2. Evaluating public preferences on alternative public transportation in Chiang Mai, Thailand

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0. Abstract

This study provides the fixed routes minibuses services for Chiang Mai city. The optimum routes has been designed to suit Chiang Mai conditions by using both geographic information systems (GIS) together with user demand analysis and public transport network design theories. Then, stated preference survey is constructed in order to examine willingness to change to the new mode of Chiang Mai people in several costs and time level. Using data obtained from a stated preference survey, the binary choice model was developed to predict modal share between auto (current mode) and transit (proposed new bus system). With statistic process, Utility function of both student and worker consist of level of service variables and socio-economic variables. Then levels of service, cost and time, variables are substituted into the constructed model. The result of sensitivity analysis can be explained that whenever bus costs are decreasing the number of individual willing to use auto are also decreased. The decreasing of percentage of current mode users is expected as the raise of number of bus's passengers.

Keyword: public preference, public transportation, binary logit, utility function

1. Introduction

Chiang Mai is located in the northern region of Thailand. The city has been developing in to a major city in the northern region since the 4th National Economic and Social Development Plan (1977-1981). The plan's objective is to distribute income and economic growth to the North by decentralizing the economic concentration of the country. This has encouraged Chiang Mai to be the regional center of several important activities, especially administration, education, tourism, commerce and finance. The city has rapidly expanded especially during the last two decades, while many problems have been occurred including traffic congestion. One of the major causes is that there is no convenient transit system.

The existing public transportation in Chiang Mai urban area consists of 3 major types, which are tuk tuk, tri-cycles and shared taxi. The entire public transportation in Chiang Mai Urban area is flexible. The main transit system is shared taxis (87 percent) and nowadays there are more than 2000-shared taxis in Chiang Mai. On the other hand, many problems have been generated by shared taxis, such as abundance of vehicles, no fixed routes, no fixed time table, as well as no fixed service costs.

Figure 1.1 Red Shared-taxi

According to the study on improvement of road traffic in Chiang Mai, carried out by Japan International Cooperation Agency (JICA), 75 percent of Chiang Mai people prefer fixed route minibuses (24-seat) as the public transportation, but the remaining 25 percent prefer the flexible route minibuses. The Chiang Mai municipality is now purchasing 26 new minibuses.

The main purpose of this study is to provide the fixed routes services for the minibuses. The optimum routes will be designed to suit Chiang Mai conditions by using both geographic information systems (GIS) together with user demand analysis and public transport network design theories.

Then, stated preference survey is constructed in order to examine willingness to change to the new mode of Chiang Mai people. Three hundred questionnaires were disseminated to two expected groups that are worker and student.

Subsequently, using data obtained from a stated preference survey, the binary choice model was developed to predict modal share between auto (current mode) and transit (proposed new bus system). Additionally, to explain the relationship of independent variable and auto mode choosing.

Choice model are constructed separately by SP survey respondent groups. Utility function of both student and worker consist of mode selecting influence variables. With statistic procedure, the effected variables of each model are refined.

The utility function of worker model comprise of 2 models that are the utility function between bus and PC and the utility function between bus and motorcycle. Where as the student model comprise of 3 models that are utility function between bus and PC, Motorcycles and school bus respectively. The influence variables: include total cost, total time, and socioeconomic variables.

The most valuable way to use a simulation model is to run it numerous times with change in inputs. Levels of service, cost and time, variables are substituted into the constructed models.

The result obtained will be used as a guideline for both improving public transit system and providing a new appropriate public transportation assessment. As the result, the transit system in Chiang Mai city will be more efficiently managed.

2. Methodology

To achieve goals of the study, research is implemented as the following three major steps.

1. Bus network design
2. State Preference survey
3. Discrete choice model

Detail of each steps and required data is described as follow.

Bus network design

In order to design the bus network, passenger demand is the important things that should consider. Passenger demand can be approximately estimated from volume of trip on road network which is the result of traffic assignment model.

In addition, flow directions of passenger are also needed. Passenger flow direction can be considered from desire line which also the result obtained from traffic assignment method.

Traffic assignment model requires 2 types of inputs that are road network and O-D matrix.

Network consist of nodes links and centroid which represent the center of traffic zone, and centroid connector which the dummy link connect centroid and link.

The required data as mentioned can be obtained form Department of civil engineering, Chiang Mai University in GIS format together with person trip O-D matrix.
Moreover, transit network design needs consideration of land use characteristic and user attractive area such as education institute, shopping center, government offices, and major facilities such as hospital or bus terminal.

