DETERMINING WILLINGNESS-TO-PAY FOR IN-VEHICLE TRAVEL TIME OF TRAVELLERS IN SALAYA DISTRICT

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Abstract

The aim of this paper is to evaluate the willingness-to-pay (WTP) in the context of public transport planning to create a transportation mode shift in Salaya District, Nakhon Pathom Province. A survey was carried out on private and public transportation users based on the stated preference (SP) technique. A series of questionnaires was designed to test the sensitivity of 4 key attributes influencing a traveler's mode choice, i.e. fare, in-vehicle travel time, wait time, and access time. The WTP of Salaya locals was approximated at 49 baht per hour for private transport mode and 97 baht per hour for public transport mode. The WTP of the nonregistered population was 56 and 106 baht per hour for private mode and public transport mode, respectively. The WTP of visitors was 66 baht per hour for public transport mode, which is considered low compared to the average income of Nakhon Pathom. The study cannot interpret the result to conclude that the WTP for visitors is using the private transport mode as the sample size was too small and the answers lacked sufficient variation. The result of this study can be used for designing service characteristics of a new public transportation system. Moreover, it can also be used for developing seamless connectivity of public transportation networks within Salaya district.

Keywords: **Willingness-to-pay, public transport planning, discrete choice model, individual choice behavior**

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Introduction

Salaya district is located in the western suburbs of Bangkok, Thailand. It is home to various settlements including 3 universities, numerous schools and markets, a department store, and a medical center. Salaya railway station, located at the heart of the district was assigned as a terminal station for the future State Railway of Thailand (SRT) Light Red Line extension project from Taling Chan to Salaya. This SRT project is a part of the railway public transportation development master plan with the aim of connecting suburban centers with the Bangkok Metropolitan Administration metro network.

The rapid growth of Nakhon Pathom induces increasing travel needs between the western suburbs and the Bangkok Metropolitan Region. Salaya station is expected to become one of the major transportation hubs west of Bangkok as it will provide a connection between the new rail transit system and the traditional rail transit system, along with various types of feeders and hired transportation modes. The area around Salaya station is considered an area of mixed land use with local communities, markets and shopping centers, government offices, universities and schools, a medical center and the future site of one the largest general hospitals in Thailand. This, coupled with the compact size of the area, has prepared Salaya as a perfect setting for a sustainable development concept known as transit oriented development (TOD). Good TOD planning with seamless transportation connectivity will encourage private transport mode users to shift to public transportation. The direct benefits to public transport users include a shorter travel time and cost saving, convenience, and safety. Not only do public transportation developments generate direct benefits but they also yield wider economic benefits for the community in the form of employment, business development, pollution reduction, and a better quality of life.

The key limitation of travel by a rail transit system is accessibility. Railway transport can merely accommodate trips from one station to another station on the rail network. In order to create a shift from private to public modes of travel, transportation planners must enhance connectivity among public transport modes. Salaya railway station must be served by a feeder system that provides sufficient coverage within Salaya district and its neighborhood.

The objective of this paper is to evaluate the travel willingness-to-pay of Salaya locals, the nonregistered population, and visitors which will be used to design the services characteristics of a public transportation system in a later stage of the study. This stage focuses on modeling the traveler's mode choice behavior based on the response to attributes influencing the mode choice decision. The willingness-to-pay is calculated from 2 sensitivity parameters as discussed in the next section.

Review of Related Literature

Willingness-to-pay

Willingness-to-pay (WTP) is the maximum price at which a consumer will definitely buy a product or service. It is based on various factors, e.g. consumer income, consumer taste, the number of consumers, and/or future price. These factors affect the demand for a product or service. WTP can be calculated by using various techniques, e.g. income/revenue, expense, demand curve, price sensitivity analysis, and random utility function, as presented in the case studies below.

