Article

A Solution of Traffic Congestion for Ko Chang Piers through Applying Access Fee

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Abstract. Ko Chang, one of the main island attractions of Thailand, is suffering from congestion at its ferry piers due to the great flocks of tourists. Due to the low vehicle-carrying capacity of the ferry, the bottlenecks are observed especially over long weekends. Over volume of private cars that are cause of negative impact to tourist destination is overtourism phenomenon. The problem could be alleviated if the tourists could be encouraged to park their cars at the main land piers and walk on to the ferry. This study aims to find out the Thai tourist mode choice preference and develops a binary logit model with its objective to alleviate the congestion via the demand management strategies. The results show that the monetary cost and wait time in the queue are the primary and secondary factors affecting the tourist's decision. It is also shown that almost half of the tourists would leave their cars on the mainland if 500-baht charge is applied with the 3 hour wait.

Keywords: Mode choice model, binary logit model, park-and-ride, public transport, logistics tourism, overtourism.
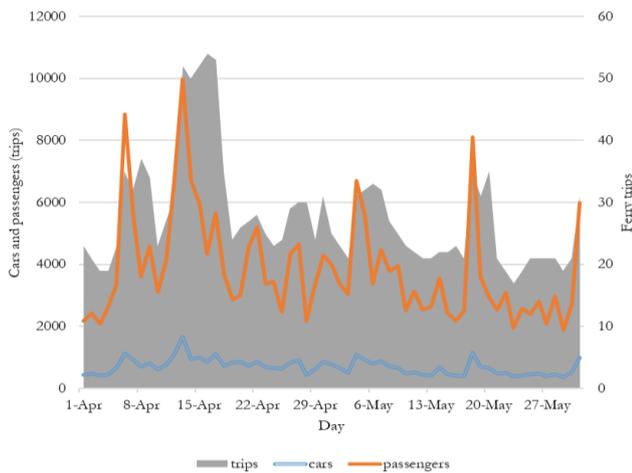
1. Introduction
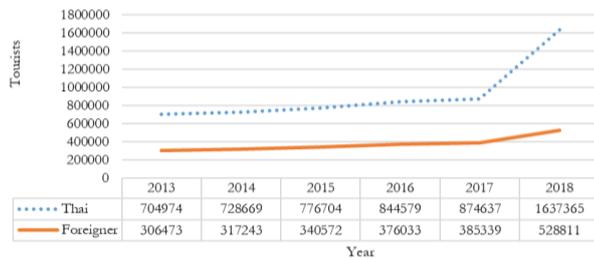
Source: Tourism and Sports office, Trat province.
Fig. 1. Number of Tourists per year.

Source: Marine Office, Trat Branch.
Fig. 2. Tourist statistics during high season of 2019.

Ko Chang or Chang island is one of the most popular destinations for summer vacation in Thailand. Figure 1 shows that more than one million tourists visit the island every year. Approximately 70 percent of these tourists are Thais. A great proportion of the Thai tourists drive to the pier and many decide to drive on to Ko Chang. On the contrary, the foreign tourists normally access the island by public transport including intercity bus and van, mostly from Bangkok. Some access Trat by airplane where the airport is located 20 minutes away from the pier.

Since there is no connection bridge, the ferry is the only way to access the island. Currently, two operators provide the ferry service to Ko Chang, namely Ko Chang International and Cenferry. The former's main customers include the Thai and foreign tourists while the latter's are the locals and government workers. Ko Chang International provides its service between Ao Thammachat on the mainland to Ao Sapparot on the island. Its large and seasonal traveler volumes usually cause serious traffic congestion formed by the long lines of the private vehicles during weekends and long holidays. The congestion greatly affects the tourists as well as the locals in terms of pollution, accidents and various forms of opportunity loss. Figure 2 shows the high demand and the variation of the tourists during the high season in 2019. The graph reaches its peak in the middle of April during

the Songkran festival. Approximately 10,000 tourists with 1,600 cars spend 4 hours on average waiting to cross to the island.

