicollinearity between service attributes using Ngene software [17]. A total of 36 combinations were created to obtain a fractional factorial design which was blocked into 3 combinations creating 12 sets of questions. Each respondent was subjected to one set of questions with three scenarios in it. This decreased the difficulty and increased rationality in response with fewer scenarios.

2.2 Sampling and survey method

This study considered three main clusters which defined the population of Salaya including residents, students, and staff of Mahidol University. In 2020, the registered population of Salaya was 11,071 [18]. Mahidol University (MU) was the important player due to a huge number of staff and students. By 2020, the population of MU students and staff were forecasted to be 30,902 and 6,022 respectively [19]. To obtain a reliable sample size, Yamane (1976) suggested adopting 95% of confidence level for the precision of ± 5%, yielding the required sample size as 397 participants [20]. The research followed a stratified sampling technique to select each distinctive group of participants as shown in Table 2 [21].

Table 2 Summary of population and sample size

Study Group	Population Size	%	Min. Sample Size	This Study
Registered Resident	11,071	24	102	108
MU Student	30,902	64	273	276
MU Staff	6,022	12	51	60
Total	47,995	100	426	444

2.3 Utility theory

Utility is used to explain the scale of attractiveness of alternatives which is a scaler quantity derived from attractiveness provided by the alternative [22]. Individuals make choices by maximizing utility and negotiating between attributes in the decision making process [23], [24]. A utility function explains components that tie up utility with factors affecting it [18], [23]. The utility function is written in the following Equation (1):

$$U_{in} = V_{in} + \varepsilon_{in} \quad (1)$$

Where, U_{in}, V_{in} and ε_{in} represent the total utility, systematic and random components provided by alternative i for individual n respectively.

Let V_{lr}, V_{pc}, V_{pb}, and V_{tx} represent the systematic components of the linear utility function of LRL, private car, public bus and taxi [25]. Then, the systematic component of utility function can be expressed as Equations (1)–(5):

$$V_{lr} = \beta_1 \times X_{lr1} + \beta_2 \times X_{lr2} + \beta_{0lr} \quad (2)$$

$$V_{pc} = \beta_1 \times X_{pc1} + \beta_2 \times X_{pc2} + \beta_{0pc} \quad (3)$$

$$V_{pb} = \beta_1 \times X_{pb1} + \beta_2 \times X_{pb2} + \beta_{0pb} \quad (4)$$

$$V_{tx} = \beta_1 \times X_{tx1} + \beta_2 \times X_{tx2} + \beta_{0tx} \quad (5)$$

In this study, time and costs are taken as generic variables, i.e., unit time and cost spent on any mode are equally appreciated. Thus, β_1 and β_2 are used as generic parameters for time and costs across all alternatives. Finally, β_{0lr}, β_{0pc}, β_{0pb} and β_{0tx} are parameters assigned to each mode to represent characteristics not included in the study.

2.4 Multinomial logit model (MNL)

To evaluate mode share, a random component of the utility function was assumed to be independently, identically and Gumbel distributed along with uniformity in response for attributes and similar patterns of variance-covariance structure in error terms throughout individuals. Modelling was performed using multinomial logistic regression to predict the probability of mode share of respective modes. The probability of the nth individual choosing alternative i over other alternatives available in choice set (Cn) using multinomial logit model (MNL) is expressed as Equation (6) [25]:

$$Pn\ (i) = \frac{e^{Vin}}{\sum_{J \in Cn} e^{Vjn}} \qquad (6)$$

2.5 Direct demand elasticity

Direct demand elasticity is used to measure the percentage change in probability of choosing an alternative with respect to the percentage change in attributes provided by the same alternative. Direct demand elasticity of alternative i with respect to attribute X with choice probability P for individual n is given by following Equation (7) [23]:

$$E_{X_{in}}^{P_{in}} = -\beta_{ik} \times X_{ikn}\ (1 - P_{in}) \qquad (7)$$

where β_{ik} is the parameter for the kth attribute of alternative i, X_{ikn} is the current level of the kth attribute of alternative i for decision maker n, and P_{in} is the estimated probability of choosing alternative i for decision maker n.

3. Results

3.1 Profile of respondents

Responses to the stated preference questionnaire were received from 444 individuals who were considered as the population of Salaya. Current

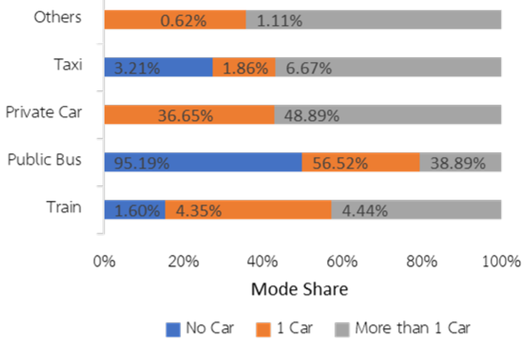

Figure 1 Current Mode Share.

mode share for commuters between Salaya and Bangkok according to their car ownership status is shown in Figure 1.