The random utility function technique with the Heckit model (Sellers-Rubio and Nicolau-Gonzalbez, 2016) was used to find the WTP for a sustainable wine in Spain. The goal was to analyze the WTP on a premium-priced wine compared to a conventional one with similar characteristics. The results showed most consumers were willing to pay a higher price for sustainable wines. In addition, consumers with more wine knowledge had a lower WTP for a premium type. In contrast, consumers with higher concerns on the environment had a higher WTP for the premium type.

The price sensitivity analysis technique (Drevs *et al.*, 2014) was used to find the WTP for public transportation in Germany. A higher WTP was found after people learnt about the necessity of public subsidies for public transportation.

Several structures of logit models were used in a large number of researches including: 1) Binary logit models (Satiennam *et al*., 2011; Eluru *et al*., 2012; Wang *et al*., 2013; Miskeen *et al.*, 2013; Alessandrini *et al.*, 2014; Le and Trinh, 2016); 2) Multinomial logit models (Nurdden *et al.*, 2007; Braun Kohlová, 2009; Atasoy *et al.*, 2011; Chiu Chuen *et al.*, 2014; Thust *et al.*, 2016); 3) Nested logit models (Khan, 2007; Hensher and Rose, 2007); and 4) Mixed logit models (Zheng *et al.*, 2016). The model is expressed in conveniently calibrated form derived by the maximum likelihood technique. This logit model is the main part which is discussed in the following choice theory section.

Choice Theory

Commonly, an individual selects an alternative that maximizes utility from all available alternatives based on various offers (Khan, 2007). Similarly, in selecting a travel mode, an individual selects an alternative that offers maximum attractions. Those attractions result from various attributes in each alternative (e.g. fare, in-vehicle travel time, wait time, and access time). The utility function can be expressed in a linear form:

$$V_{in} = \beta_0 + \beta_1 X_{in1} + \beta_2 X_{in2} + \beta_3 X_{in3} + \beta_4 X_{in4} + \dots + \beta_k X_{ink} \quad (1)$$

where V_{in} is the utility function of alternative n for individual i; $\beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \dots, \beta_k$ are the weights associated with attribute X_{ink} and alternative n; and $X_{in1}, X_{in2}, X_{in3}, X_{in4}, \dots, X_{ink}$ are attributes of alternative n for individual i.

Instead of a direct survey, the WTP associated with each attribute can be indirectly estimated from the corresponding coefficient (β) in the equation above. Once the model is calibrated, the WTP or value of travel time saving (VTTS) can be written as the following: $VTTS = (\beta_2 / \beta_1)*60$ (baht per hour), where β_1 is the weight associated with the fare (X_1); and β_2 is the weight associated with the travel time (X_2).

Attributes and Attribute Levels

The context discusses key attributes influencing the mode choice decision as well as levels of attribute. Those attributes can be presented as follows:

Travel cost of public transportation (fare) has been discussed in many studies. Mainly, the studies divided the fare (ticket fare) into levels, e.g. free, 2, and 4 baht per trip (Satiennam *et al*., 2011; Zheng *et al*., 2016). In addition, out of pocket cost value was instead used as the fare in a study in the Czech Republic (Braun Kohlová, 2009). Conversely, another study in Europe identified the fare by dummy coding (-1, +1) (Alessandrini *et al.*, 2014). It should be noted that a study in the north-west of Australia separated the access bus fare from the main mode fare (Hensher and Rose, 2007).

The study in the Czech Republic identified accessibility distance by dummy coding (-1, +1), which was equal to 1 if the respondent could access the bus stop from his/her residence and was equal to 0 when the respondent could not (Braun Kohlová, 2009). Another study in Shanghai identified this factor by the time between the residence and the bus stop in 4 levels (Wang *et al*., 2013).

Travel time may consider in-vehicle time only (Satiennam *et al.*, 2011; Chiu Chuen *et al*., 2014) or a combination of out-of-vehicle travel time (e.g. access time, egress time, and waiting time) and in-vehicle time (Atasoy *et al*., 2011; Thust *et al*., 2016).