2. Background of the Study

The phenomenon of overcrowding of tourists that generates negative impact to the environment and the residents is known as overtourism [1]. Benefits from tourism may not be equally distributed to all local communities, while their quality of life is greatly affected regardless [2]. Overtourism occurred from three main reasons: sociological, business, and technological and economic factors [3]. The sociological factor involved the state of unhappiness. People were stressed from overworking and believed that travel could relieve the burnout syndrome. The business factor addressed the influence of marketing. Marketing planners sought various strategies to increase tourism demand. Lastly, the technological and economic factor involved the advancement of internet and transportation. Travelers accessed and shared more information on various social media platforms, thus increase travel demand. Meanwhile transportation businesses were gearing toward low-cost services. Travelers made intercontinental trips with lower fare and charges.

The overtourism in East African countries affected many vulnerable historical and environmental attraction and thus irritated local people [4]. The proposed solution called for collaboration among government, stakeholders, and local communities to identify limit of acceptable change. Meanwhile, the proportionate taxation systems and monitoring program should be exercised by the government to ensure an acceptable level of tourism activities. A study in Krakow, Poland recommended the co-management strategy and agreement in value chain between the government and stakeholders at different levels [5]. A study in Algeria suggested that overtourism could be prevented by building awareness of environment to stakeholders, local community and tourists [6]. A research of endangered species in an Australian national park suggested the number of tourists should be limited by using a conservation penalty system. The national park would gain profit despite a smaller number of visitors. It will become high quality tourism [7]. A research of marine travel in Chile also recommended charging visitor fees based on the willingness-to-pay to prevent overtourism. [8]. However, the visitor fees should be set at a reasonable and affordable level. Otherwise, only high-income tourists can afford to visit. The willingness-to-pay was also found to increase if the purpose of fee collection was well explained [9].

The congestion on Ko Chang, which can be considered an aftermath of overtourism, normally occurred on long holiday. The traffic problem apparently was caused by excess vehicles compared to the ferry service capacity, the pier facilities and relevant infrastructure. Reducing the number of vehicles and promoting pedestrianization and public transportation on

the island should be the key to alleviate this overtourism effect.

3. Individual Choice Theory and Its Applications

This research determines the factors affecting the decision to take or to leave the private cars and establish the strategies to alleviate the traffic congestion. The tourist travel behaviors have been analyzed and the mode choice model has been developed to understand the reasons behind decisions. The model was developed based on the discrete choice and applied to the modes of transport using the Random Utility Theory. The model assumes that the consumers will choose the alternative with the highest utility by comparing with those from other alternatives. The systematic utility is the measurable part containing sum of the weighted quantitative attributes and choice specific constant or unobserved attributes. The random utility part involves an error term reflecting the random bias in choosing one mode over the others [10] The following denotes a linear utility function.

$$U_i = V_i + \varepsilon_i \qquad (1)$$

where

U_i = utility of choice i
V_i = systematic utility of choice i
ε_i = error term
i = individual's alternative

Systematic variables are weighted by parameters. The parameters are estimated from consumer behavior's observation. The following is systematic variable equation.

$$V_i = \beta_{0i} + \sum \beta_{ki} X_{ki} \qquad (2)$$

where

β_{0i} = alternative specific constant for choice i
β_{ki} = parameters representing the weight of attributes k for choice i
X_{ki} = attributes k for choice i
i,j = alternatives
k = attributes

A binary logit model is applied to the specific situation with only two modes to explain the choice behavior. It takes the following form:

$$P(i) = \exp(\Delta V) \,/\, 1+ \exp(\Delta V) \qquad (3)$$

Where

P (i) = probability of choosing mode i over mode j
ΔV = the difference of systematic utility of mode i and j, i.e. $V_i - V_j$