Stated preference survey

This survey conducted by using questionnaire interviewing method .The study team not only offer the optimize bus route and compute both time and cost of the new public transport but also response to every question from interviewee.

Three hundred questionnaires were disseminated to two expected groups that are worker and student. Questionnaire consists of 3 parts. The first part cover trip characteristic of individuals. The second part related to individual choice, the respondents will be asked to compare and make a preference decision between current mode and proposed mode. In the third part socio-economic data which are related to individual mode choice are collected in order to be the components of further choice model.

Discrete choice model

The final step of this study is to construct binary choice models for predict modal share under the proposed minibus system by using data obtained from the stated preference (SP) survey.

3. Setting up public transit network

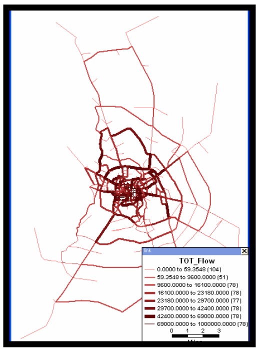
3.1 Demand estimation with Traffic assignment

A traffic assignment model is used to estimate the flow of traffic on a network. These models take as input a matrix of flows that indicate the volume of traffic between origin and destination (O-D) pairs. The flows for each O-D pair are loaded onto the network based on the travel time or impedance of the alternative paths that could carry this traffic.

This study use TransCAD program as an implementation tool. TransCAD is the transportation GIS software which matches for methodology requirement.

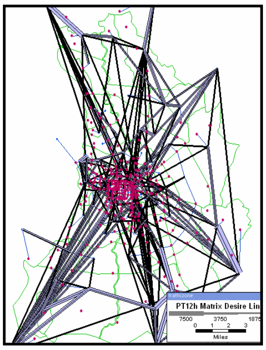
Required data for traffic assignment include an *O-D matrix* and *network* with the appropriate attribute fields, and the line layer from which the network was derived. In order to implement the TransCAD, network need to be transformed into TransCAD special data structure. Moreover, required network attributes vary, depending on the assignment method used. For Stochastic User Equilibrium, required attributes are atleast time and capacity.

The O-D matrix contains the vehicle volumes to be assigned for each O-D pair. The IDs contained in the row and column headings of the matrix view must match the node IDs in the network.
The person trip data obtained form Department of Civil Engineering, Chiang Mai University consist of ,PT 12 hour, PT peak AM (7-8 am) and PT peak PM (5-6 pm).



After all many processes, the assigned link volumes are the primary output of the assignment model. The result of link volume implemented by traffic assignment method is shown in figure 1.2 left. The thick dark color represented the most high volume link.

Figure 1.2 Link volume of person trip 12 hour.



In addition, one of traffic assignment results is desire line. Using centroid or traffic zone layer together with OD matrix, desire line can be easily obtained. Desire line informs direction of link flow. This is the important component in transit network design.

Figure 1.3 Desire line of person trip 12 hour.

3.2 Analyzed Chiang Mai road network

As Chiang Mai is the old cities with more than 700 years history, the most activities are concentrated in the downtown area as similar as other ancient cities all around the world. Street car line fanned out in a radial pattern form the city center into the suburbs. Road characteristics in Chiang Mai consist of 2 types

- Radial and ring system

The system is said to have evolved largely from the structure of the ancient walled city with radial roads branching out from its city gates.

- Grid pattern in site the ancient city

Street within the old city are narrow and laid out in a pseudo-grid pattern bound with the old city moat which divides a pair of one-way streets.

These ring and radial roads carry most of the city traffic and are the arterial or primary roads except super highway is a high-grade 6 lane

In Chiang Mai, this group of collector roads is conspicuously inadequate. The result is that many smaller access roads connect directly to major thoroughfare without first linking to the collectors. In order to create bus network, the road which has an ability to be the bus route should be the arterial streets which have the adequate surface and their geometric characteristics should allow a comfortable movement for buses.

3.3 Analyzed Land used and attractive location

Land used characteristic of Chiang Mai city can be explained as the following.

The dense residential area located within super highway ring road. Within the city center there is generally mixed use area included shophouse, residential area public high school, government office and ancient building.

The city expansion characteristic of scattering the population along the radius roads around the metropolitan area causes high traffic between residential areas and the areas where business and services are located, which are still concentrate inside the city west of the Ping River. Recently, many big department stores, factories, and warehouses have built up where previously only government offices, airport and educational institutions were present at the beginning of the roads in and out of town.