A few irrational responses were cleaned out from the analysis set. Out of total respondents, 187 did not own a private car (42.7%), 161 owned one (36.8%), and 90 owned more than one private car (20.5%). Figure 1 shows the dominant mode for the commuters without a private car were public bus (95.2%), while taxi (3.2%) and train (1.6%) only received small shares. Most commuters owning one private car were found to use public bus (56.5%) followed by private car (36.6%), train (4.4%), and taxi (1.9%) and other modes including motorcycle, bicycle, and walk (0.6%). Commuters with more than 1 private car normally used private car (48.9%) followed by public bus (38.9%), taxi (6.7%), train (4.4%), and other modes (1.1%).

3.2 Mode choice models

A total of 1332 stated preference (SP) choice responses were collected. Multinomial logit models were developed using NLOGIT 6 based on 3 categories of commuters classified under car ownership status. These commuters could not be accommodated in the same model because of the difference in the choice set. Private car was removed from the choice set for commuters with no private car. Therefore, market segmentation was evident and ought to make a choice from a set of alternatives with LRL, public bus and taxi (MNL-I). However, a pooled model was calibrated for commuters owning private cars (MNL-II).

Collected data were divided into two sets. The first 70% of the responses (361 for MNL-I and 510 for MNL-II) were used for model calibration whereas the remaining 30% (184 for MNL-I and 243 for MNL-II) were used for model validation [8]. Table 3 lists variables with their descriptions used for this study. Tables 4 and 5 show the estimated parameters for the utility functions.

Table 3 Variable descriptions

Variable	Description
ASC_i	Alternative Specific Constant for mode "*i*"
Time	Parameter of Total Travel Time
COST	Parameter of Total Travel Cost
$Time_i$	Travel Time on mode "*i*"
$COST_i$	Travel Cost on mode "*i*"
TRAN	Transfer for LRL
$CARM1_i$	Ownership of more than 1 Car for mode "*i*"

Table 4 MNL-I respondents with no private car

Attributes	Coefficient	z	*p*-value
ASClr	–0.31985	-0.85	0.3938
TIME	–0.02025	–3.75	0.0002
COST	–0.01075	–2.15	0.0313
ASCtx	–0.95469	–0.90	0.3678
Total Observation	361		
LL Function	–264.3305		
LL Ratio (-2LL $_{(2)}$)	20.54142		
Chi-Square ($\chi^2_{(2)}$)	5.99		

Table 5 MNL-II respondents owning private car

Attributes	Coefficient	z	*p*-value
ASC_{lr}	0.21256	0.87	0.3842
TIME	–0.01281	–3.13	0.0018
COST	–0.01110	–3.10	0.0019
TRAN	–0.31556	–1.76	0.0785
$CARM1_{lr}$	0.54277	2.24	0.0249
$CARM1_{pc}$	0.69274	2.51	0.0121
ASC_{pb}	–0.31113	–1.14	0.2524
ASC_{tx}	–0.34447	–0.60	0.5482
Total Observation	510		
LL Function	–549.56431		
LL Ratio (–2LL $_{(5)}$)	29.51365		
Chi-Square ($\chi^2_{(5)}$)	11.07		

Utility functions for MNL-I are expressed Equation (8)–(10) as:

$$V_{lr} = –0.31985 – 0.02025 \times \text{TIME}_{lr} – 0.01075 \times \text{COST}_{lr} \quad (8)$$

$$V_{pb} = –0.02025 \times \text{TIME}_{pb} – 0.01075 \times \text{COST}_{pb} \quad (9)$$

$$V_{tx} = –0.95469 – 0.02025 \times \text{TIME}_{tx} – 0.01075 \times \text{COST}_{tx} \quad (10)$$

Utility functions for MNL-II are expressed Equation (11)–(14) as:

$$V_{lr} = –0.21256\text{-}0.01281 \times \text{TIME}_{lr} – 0.0110 \times \text{COST}_{lr} – 0.31556 \times \text{TRAN} + 0.5427 \times \text{CARM1}_{lr} \quad (11)$$

$$V_{pc} = –0.01281 \times \text{TIME}_{pc} – 0.01110 \times \text{COST}_{pc} + 0.69274 \times \text{CARM1}_{pc} \quad (12)$$

$$V_{pb} = –0.31113 – 0.01281 \times \text{TIME}_{pb} – 0.0111 \times \text{COST}_{pb} \quad (13)$$

$$V_{tx} = –0.34447 – 0.01281 \times \text{TIME}_{tx} – 0.01110 \times \text{COST}_{tx} \quad (14)$$

3.3 Model validation

3.3.1 Coefficient signs

Signs of the coefficients play a vital role for model validation. Models cannot be correctly utilized if the signs of the coefficients are irrational compared to the response variables. In this study, all the variables exhibit rational signs for their respective coefficients in this study.