The Mode Choice Theory has been applied to transportation studies in many ways. Previous studies found that the tourists who travelled during the weekdays liked to plan the trip. If the total costs for private car driving increased, they would shift to the alternative mode. On the other hands, the tourists during holidays were more concerned about time than cost. They preferred to drive and would change the pattern of the trip if the travel time was longer [11]. A study in southern Thailand used the Reveled Preference (RP) technique to study the present mode shares in a university and using the Stated Preference (SP) technique to study the effect of various elements including parking control, parking fee, quality of public transport and quality of facilities. It was found that the visitors switched to walk, biked a ride and used electric bus more often than the students and staff [12]. The congestion in China was studied and found that the travelers would shift to the public transport if the cost was higher, assuming such situation as the increasing parking fee and the discounted transit fare, while time had more effect on work trips [13]. Another study conducted on the urban mode shift from the motorcyclists to the public transport in Iran found that the travel time was the most influencing attribute. If they decided to shift the mode, they would prefer the light rail transit due to the lower travel time during the morning period [14]. A study of private car usage in Khon Kaen found that travel time and travel cost were the key factors influencing mode choice decision [15]. A car-rail mode shift study in Mumbai found that waiting time, travel time, travel cost and discomfort greatly impact traveler's decision [16]. Same as the research in Ahmedabad found that travel time and travel cost are mainly affected to increase feeder user [17]. A study in northern of Thailand found that travelers will shift to travel by rail because of travel time. Travelers expect that the schedule should be punctually and flexible with traveler's trip [18]. The study in Netherland found that travel time is the most important for transit between car and train for medium and longer distance trips. Travel time includes in-vehicle, transfers and waiting time [19]. Another mode choice study was carried out on disaster evacuation in Thailand. Three separated binary logit models were developed to explain behaviour of people in areas of floods and landslides. It was found that 2 factor groups were affecting mode choice including socioeconomic characteristics and transport system. Socieconomic included sex, household size, family with young members, education, car ownership etc. Transport system included travel time and walking time[20]. A study of park and ride facility in Bangkok was also conducted using binaty logit model. The study concluded that travel time and driving distance from and to park and ride affect user's choice[21].

4. Materials and Methods

4.1. Population and Sampling

The population of the study includes the Thai travelers who always drive their private cars onto the island especially during a high season. The foreign visitors and other types of ferry passengers were neglected as they combined to only minority of the total passengers and the

vehicles crossing to the island. Data collection was conducted in 4 areas including Ao Sapparot pier, White sand beach, Bang Bao bay and Mhu Ko Chang National park viewpoint. This study estimated the sample size by Cochran's method [22]. From the previous statistics, it is assumed that 70% of the tourist are Thai with an error of 5 percent. The minimum sampling is 323 choice tasks.

$$n = \frac{P(1-P)Z^2}{e^2} \qquad (4)$$

$$= \frac{0.7(1-0.7)\,1.96^2}{0.05^2}$$

$$= 323$$

Where

n = sampling size

P = population = 70%

Z = standard deviation = 95% = 1.96

e = error = 5%

4.2. Construct questionnaires from experimental design

Use The attributes affecting the mode choice can be categorized into three groups: socioeconomic, trip, and mode characteristics. The socio-economic characteristics include such factors as gender, age, education, marriage status, income, vehicle ownership, and driving license. Previous study found that male and female usually had different sensitivities to various travel factors. Schoolboys walk more than schoolgirls in all ages [23]. Some studies found that the elderly were concerned about convenience because of their health problems. On the other hand, some elderly preferred to exercise so they would be concern about safe and convenience access to the transit points [24]. Families with children were more concerned about safety, reliability, comfort and convenience [25]. Income was still the main effect to the travel choice. The travelers from some specific income group would change the mode of transport if the price was higher, while others still preferred to pay higher if they could save time [14]. This study will apply gender, age and income to study the traveler's behavior.

The trip characteristics include such factors as trip purpose, trip origin, trip destination, companions, traveling with luggage, among the others. Previous study found that distance is related to the selection of the mode of transport. Travelers preferred to drive a car in long distance trips. Destinations may also have an effect to the traveler's decision [26]. It was also found that companions affected the transport mode choice. The travelers would switch mode if they traveled with their families [25]. Luggage affected the mode of transport if the travelers had to transfer. Travelers may think of cost, safety and convenience when accessing other modes [27]. In this

study, the trip purpose is not considered because the travelers have the same vacation purpose.

Mode characteristics include relevant attributes such as travel cost, travel time, convenience, comfort, accessibility, safety, reliability, weather, flexibility among the others. This study will use the travelling time and the travelling cost because they are widely accepted as the most common attributes for the mode choice analysis [11]-[21]. This study also studies about the access time. Previous study found that some travelers preferred to use the private car even the cost of driving was higher. They preferred the direct trip rather than transfer, and if they had to use the transit, they preferred not to change the modes. Other transfer conditions such as accessing time, transfer time, baggage transfer, convenience and connecting insurance were also found as the main effects on the transport mode choice [27].