Transit attractive points consist of education institute, big department store, market, hospital and government office which its locations distributed around Chiang Mai city.

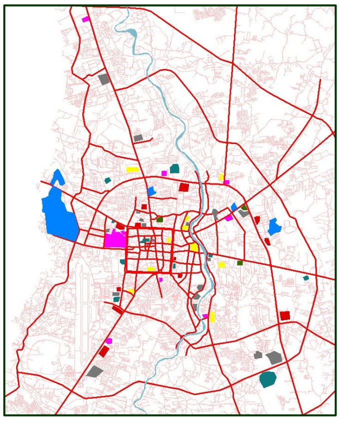


Figure 1.4 Transit attractive area

In addition the following criteria are also considered in order to design bus route.

- Bus route should follow arterial street as much as possible and avoid minor streets
- Bus route should be straight and direct as much as possible. Deviation gives passengers the impression that they are wasting time in unnecessary routing or that they do not follow a more or less direct route to their destination.
- Bus route should pass the major building such as a high school, hospital or shopping center.
- Avoiding of overlapping between bus line
- Both direction of travel for the same route should be on the same road
- Bus route should goes through the urban centre instead of terminating there for

avoiding congestion

- The bus line should be adequately surfaced and their geometric characteristics should allow a comfortable movement for buses.
- The total length of bus line should not exceed a certain limit. It was studied that for Chiang Mai the maximum length should not exceed 15 Km. and not be lower than 5 Km because the average trip length of CM people is 5 Km.

3.4 The designed bus network

Referred the criteria mentioned above 10 bus routes has been designed.

The average bus length of bus routes is 13.56 km which less than the certain limit mention previously. However, there is a route which length over than 15 km.

The average time for bus route computed with boarding time is 33 minutes. The longest route is route 8 on the return route which length 17 km and in vehicle time around 55 minutes.

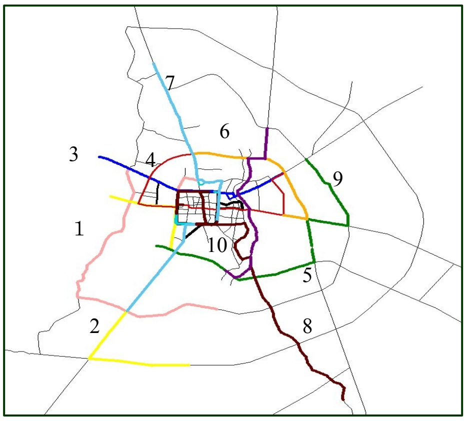


Figure 1.5 Designed bus network

4. Stated preference survey and construction of discrete choice model

4.1 Stated preference survey and the survey result

Stated preference survey is constructed in order to examine willingness to change to the new mode of Chiang Mai people. Three hundred questionnaires were disseminated to two expected groups that are worker and student. 310 questionnaires were distributed to 170 students and 140 workers in 24 specific places such as academic institutes, work places including government offices, university, business districts, big company and shopping centers.

Questionnaires consist of 3 parts. The first part cover trip characteristic of individuals. The second part related to individual choice. New bus network will be proposed to respondent to select their optimize routes then time and cost are also informed. The respondents will be asked to comparing and making a preference decision between current mode and proposed mode.The respondents will be given 4 situations, each situation consist of access time, waiting time, number of transfer, fare, in-vehicle time. In the third part of questionnaire, socio-economic data are collected, in order to be the components of choice model which will be constructed to predict traveller mode selection.

As the result of surveying, travel behavior of Chiang Mai people can be explained as follows

- The most popular mode for both student and worker is motorcycle and personal car relatively. School bus occupied 24.4 percent of student. Whereas Shared-taxi and Kwanweing bus has very low market shared.
- Shared-taxi occupies only 6 percent of student and 10.1 percent of worker. In fact, according to consideration of ability in choosing mode of travel worker can use shared-taxi highly to 48.9 percent, and more than half of students can choose shared-taxi for commuting.
- Most of female uses shared-taxi where as male has very few number of shared-taxi user. However, male has higher percentage of personal car use than female. Both male and female equally use motorcycle
- Most of mothers usually uses shared-taxi service, while fathers highly use personal car and child highly use motorcycle.