3.3.2 Significance of Independent Variables

The significance of independent variables was inspected using z statistics. This study adopted 90% level of confidence ($Z_{0.90}$), i.e. a coefficient of the variable of interest was considered equivalent to zero if the z value lied between the critical range of ±1.645 and was removed from the utility function. However, ASC for all the modes were considered in the utility function regardless of its z value to reflect the bias towards non-quantifiable characteristics of each mode.

3.3.3 Forecast accuracy

Evaluation of the model's forecasting efficiency is based on the percentage of correct forecasts yielded by the remaining 30% of data for the calculated utility by model from 70% of data. Both models were validated with reasonablely good forecasting efficiency similar to previous research and according to Mean Absolute Percentage Error (MAPE) [24] as shown in Table 6.

Table 6 The models' forecasting efficiency

Model ID	Observed no. of Choice	Matched no. of Choice	Accuracy (%)
MNL-I	184	132	71.74
MNL-II	243	169	69.55

3.3.4 Log-Likelihood ratio test (-2LL)

Comparison of the likelihood function of estimated model versus base model determined the predictive capability of the parameters. Log-Likelihood ratio tests of calibrated models are shown in Table 7. Since, −2LL value exceeded the Critical χ^2 value for both MNL-I and MNL-II, the null hypothesis stating that estimated model was no better than the base model was rejected.

Table 7 Log-Likelihood ratio test

Model	−2LL	$DF_{(base-estimated)}$	Critical χ^2
MNL-I	20.541	2	5.99
MNL-II	29.513	5	11.07

3.4 Direct demand elasticity of light red line's travel attributes

Direct demand point elasticities with respect to time and cost were evaluated using the principle given in section 2.5. The elastic model aggregation assumed the estimated logit function passes through the point defined by the base levels of attributes. Thus, the base levels of time and cost attribute for LRL (55 mins. and 60 THB) and their respective probabilities of using LRL were used to calculate direct elasticities of LRL with respect to time and cost as shown in Table 8.

Table 8 Direct point elasticity of attributes for LRL

Commuter	LRL Travel Attributes	Elasticity
No private car	Total Travel Time	–0.512
	Cost of Ticket/Head	–0.297
One private car	Total Travel Time	–0.411
	Cost of Ticket/Head	–0.388
More than one private car	Total Travel Time	–0.383
	Cost of Ticket/Head	–0.362

Direct demand elasticity with respect to total travel time showed that LRL demand was relatively inelastic. Commuters with one private car showed the highest sensitivity compared to other categories of commuters for similar increments in time attributes which also revealed their higher sensitivity to total travel time than others. Commuters without a private car also showed higher disutility on LRL total travel time over those with private cars in the utility function.

Cost of ticket/head of the LRL for all commuters were also relatively inelastic. Point elasticity revealed that commuters owning one car showed the highest sensitivity followed by commuters owning more than one car and no car for similar increments. This implied commuters with one private car were more likely to shift to other available modes for a similar increase in cost of ticket/head. The models for commuters owning private car exhibited higher magnitudes of disutility on cost of ticket/head of LRL above individuals not owning private car in the utility function.

4. Discussion and Conclusions

Individual preferences on total travel time, total travel cost, frequency and transfer were investigated by this research. Out of these attributes, total travel time, total travel cost and transfer showed 90% level of significance. Frequency did show a substantial level of significance, therefore was not considered in the utility function.

Results from MNL-I showed travel time as a highly significant travel attribute for mode choice compared to travel cost, while transfer and frequency did not show any significant effect for commuters without a private car. With labelled choice experiments, the respondents knew the name (i.e., label) of the alternatives and were expected to show their bias towards some given modes regardless of their quantitative attributes.

The second model explained behavior of the commuters who own at least one private car. The effect of travel time had higher significance on mode choice decision compared to travel cost for this group of commuters. The positive signs of the parameters $CARM1_{lr}$ and $CARM1_{pc}$ implied that commuters who owned more than one car were more likely to use their car or light rail than those with only one car. In addition, transfer for LRL was also found as a significant attribute for commuters owning private cars. The frequency of public mode did not show any significant effect in mode choice decision after introduction of LRL.

4.1 Value of time

Value of Time (VOT) was observed as the ratio of coefficients of travel time and cost attributes. The VOT were 113.02 and 69.24 THB/hour for commuters without and with private cars respectively. This illustrated commuters with no car had higher willingness to pay for travel time compared to those with cars. This outcome appeared to be unique for the area and against the norm since car ownership was usually associated with higher income and willingness to pay. However, the results might have been influenced by other unaccounted attributes, e.g. travel expenses, time of day, and trip purpose.