The analysis relies on the stated preference (SP) experiment technique. The questionnaires are divided into four sections: the information on the travelers, the trips being made, the mode choice scenarios under different attributes, and the quality attributes under Likert scales respectively.

4.3. Experimental Design

Use Two alternatives are available for the travelers to access the island. The first choice is to take the private car on the ferry and drive it on the island. The second is to park near the ferry pier on the mainland and get on the ferry on foot. If making this choice, the travelers must rely on the public transport while staying on the island. As Ko Chang is well-known destination for Thai tourists, the study assumes the decision makers have prior information about other services at the time they make the decision. In other words, this study will focus only two combinations of the mode choices which are Car-Ferry-Car ("Car" choice) and, Car-Parking-ferry-pedestrian ("Park" choice). Attributes in consideration are as shown in Table 1 with the corresponding levels.

The travel costs for the car and park comprise the ferry's fare and the parking fee. Access distance refers to the distance between parking and the ferry pier and is only specific for the park choice. Waiting time for both choices means the waiting time in the corresponding queues (i.e., car and pedestrian) at the ferry pier. Lastly, the public transport fare on Ko Chang is only for park choice.

Table 1. Attributes levels for full fractional design.

Attribute	Attribute level	
	Car	Park
Travel cost (baht)	200, 400, 800	80, 130, 180
Access distance (metre)	-	300, 600, 900
Waiting time (hour)	2, 3, 4	0.5, 1, 1.5
Public transport fare (baht)	-	50, 100, 150

The possible choices and attribute combinations in the questionnaire are reduced by using the NGENE program to generate the balanced orthogonal fractional factorial designs [28]. The resulting design contains 36 choice tasks divided into 12 blocks. In other words, each respondent will have to decision on 3 scenarios or choice tasks. Other attributes are the quality factors that will be evaluated by Likert scale.

Table 2. Example of a choice task in questionnaire.

Scenario 1	Car (1)	Park (2)
Travel cost including ferry fare for both car and person and parking fee (per person)	400 baht	130 baht
Distance from parking to the pier	-	600 m. (walking 10 minutes)
Waiting time at the pier	2 hours	1.5 hours
Mini bus fare per day	-	150 baht
Choose (1) or (2)	☐	☐

4.4. Generic and Alternative Specific Attributes

There are two kinds of attributes which are the generic and alternative-specific attributes. Generic attributes mean the general variables that directly affect the utility of all modes. This study assumes that cost is the generic attribute for the parking and car modes because the tourists pay out-of-pocket for both modes and no other hidden cost are charged. Alternative-specific attributes involve the alternative-specific variables that affect some modes. This study assumes that the access distance and public transport fare are specific for the park mode. Waiting times for the park and car modes are also the specific attribute. The travelers prefer comfortably waiting in the cars while waiting in the passenger terminal.

5. Results

5.1. Traveler's Information

Data were collected on 23-24 November 2019 and 7-8 December 2019 from 09.00 a.m. to 3.00 p.m. at the Ko Chang's Ao Sapparot pier, White sand beach, Bang Bao bay and Mhu Ko Chang National park viewpoint. 12 stated preference (SP) choices were developed. Each respondent can answer 3 SP choices. Thus, minimum sampling is 108 persons,for 324 scenarios. The questionnaires were distributed to 205 respondents, each

of whom answered 3 choice tasks, for a total of 615 scenarios. Table 3 shows the information on the respondents' gender, age and income distributions. The proportion of male and female were quite similar. The female respondents accounted for 54 percent while the males accounted for the other 46 percent. It was also found that the majority of the travelers are of early working age. The elderly belong to the smallest age group. The data also shows that most of the travelers have the low to the medium income, under 36,000 baht (approximately US$1,200) per month. (Information from Adecco Thailand Salary Guide 2019 [29] shows that new graduates earned salary between 18,000 baht to 25,000 baht. Employees who had 5 years experienced working had salary between 35,000 baht to 120,000 baht. This research divided into 3 groups based on their income includes workers who earned daily wages and new graduates who earned entry-level salary, general wokers , junior and senior level workers. Therefore, low income ranged less than 18,000 per month. Medium income ranged between 18,000 – 36,000 per month. High income ranged more than 36,000 per month.)