Out-of-vehicle travel time for public transport mode has been discussed as follows: 1) Waiting time was used to include waiting time at a bus stop (departure time), at a gasoline station, and/or in traffic congestion. For example, this factor was divided into 3 levels, i.e. 2, 6, and 10 min (Satiennam *et al.*, 2011; Zheng *et al.*, 2016), and was identified by an average time (Eluru *et al.*, 2012; Alessandrini *et al.*, 2014); 2) Access time was used to discuss walking time to a bus stop. A study in Australia divided this factor into 3 levels (Zheng *et al.*, 2016), whereas some case studies identified this factor by an average time (Satiennam *et al.*, 2011; Eluru *et al.*, 2012); and 3) Egress time was used to discuss walking time to a destination. This factor was divided into 3 levels (Zheng *et al.*, 2016). However, a study in Thailand identified this factor by an average time (Satiennam *et al.*, 2011).

Generation of Choice Set in the Stated Preference (SP)

The stated preference technique is used to study the mode choice of individual behavior based on hypothetical scenarios. In a study in Australia, Zheng *et al*. (2016) used this method to study attributes that influence a traveller's mode choice and willingness to pay. A mixed logit model was used to analyze the utility function of 3 alternatives (i.e. car, train, and bus). In the SP survey, they determined 6 attributes for the bus, i.e. time to station (2.5, 5, 7.5 min), waiting time (3, 6, 9 min), time in vehicle (16, 32, 48 min), fare (1.2, 2.4, 3.6 AU$), crowding level (6 levels), and time to destination (2.5, 5, 7.5 min).

Hensher *et al*. (2005) mentioned that to ensure the reliability of the SP data, the SP scenarios must be generated with an efficient design. Therefore, Ngene software was used to design the discrete choice experiments of the study in Australia. For generating the mode choice scenarios above, an orthogonal design was applied to obtain balance and independence between the attribute levels.

Methods

Basic Information

The study area includes Salaya district which was divided into 6 homogeneous zones as shown in Figure 1. These 6 zones are further divided into 16 subzones, which are assigned to new bus stops as shown in Figure 2. This study not only includes the zones in Salaya district, but also 3 extra nearby zones. These zones are 2 community centers and an important transportation hub that generates traffic in Phutthamonthon district, a western

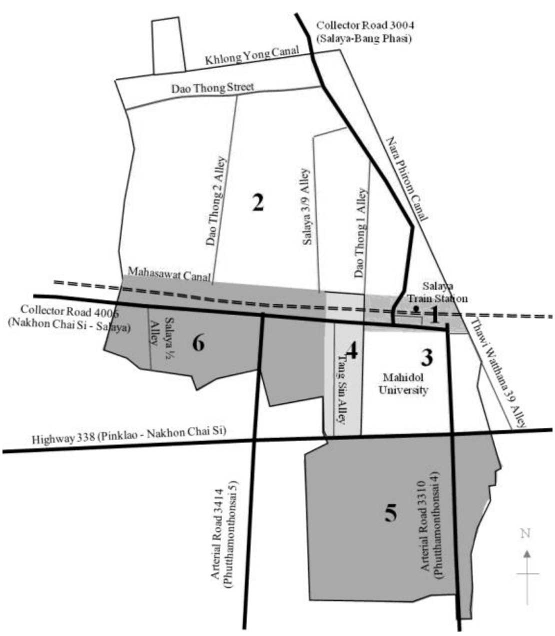

Figure 1. Traffic analysis zone for Salaya

suburb of Bangkok. These extra zones will contribute to higher ridership, if they are considered for a new bus route.

The six zones consist of:

- Zone 1: Salaya railway station. It borders Maha Sawat canal in the north, Mahidol University in the south, and Mahidol University in the west. This zone can access 3 zones i.e. zone 2, zone 3, and zone 4.

- Zone 2: educational and residential zone. Zone 2 can access zone 1 at route number 3004, and zone 6.