4.2 Construction of discrete choice model

This part is to develop the basic theory of random utility models into a class of operational binary choice models, to explain the choice between independent variable and auto mode. This part is to find out which kind of characteristics influence the choice of transportation mode. In addition, constructed model will be used for predict modal share under the proposed minibus system by using data obtained from a stated preference (SP) survey.

Within the purpose of this study to predict number of users to use the new mode, this mean there are individual binary choice between the current modes and the newly proposed bus. As referred, basic idea is pursued further by considering the special case where choice set contains exactly two alternatives. Such situations lead to what are termed **binary choice models**.

The determined model is given by the following:

$$P_n(c) = \Pr(U_{cn} \geq U_{bn}) \text{ and } P_n(b) = 1 - P_n(c)$$

It is denoted the choice set C_n as {c, b} alternative *c* is the current mode and alternative *b* is the proposed bus. The utility function of both worker and student groups can be written as

$$U_{cn} = V_{cn} + \varepsilon_{cn}$$

V_{cn} is called systematic components. The choice probability for alternative *c* is given by

$$P_n(c) = \Pr(U_{cn} \geq U_{bn})$$

$$= \frac{1}{1 + e^{-\mu(V_{cn} - V_{bn})}}$$

Utility functions can be written as :

$Uc = a_o + a_1TOTCOST + a_2TOTTIME + a_4AV\_PC + a_5AV\_MC + a_6AV\_ST + a_7SEX + a_8AGE + a_9OCUP1 + a_{12}EDU + a_{14}INCOME + a_{15}FMEM + a_{16}WHH + a_{17}STATUS1 + a_{21}PCLS + a_{22}MCLS + a_{23}NPC + a_{24}NMC$

$U_b = a_1TOTCOST + a_2TOTTIME$

The variables in utility function can be separated into 2 groups. That is generic and specific variables. Generic variables mostly are level of service variables such as cost and time. Cost which input in function are one way trip cost whereas time are total time spending in trip include access time, waiting time and in vehicle time. Specific variables are socio-economic variables that are gender (SEX), age (AGE), occupation (OCUP), availability of personal car, motorcycle and shared taxi (AV_PC, AV_MC, AV_ST), education level (EDU),monthly income(INCOME), family members (FMEM), number of worker in household (WHH), household status (STATUS), number of occupied PC and MC diver license (PCLS,MCLS) and number of personal car and motorcycle in household(NPC,NMC) which are designed to be 1 or 0.

Generally, inadequate number of model input will be cause of insignificant statistic value in model. Explicitly, the obtained number of respondents currently uses shared –taxi is very low. Therefore, utility function of worker models are include utility function between bus and PC (personal car) and utility function between bus and motorcycle (MC) where as utility functions of student models include utility function between bus and PC, utility function between bus and MC and utility functions between bus and school bus (SCB).

Parameter calibration procedure can be explained as the follows;

① Input all variables into models
② Examine the correlation between variable, a pair of two variables with high correlation should be excluded to avoid multicorrenearlity problem , and also consider the significant value of each variable
③ Selected variables with good statistic value (Significant value< 0.20) and check sign of parameters, for instead cost and time should be minus.
④ Input variable selected in ③ again in model
⑤ Repeat steps ②- ④ until entire of remain variable has prospected significant value.

All of models are examined with *%correct* and *Estimated/Actual.* Models which has high %correct are selected to use in sensitivity analysis.

Worker models
With 42 number of samples, selected model for worker who's usually use *PC* for work is written below.

U_c = 2.669- 0.026TOTCOST – 0.119TOTTIME- 1.780 AGE+1.019EDU1+0.824INCOME+1.118STATUS1+0.981PCLS
U_b = - 0.026TOTCOST – 0.119TOTTIME
With 78.6 %correct

Where as selected model for worker whose use *MC* is

U_c = 1.077 -0.005 TOTCOST -0.002TOTCOST +1.123INCOME -1.274STATUS1 -0.083FMEM
U_b = -0.005 TOTCOST -0.002TOTCOST
With 66.7% correct, using 75 number of samples.

Student models
Utility functions of student who go to school with *PC* is

U_c = 5.435 -0.132TOTTIME -0.021TOTCOST +1.149SEX +1.403AGE
U_b = -0.132TOTTIME -0.021TOTCOST
With 85.7%correct, using 49 samples.

Utility functions of student who go to school by *motorcycle* is

U_c = 8.578 - 0.012TOTCOST – 0.316TOTTIME – 1.699SEX + 0.922INCOME +0.195WHH
U_b = - 0.012TOTCOST – 0.316TOTTIME
With 92.5 %correct, using 67 samples.