Table 3. Traveler's information.

Information		Quantities	Percentage
Gender	Male	94	46
	Female	111	54
Age	< 25	41	20
	25-34	81	40
	35-44	52	25
	> 45	31	15
Income (baht)	Under18,000	98	48
	18,000-36,000	80	39
	> 36,000	27	13
Origin	Bangkok	58	28
	Central	27	13
	East	88	43
	North	10	5
	Northeast	20	10
	South	2	1
Destination	1 Salak Phet Bay, Salak Khok Bay,Red Sand Beach	18	1
	2 Khlong Son Bay, White Sand Beach	49	10
	3 Pearl Beach	1	15

Information		Quantities	Percentage
	4 Khlong Phrao Beach	20	9
	5 Kai Bae Beach	31	10
	6 Lonely Beach, Bai Lan Beach	19	22
	7 Bang Bao Bay	21	24
	8 More than 1 destination	46	9
Number of companions	0	17	8
	1-2	71	35
	> 2	117	57
Type of companions	No	16	8
	Family	97	47
	Friend	78	38
	Family and friends	14	7
Length of stay	1 day	47	23
	2 days 1 night	96	47
	3 days 2 nights or larger	62	30
Luggage (piece)	1	74	36
	2-3	91	44
	> 3	40	20
Travel budget (baht per person per visit)	< 1,000	27	13
	1,000 – 2,000	107	52
	> 2,000	71	35

5.2. Model Calibration

The utility equations of the car and parking modes are calibrated for the parameters by the estimation using the maximum likelihood method. The parameters are estimated from the customer's survey showing the trend how they make their decisions. The maximum likelihood method is applied of which function is given as

$$L(\theta \mid x_1, x_2, \ldots, x_n;) = \Pi_{n=1}^{N} P_x(x_t \mid \theta) \qquad (5)$$

Eq. (5) is maximized by using the NLOGIT program. The SP survey data are the input into the program. The aggregate analysis shows that the car users are affected by the cost and waiting time with 5 percent significance. Meanwhile, the access distance and public transport fare on the island become non-factors in the mode choice as both show low z scores. The detailed coefficients and

indicators are shown in Table 4. The sample were then split into three groups based on income, in an attempt to determine whether they hold different sensitivity towards the selected transport factors. Tables 5 to 7 show the calibration of the key values for all three groups. It was found that the travelers with all levels of income are affected by cost and time with 99 confidence level. Low income travelers are highly affected by cost with significance of 95 percent. Medium income travelers are affected by cost with significance of 99 percent. Travelers are affected by waiting time when driving car with significance of 95 percent. Therefore,the medium income group is the only group that is affected by the waiting time when using car. High income travelers are affected by cost with significance of 99 percent. Further t-test showed that the sensitivities of the low and medium income group are not significantly different. It shows that t-test score for low and medium model is 1.08. On the other hand, t-test score for medium and high model is 2.36. Thus, the data from the low and medium income groups are considered homogeneous and calibrated for a single set of parameters as shown in Table 8. Low-to-Medium income travelers are affected by cost and time car with significance of 99 percent. (The result will show significant level of each attributes as *, **, ***. It means 90%, 95%, 99% level of confidence, respectively.)

Table 4. Results from all levels of income.

Parameter	All levels of income		
	Coefficient	Standard error	Z
Cost	-0.00161***	0.00033	-4.84
Timecar	-0.29277***	0.1024	-2.86
ASC_car	1.43925***	0.34341	4.19
Log likelihood function	-410.14227		
Chi-squared	32.24584		
Number of observations	615		

Table 5. Result from low income group.

Parameter	Low		
	Coefficient	Standard error	Z
Cost	-0.00116**	0.00047	-2.46
ASC_car	0.33016*	0.19488	1.69
Log likelihood function	-200.59374		
Chi-squared	6.16534		
Number of observations	294		

Table 6. Result from medium income group.