- Zone 3: Mahidol University. This zone can access zone 1 at gates 5 and 6 of Mahidol University, and route number 3310. In addition, it can access zone 5 at the Faculty of Nursing and College of Music, Mahidol University on route number 3310.

- Zone 4: residential zone, i.e. Sahaporn community, condominiums, dormitories, and monthly rental houses. This zone can access zones 1 and 6 at route number 4006. Moreover, it can access zone 5 at Baan Tang Sin alley.

- Zone 5: medical center and residential zone. This zone can access zones 3 and 4.

- Zone 6: educational and residential zone. It can access zones 2 and 4 at route number 4006.

The 6 zones above have significantly different utilization and characteristics. A high level of activities and travel demand are likely to occur in these zones.

Model Specification

Considering the difference in population characteristics, disaggregated models are constructed to represent the unique preference of each population group. Initially, the authors divided the Salaya population into 6 groups based on their residences and modes of travel, as shown in Table 1.

Groups 1 and 2 are people who have a permanent residence in Salaya district, e.g. single-family homes and town houses. The first group involves trip makers who use a private mode of transportation. The second group involves trip makers who use public transportation.

Groups 3 and 4 are people who have a temporary residence in Salaya district, e.g. in a condominium, dormitory, or monthly rental

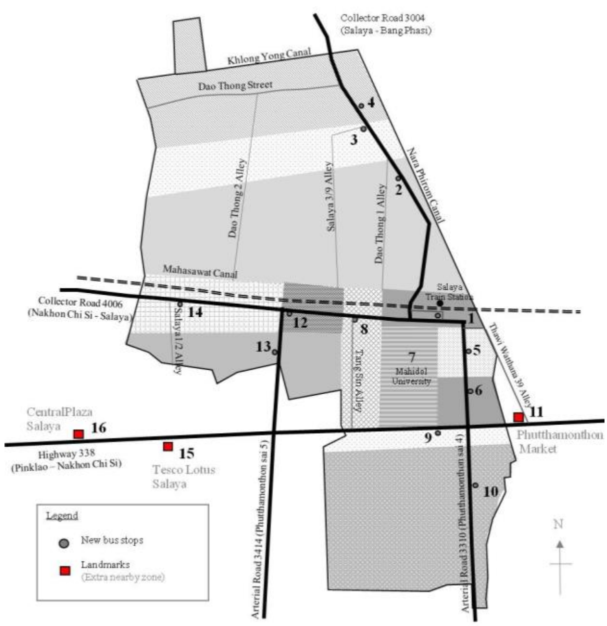

Figure 2. The zoning for consideration of new bus stops

house, and who study or work using a trip from their home base. The third group involves trip makers who use a private mode of transportation. The fourth group involves trip makers who use public transportation.

Groups 5 and 6 contain visitors to or passersby of Salaya district and people who carry out 1-day activities, e.g. shopping, tourism, transit to Salaya district or nearby. The fifth group involves trip makers who use a private mode of transportation. The sixth group involves trip makers who use public transportation.

Attributes Selection

The authors selected 4 key influencing attributes for 4 reasons which are: 1) consistent with local context; 2) quantifiable; 3) communicable; and 4) policy-driven from a literature review. Those attributes are fare, in-vehicle travel time, wait time, and access time. The 4 attributes above were set up in a questionnaire with the stated preference (SP) technique. Each attribute was assigned 4 attribute levels, as shown in Table 2.

The value of these levels was specified base on the current traveling situation within Salaya district, as shown in Table 3.

Scenario Design

Stated preference questionnaire design

The questionnaire includes 3 parts. The first part involves the general information about the respondents. The second part concerns travel information for 2 cases, i.e. internal and external trips. The temporary residents and visitors/passersby groups were asked for information about an internal trip only, because the scope of this study focuses only on the public transportation system in Salaya district.