4.2 Impact to transport policy

Commuter's choice for travel mode depends

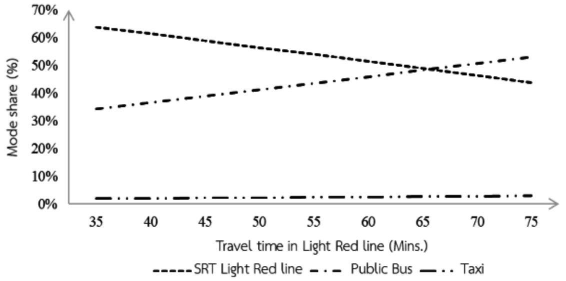

Figure 2 Effect of LRL travel time on mode share for commuters with no private car.

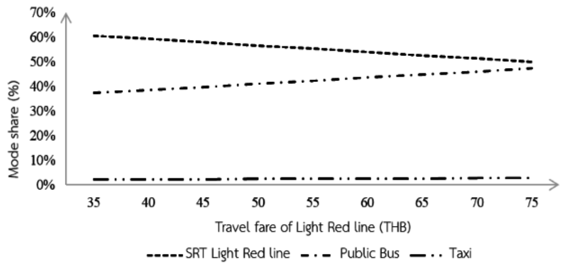

Figure 3 Effect of LRL fare on mode share for commuters not owning a private car.

on the level of service provided by alternatives between Salaya and Bangkok in future days. Models calibrated in this research allowed the researcher to estimate mode share for various sets of service characteristics provided by alternatives according to car ownership status. The projected mode shift could further depict understanding of the effects of these attributes to the commuter's decisions. A sensitivity test was performed to find out the effects of attributes on individual's choice of mode selection. This analysis helped to understand and explain the attributes' ability to enhance operations of LRL over other modes.

4.2.1 Impact of travel time of light red line

Adopting travel time and travel cost in LRL as 55 minutes and 60 THB, it would achieve 53.99%, 31.88% and 35.47% of mode share for commuters owning no car, one car and more than one car, as shown in Figure 2. Decreases in LRL travel time by 10 and 20 minutes would result in 4.97% and 9.77% increase of mode share for commuters with no private car. Similarly, the mode share of LRL for commuters owning one private car grew by 3.14% and 6.33% and for commuters with more than one private car by 2.72% and 5.48%.

4.2.2 Impact of travel fare of light red line

The cost coefficients in the utility functions took negative signs which reflected their negative impact to LRL mode share. Figure 3 shows the effect of fare to ridership. Reductions of 10 and 20 THB in fare would increase the mode share to 58.6% and 63.8% respectively for commuters without private car. Likewise, with similar fare decrease for commuters owning one or more private car mode, the share for LRL would increase by 8.7% to 17.8% over the base level.

4.3. Conclusion and recommendation

4.3.1 Conclusion

This research focused on commuters' mode choice behavior for travelling to and from Salaya and Bangkok. The study targeted commuters based on their private car ownership status and identification of crucial attributes contributing to mode shift to LRL from other available modes in the study area.

Travel time was found as the most crucial attribute followed by travel fare for all categories of commuters in this study. Moreover, transfer of the Light Red Line was found to significantly affect mode choice decisions for commuters owning private cars, whereas frequency of LRL did not show statistical significance on mode share. A comparison of the magnitudes of the coefficients of CARM1 for LRL and private car indicated the car ownership as a barrier to mode shift to LRL.

This research showed that LRL would enjoy a significant market share with the base values of attributes. Providing 55 minutes of travel time from Salaya to Victory Monument with 60 baht fare the LRL would receive 42.5% of the trips. By category, LRL would enjoy 54.0%, 31.9% and 35.5% share for commuters with no car, one car and more than one car.

4.3.2 Recommendation

Although travel time was found to be the most crucial factor in shifting to LRL, speed improvement would be limited to engineering capacity. With a proper operational plan for all categories of commuters including an efficient transfer-based system, seamless connectivity from origin/destination to station of LRL (feeder line) and express train operation with fewer stops, mode share for LRL could be increased.

Demand elasticity with respect to cost showed that a rise in ticket cost would generate more revenue. Nonetheless, high ticket cost would defeat the social and economic objectives of the LRL project. Instead, extra revenue could be gained using a price discrimination scheme based on demand elasticities of commuter groups, while maintaining the optimum social benefits.

Public bus and private car also gained fair mode shares in this research. This opens the door for LRL operator/stakeholders to devise such schemes as economical park and ride facilities and discounts on ticket price of LRL with bus tickets which would aid mode shift to LRL.

This research faced some limitations. A few factors were purposely excluded to simplify the questionnaire and analysis. Future research could introduce other attributes such as punctuality, reliability, passengers traveling together, and other socioeconomic characteristics of the commuters to set up more effective operating policies.

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