Parameter	Medium		
	Coefficient	Standard error	Z
Cost	-0.0018***	0.00054	-3.34
Timecar	-0.39802**	0.16472	-2.42
ASC_car	1.7162***	0.56164	3.06
Log likelihood function	-157.73179		
Chi-squared	16.83027		
Number of observations	240		

Table 7. Result from high income group.

Parameter	High		
	Coefficient	Standard error	Z
Cost	-0.00334***	0.00104	-3.20
ASC_car	1.80318***	0.47412	3.80
Log likelihood function	-47.18458		
Chi-squared	11.2991		
Number of observations	81		

Table 8. Result from Low-to-medium groups.

Parameter	Low-to-medium		
	Co-efficient	Standard error	Z
Cost	-0.00142***	0.00035	-4.01
Timecar	-0.30504***	0.10934	-2.79
ASC_car	1.32813***	0.36599	3.63
Log likelihood function	-357.6859		
Chi-squared	24.3025		
Number of observations	534		

Definition of Cost is the total travel expenses including ferry fare for both car and person and parking fee per person. The meaning of Timecar is waiting time at the pier for car mode.

The log-likelihood values of the models depend on the number of sampling. The log-likelihood in all group scenarios produces the highest negative value because it has a lot of samplings, while the log-likelihood of the high income model is the lowest as it relies on only 81 responses.

The Chi-square values are also applied to prove the hypothesis. H_0 means Homoscedasticity and H_1 means Heteroskedasticity. The Chi square should be in null hypothesis (H_0). The result shows that all medium, high,

and low-to-medium models yield the Chi-square higher than the critical value at the level of confidence at 99.99%. The low model yield the acceptable value at the level of confidence at 95%. Thus, all models have proved that each alternative is independent.

5.3. Random Utilities Application

The random utility equations are concluded from the aforementioned tables for the low-to-medium income (U_{lm}) and the high income model (U_h) as follows:

$$U_{lm}(Car) = 1.32813 - (0.00142*CostCar) - (0.30504*TimeCar) \qquad (6)$$

$$U_{lm}(Park) = -0.00142*CostPark \qquad (7)$$

$$U_h(Car) = 1.80318 - (0.00334*CostCar) \qquad (8)$$

$$U_h(Park) = -0.00334*CostPark \qquad (9)$$

To illustrate the effect of the travelling cost, a base case is established for the pedestrian passengers to pay a fare of 100 baht per person and free parking. The cost of the car mode includes passenger fare of 100 baht per person and the car charge ranges from 100, 200, 300 and 400 baht. The car's waiting time in the queue is varied from 30 minutes, 1, 2, 3 and 4 hours. Figure 3 shows the probability of taking a car on the ferry to Ko Chang under the aforementioned travel cost and time scenarios. It is found that the ferry fare apparently affects the traveler's mode choice. If the price is high, more travelers will shift to the park and ride mode. The low-to-medium income travelers will shift the mode if the waiting time is longer. Figure 4 shows the probability of the utility car for the high income travelers. When the cost is 200 baht, 81 percent still choose to drive onto the island. The proportion gradually decreases to 76, 69 and 61 percent at costs 300, 400 and 500 baht respectively.

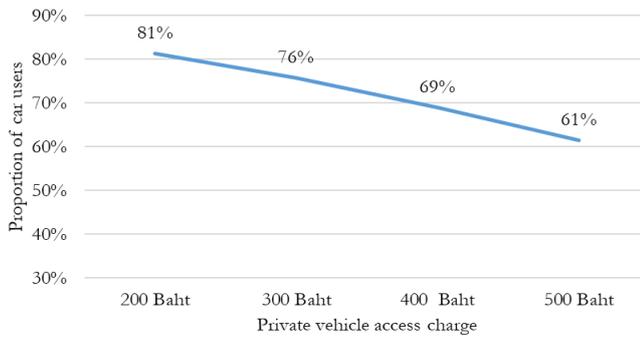Fig. 3. Proportion of car users for low-to-medium income.

Fig. 4. Proportion of the car users for the high income.