The third part of the questionnaire focuses on traveller preferences based on the responses to the attributes. The questionnaire consists of 8 choices, 4 tasks for an internal trip and the other 4 for an external trip. Each choice set includes 3 sections. The first section is a revealed preference (RP) consisting of 4 modes (i.e. car, walking, motorcycle taxi, and pick-up bus for an internal trip and car, taxi, van, and bus for an external trip). The second section is a stated preference (SP) consisting of 3 choices for a feeder access mode in the future. In the last section, only 1 alternative from the first and second sections must be selected, as shown in Figure 3.

A choice task generating for SP

Since no prior knowledge is available for the area, the choice tasks of the study were generated by an orthogonal design. This design can reduce the number of choice tasks as well as the number of respondents. The orthogonal design is a method to produce fractional factorial combinations of alternative scenarios.

Table 1. Population cross-classification

	Private mode	Public transportation
Permanent residence	Group 1	Group 2
Temporary residence	Group 3	Group 4
Visitors/ Passersby	Group 5	Group 6

Table 2. Attribute levels determination

Attribute levels of New feeder access mode	Fare (baht)	In-vehicle travel time (min)	Wait time (min)	Access time (min)
Level 1	5	3	5	1
Level 2	10	6	10	3
Level 3	15	9	15	5
Level 4	20	12	20	7

The orthogonal design was selected to generate the experiments for this study.

A choice task as discussed above is generated from the attribute levels in Table 2 by Ngene software (Choice Metrics Pty Ltd, 2014). This study includes 32 choice situations, which are separated into 8 choice sets. Each choice set consists of 4 choice tasks.

Sampling

There are 2 target populations of the study, i. e. Salaya locals (the Salaya population), and the nonregistered population and visitors. From a simple random sample by Yamane (1973), an equation can calculate the minimum sample size for both target populations.

A simple random sample of the Yamane equation can be applied to the study of the Salaya population of 20,114, with a 5% level of precision. Therefore, the Salaya locals have a minimum sample size of 433 (i.e. 393 + 10% tolerance of 393). However, information on the number of the nonregistered population and visitors is not available. Thus, the authors used the simple random sampling table of Yamane of 95% to calculate the minimum sample size, where the level of precision is 5% and the number of the nonregistered population and visitors is infinite. Therefore, the minimum sample size is 440 (i.e. 400+10% tolerance of 400).

Each respondent must select preferred alternatives from the 4 choice tasks in the third part of the questionnaire. Therefore, the numbers of decision makers required are 109 and 110, respectively, as shown in Table 4.

Results and Analysis

The study separated the parameter estimation into 2 cases, i. e. internal trips and external trips. The discrete choice model function of the Nlogit software was used to estimate with the backward selection technique for independent variable selection. For the first step, all variables were entered into the model. Then, those variables with a P-value larger than 0.05 were discarded from the model. The estimation of this model by the Nlogit software, as shown in Table 5, is summarized as follows:

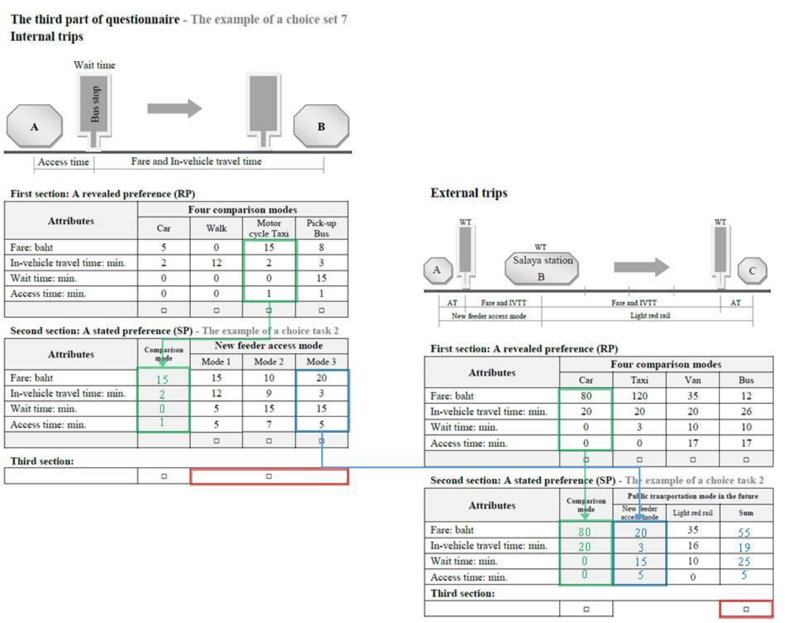

Figure 3. The example of the questionnaire

1) In the fifth group, only 1 attribute has a P-value larger than 0.05 (i.e. wait time). This clearly shows that these attributes do not influence a traveller's mode choice. In other words, this group is presented as being indifferent to the transportation system service characteristics in this study, and is highly unlikely to shift from private mode to public mode of transportation.

2) The access time attribute of the remaining 5 groups can be similarly disregarded as all of them have large P-values. This can imply that access time is unlikely to influence a traveller's mode choice.

3) Judging from the t-test, the people from the private mode of transportation group are most sensitive to the out-of-pocket cost of travel (i.e. fare). In-vehicle travel time and wait time come second and third in terms of sensitivity. People who are in the public transportation group are most sensitive to in-vehicle travel time. Fare and wait time come second and third.

4) Two types of WTP are the ultimate issue for this stage, as shown in Table 6.

The summary above reveals that trip makers who are in the public transportation group have more of an IVTT WTP than trip makers who use the private mode of transportation. The travelers from group 4 have the highest WTP for IVTT and group 1 shows the least WTP for IVTT. Meanwhile, all groups have a similar WTP for wait time. Access time is unlikely to influence a traveller's mode choice as stated above.

In addition, the authors also conducted grouping by other characteristics, e.g. age, gender, and student status. The estimation in Table 7 summarizes the WTP of each socioeconomic grouping.

Table 3. The current traveling situation from zone 1 to other zones

Zone 1 to other zones (Figure 2)	Fare: baht					In-vehicle travel time: min				
	Public Transportation					Public Transportation				
	Hired public transport mode		Public transport mode			Hired public transport mode		Public transport mode		
	Taxi	Motor cycle Taxi	Pick-up Bus	Bus	Van	Taxi	Motor cycle Taxi	Pick-up Bus	Bus	Van
Min	38	15	8	9	14	2	2	3	3	3
Average	52	27	9	10	14	5	6	7	8	4
Max	80	60	10	11	14	13	12	12	13	4
S.D.	11	11	1	1	0	3	3	4	4	1

Zone 1 to other zones (Figure 2)	Wait time: min					Access time: min				
	Public Transportation					Public Transportation				
	Hired public transport mode		Public transport mode			Hired public transport mode		Public transport mode		
	Taxi	Motor cycle Taxi	Pick-up Bus	Bus	Van	Taxi	Motor cycle Taxi	Pick-up Bus	Bus	Van
Min	-	-	10	5	20	3	1	1	1	3
Average	-	-	13	10	20	3	2	2	1	3
Max	-	-	15	15	20	3	2	2	2	3
S.D.	-	-	3	5	0	0	0	1	1	0

Table 4. The required sample size

	The minimum sample size	The number of decision makers
Sample 1	433	109
Sample 2	440	110

Age grouping shows that travellers aged 26-30 years have the most WTP. The second most WTP is the group aged more than 60 years. The WTP tends to decline between the ages of 31-60 years. It may be because travellers aged 26-30 years are entry level workers with a high time constant, while those who are aged more than 60 years are willing to pay for a convenient trip. This is probably because the sample size is too small. Therefore, it is difficult to summarize based on age.

Two remaining groupings show that males and those of other status choose 1 alternative, which is a low fare, while females and those of student status consider 3 attributes equally, i.e. fare, in-vehicle travel time, and wait time. They are willing to pay more than males and those of other status when they want to save travel time (IVTT and WT).