Utility functions of student who go to school by *school bus* is
U_c = 4.562 – 0.179TOTCOST – 0.040 TOTTIME + 1.405EDU1 – 2.406 STATUS
U_b = – 0.179TOTCOST – 0.040 TOTTIME
With 78% correct, using 41 samples.

The most valuable way to use a simulation model is to run it numerous times with change in inputs. This section attempts to substitute level of service (LOS) variables, cost and time, into constructed models. By modify cost and time values in models, percent of bus user changing are evaluated as shown in the following figures.

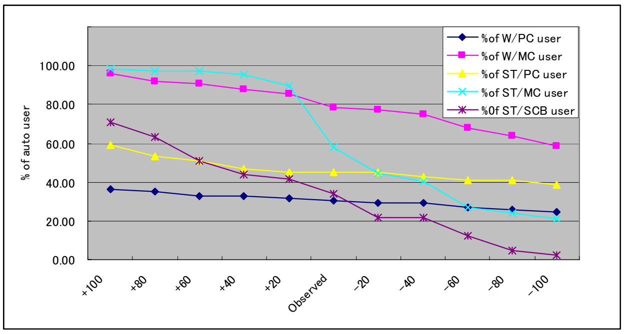


Figure 1.6 Sensitivity analysis in cost adjusting in each mode.

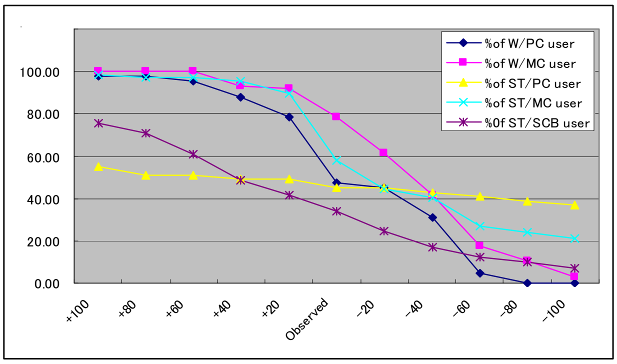


Figure 1.7 Sensitivity analysis in time adjusting in each mode.

Model is substituted numerous times by adjusting level of cost and time into 20,40,60,80 and 100percent respectively. Then, probabilities of individual selecting mode are computed. Shown in figure 1.6 are percentages of auto remaining user when bus costs are adjusted where as figure 1.7 are percentages of each current mode remaining user when bus time are adjusted. It can be explicitly explained that while bus cost and time are decreasing the number of individual willing to use auto are also decreased.

5. Conclusions

This study can be concluded separately by research objectives that are 1) To understanding trip characteristic of Chiang Mai people 2) To setting up efficient public transportation 3) To evaluate the efficiency of new alternative proposed in term of user satisfaction.

5.1 Trip characteristic

Usage Pattern

Most trips are from vicinity to city center. The most TP shared is Motorcycle, (School bus) and Shared-taxi respectively

Attractive of each mode

- The average cost of work trip by personal car is 56.77 THB this is more than third time larger than the second expensive mode; motorcycle.
- For school trip, the most expensive is personal car as similar as work trip. Which the average cost of school trip by PC is 39.80 THB. School bus spend more time than others mode.

Specific relation of socio-economic and auto use

- Most of female uses shared-taxi where as male has very few number of shared-taxi user. However, male has higher percentage of personal car using
- Most of mothers usually use shared-taxi service, while father are highly use personal car and child highly use motorcycle.
- Individual aging between 26-40 years, high income individuals and government officer occupies highest percent of PC user.

5.2 Setting up transit network

- With result of traffic assignment, link volume and desire line, together with Chiang Mai road network characteristic and land use characteristic consideration 10 bus routes are designed.
- The average bus length of bus routes is 13.56 km
- The average time for bus route computed with out time spending while dropping passenger is 33 minutes.
- The longest route is route number 8 on the return route which length 17 km and in vehicle time around 55 minutes.

5.3 Efficiency of new alternative proposed

- As the results of survey, the most frequent used bus route for work trip is route 7. Whereas the most frequent used for school trip is route 8 which pass the numerous of high schools.
- Whereas bus fare is proposed at 5 THB with 5 minutes waiting time, individual prefer bus service. Logistically, while bus fare and waiting time become high, individual tend to remain existing mode

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