5.4. Other influential factors

They are also investigated in a qualitative technique. The respondents were asked to score in Likert scale for their opinions on the significance of the qualities of the parking security system, parking area, parking terminal, ferry service, public transport drivers, public transport vehicle, day pass program, luggage service and tracking application. The results show that the travelers strongly agree on improving the passenger terminal and also agree in improving the parking area. The comments are neutral towards other factors.
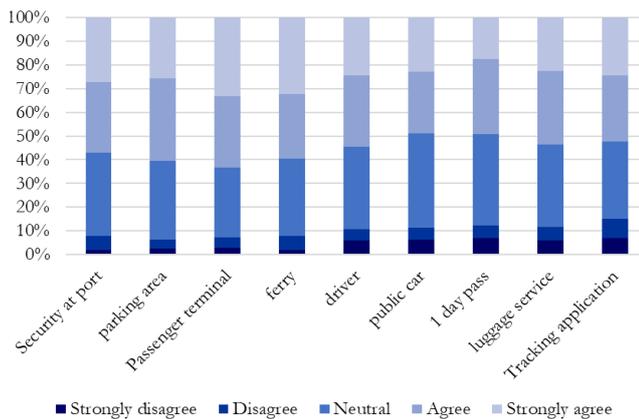

Fig. 5. Improvement satisfaction by Likert scale.

6. Discussion

The access distance and public transport fare on the island become non-factors becuase the respondents may not realized the actual cost of access distance at the time of survey. Obviously, the travelers who have the low-to-medium income are affected by cost and time. A few previous studies supports this fact [15]-[17]. The travelers with the high income are also affected by the cost of travel, but with the lower sensitivity supported by previous study that found some travelers preferred to use the private car even the cost of driving was higher[27]. Time difference between two modes is not significant. In addition, visitors are likely to accept long wait during holidays. Thus, the study suggests that the government set the new policy under willingness to pay supported by previous research [8]-[9]. This study also simulates the policy by reducing the parking fee until it is free and increases the car access cost in Table 9. Pedestrian passengers fare are 100 baht per person and free parking. The cost of the car mode includes passenger fare of 100 baht per person and the car charge ranges from 100, 200, 300 and 400 baht. In the real situation, 10,000 travelers accessed to Ko Chang on the first day of the Songkran festival, 70 percent of which are Thais. Number of travelers are 7,000 persons. According to the respondence survey that has low-to-medium income 6,090 persons (87%) and high income 910 persons (13%). In fact, travelers have to wait at least 3 hours, so the research is applied 3 hours model. The result of price policies shows that proportion of car user will shift 6% ,13% and 20% percent by policy 1 ,2 and 3 respectively.

Table 9. Simulation for cost policy.

	Cost		Mode choice		%
	Car	Park	Car	Park	Shift
Base	200	100	4,195	2,805	N/A
Policy1	300	100	3,930	3,070	6%
Policy2	400	100	3,653	3,347	13%
Policy3	500	100	3,369	3,631	20%

The travelers are also looking forward to the improvement of the passenger terminals and the parking areas. There are 4 parking lots near both ferry piers, for a total of approximately 500 spaces. The parking lot closest to Ao Thammachat has more than 100 parking spaces. We recommend to increase parking lots and improve facilities for pedestrians. The operators should set the new standard to support the public transport. It is also recommended that the ferry operators improve the queuing system management at the ferry pier. Cars and passengers should experience different waiting time at the queue. The travelers should be able to be informed of the waiting time to decide on the mode of travelling.

7. Conclusion

Private car driving greatly affects congestion. The study of the traveler's behavior would alleviate this problem by forcing the travelers to switch to the preferred choice. It is found that the cost and time were the major factors causing the traveler to shift from the private car to the pedestrian. However, this study is still limited to regulate the policies and the strategies because it does not study about the cost analysis. If the travel cost increases to a certain level, some travelers will change to another destination. Models could be further defined by separating the models by age, trip purpose, trip length, companions or luggage. Furthermore, the policy is subject to the feedback loop. If the price is higher, the proportion of the car users will decrease and the waiting time at the pier will also decrease. When the waiting time decreases, the proportion of the car users will increase again. Thus, it is recommended that the study on the cost and time in a dynamic system should be conducted in the future.

Further studies could be conducted on policy regulations including environmental taxation or ferry dynamic pricing. Further studies could be study access to other modes such as park and ride for airplane mode or train mode.

Acknowledgement

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