Finally, those of other status (including workers) have less of a WTP for IVTT and WT than those of student status. The possible reason is that those of other status mainly involve Salaya locals. They have a low WTP for travel time because mostly their trips are optional trips, e.g. a shopping trip, while trips for those of student status are mandatory trips.

The authors can show the alternative specific constant (ASC) of 4 comparison modes, i.e. car, walking, motorcycle taxi, and pick-up bus, as shown in Table 8 and in the following discussion:

1) Groups 1 and 3, who are trip makers who use a private mode of transportation, showed more of a greater ASC for car than for motorcycle taxi, walking, and pick-up bus, respectively.

2) Conversely, groups 2 and 4 who are trip makers who use public transport mode

Table 5. **Estimation results of new feeder access mode for internal trip case**

The utility function: $U = \beta_1 * Fare + \beta_2 * In\text{-}vehicle\ time + \beta_3 * Wait\ time$					
	Variables	**Coefficient**		**T-test**	**P-value**
Group 1	Fare	β_1	-0.1148	-8.795	0.0000
	In-vehicle travel time	β_2	-0.0941	-4.953	0.0000
	Wait time	β_3	-0.0567	-5.849	0.0000
Group 2	Fare	β_1	-0.0831	-3.492	0.0005
	In-vehicle travel time	β_2	-0.1342	-3.656	0.0003
	Wait time	β_3	-0.0351	-2.109	0.0349
Group 3	Fare	β_1	-0.1080	-7.520	0.0000
	In-vehicle travel time	β_2	-0.1015	-5.194	0.0000
	Wait time	β_3	-0.0527	-5.042	0.0000
Group 4	Fare	β_1	-0.0740	-3.151	0.0016
	In-vehicle travel time	β_2	-0.1310	-3.707	0.0002
Group 6	Fare	β_1	-0.1635	-2.583	0.0098
	In-vehicle travel time	β_2	-0.1790	-2.714	0.0066
	Wait time	β_3	-0.0779	-2.124	0.0336

Table 6. **Traveler willingness-to-pay for internal trip**

	In-vehicle travel time WTP: IVTT WTP (baht per hour)	**Wait time WTP: WT WTP (baht per hour)**
Group 1	49	30
Group 2	97	25
Group 3	56	29
Group 4	106	N/A
Group 6	66	29

showed a lesser ASC for car than for walking and motorcycle taxi. This result from these groups may be because they prefer a car less than walking and motorcycle taxi because they might dislike driving a car.

3) The ASC of a pick-up bus was the lowest value for all groups because respondents gave it less of a handicap than the other mode choices.

4) Finally, the ASC of all modes was a negative value when those modes were compared with new public transport. It might be that this result involves a tendency or "response bias" because the respondents answered the questionnaire with attention to the public transport development in the study area for which they were direct beneficiaries.

The external trips analysis deals with trips that use a new feeder access mode inside the study area and connects with the Light Red Rail Transit at Salaya station for travel to outside the study area. The estimation of this model with the Nlogit software, as shown in Table 9, is summarized as follows:

1) The disaggregate model cannot generate a meaningful representation of the travellers' decision because almost all attributes from all groups have a P-value more than 0.05. Thus, the aggregate model was applied to estimate the model parameters.

2) In-vehicle travel time and wait time are unlikely to influence a traveller's mode choice because both attributes have P-values larger than 0.05.

Table 7. Willingness-to-pay of grouping by other characteristics

Grouping by		Coefficient		T-test	IVTT WTP (baht/ hour)	WT WTP (baht/ hour)
Age	18 years - 25 years	β_1	-0.1043	-7.125	56	24
		β_2	-0.0979	-4.557		
		β_3	-0.0416	-4.016		
	26 years - 30 years	β_1	-0.0941	-3.547	96	71
		β_2	-0.1502	-4.058		
		β_3	-0.1119	-5.195		
	31 years - 40 years	β_1	-0.0884	-4.857	67	42
		β_2	-0.0981	-3.729		
		β_3	-0.0625	-4.640		
	41 years - 50 years	β_1	-0.0823	-4.970	60	24
		β_2	-0.0823	-3.339		
		β_3	-0.0335	-2.587		
	51 years - 60 years	β_1	-0.1100	-5.044	44	17
		β_2	-0.0805	-2.790		
		β_3	-0.0309	-1.934		
	more than 60 years	β_1	-0.0780	-2.885	88	36
		β_2	-0.1144	-2.968		
		β_3	-0.0472	-2.312		
Gender	Female	β_1	-0.0942	-4.767	70	23
		β_2	-0.1092	-3.707		
		β_3	-0.0361	-2.487		
	Male	β_1	-0.1249	-9.583	42	29
		β_2	-0.0879	-4.884		
		β_3	-0.0604	-6.448		
Student status	Other	β_1	-0.1047	-6.249	46	27
		β_2	-0.0798	-3.323		
		β_3	-0.0466	-3.691		
	Student	β_1	-0.1083	-5.184	79	39
		β_2	-0.1427	-4.570		
		β_3	-0.0700	-5.043		

3) Fare and access time are the 2 most sensitive attributes, respectively.

4) The WTP of this model has only access time WTP, for which it has a high value upto 236 baht per hour.

Discussions and Conclusions

The objective of this paper is to evaluate the travel willingness-to-pay of Salaya locals, and the nonregistered population and visitors. This stage focuses on modeling traveller behavior based on response to attributes for a mode choice decision, from which the authors can reliably summarize 2 issues, as follows: 1) Fare, in-vehicle travel time, and wait time are likely to influence a traveller's mode choice for an internal trip; 2) Fare and access time are likely to influence a traveller's mode choice for an external trip.

The private mode of transportation in the study includes private vehicle use (i. e. motorcycle and car) and soft mode use (i.e. walking and bicycle). Therefore, the WTP for the time to travel of the private mode user is low when it is compared with the public transportation user. Thus, the authors can conclude that all groups have a similar wait time WTP.

The WTP reflects the sensitivity of Salaya travelers to in-vehicle travel time. The public transportation system will be designed in a later stage considering trade-offs between out-of-pocket expenses and speed of service based on the findings of this study and various scenarios will be tested. The utility function derived from each scenario will be used to forecast the new public transportation demand with the best service characteristics, i.e. fare, in-vehicle travel time, and wait time. The authors expect the study outcome will provide a guideline for related organizations in development of public transportation networks. Moreover, seamless connectivity will reduce the number of private mode travellers as well as improve travel time and minimize other societal costs.

Appendices

The Average Income of Nakhon Pathom

The average income of Nakhon Pathom was calculated by gross provincial product (GPP) at current market price per capita. In 2015, the GPP per capita of Nakhon Pathom was 288820 baht (Office of the National Economics and Social Development Board, 2015). Therefore, an average income can be calculated in the following way: The average income = (288,820 baht per year) / (1920 hours per year).

Table 8. Alternative specific constant

	ASC_{car}	ASC_{walk}	$ASC_{motorcycle\ taxi}$	$ASC_{pick\text{-}up\ bus}$
Group 1	-0.6936	-2.2584	-1.4768	-3.6816
Group 2	-2.7686	-1.2684	-2.0065	-3.8965
Group 3	-1.0300	-1.6877	-1.3258	-2.9053
Group 4	-3.0001	-2.8826	-0.9199	-3.5204

* The ASC of Group 6 is not mentioned because this is a comparison between a new feeder access mode and 4 modes for trips within the study area.

Table 9. Estimation results of new feeder access mode for external trip case

Variables	Coefficient		T-test	P-value
Fare	β_1	-0.0210	-5.092	0.0000
Access time	β_4	-0.0826	-4.608	0.0000

Normally, working time is 8 h per day and people work 5 days per week. Thus, they have 1920 h for working per year. From the calculation, the average income of Nakhon Pathom is 150.43 baht per hour.

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