Assessment for Transport Development with Attractiveness Measurement of Travel in Asian Developing Cities: a Case Study of Bangkok

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Abstract: Low-carbon transport systems are increasingly required for Asian developing cities where economic growth causes further growth in CO_2 emissions from urban transport. However, low-carbon performance is hardly priority for their transport policies, and it is therefore necessary to make such transport systems more attractive. This study is aimed at quantitatively examining the impacts of transport development on attractiveness to use transport modes in Asian developing cities. With data of a questionnaire survey in Bangkok, it measures preferences to various attractiveness factors related to use of transport modes, classifying them into convenience, comfort and safety elements. Using the preference measures, the impacts of road-oriented development and rail-oriented development on the attractiveness are assessed respectively for car use and railway use. The results show that, in rail-oriented development, railway use could be more attractive than car use, even though residual attractiveness apart from travel time saving could be more significant in car use.

Keywords: Rail development, Attractiveness, Stated Preference, Transport Mode Choice, Asian Developing City

1. INTRODUCTION

As low-carbon development has become a globally important challenge, developing countries are increasingly required for their contribution to it. Particularly, Asian developing countries face rapid growth in CO_2 emissions due to economic growth. The transport sector is one of the most responsible sectors for the emissions, and the development of a low-carbon transport system is necessary there. Strategies to realise a low-carbon transport system can be classified into ones to AVOID unnecessary travel demand, to SHIFT travel modes to lower-carbon ones, and to IMPROVE technologies of transport-related emissions (Nakamura and Hayashi, 2012).

However, priority to low-carbon development has not been high in decision making of transport policies in Asian developing countries. Their transport policies have focused more on road-oriented development as a short-term measure to tackling serious traffic congestion which has been worsened due to rapid motorisation. In order to develop a low-carbon urban transport system, it may be more effective for the SHIFT strategy to introduce mass-transit systems, such as urban railways and BRTs. Nevertheless, attractiveness of car use is so high, as it is more convenient and more comfortable, that promotion of public transport use is not an easy task.

Such perception to transport modes may be different between developed countries and developing countries due to different development paths and stages. Road-oriented development in Asian developing cities has made people increasingly familiar with car use than transit use. Accordingly, once people start to use cars in their mobility development process according to economic growth, they easily rely on car use and hardly shift their travel modes back to public transport use. While recent mass-transit development in Asian developing cities may change their perception to transit use, it is uncertain whether their preferences to transit use could become higher than those to car use.

This study is aimed at examining attractiveness of future transport systems for Asian developing cities, paying attention to factors of convenience, comfort and safety. First, a literature review is made on previous studies to directly and indirectly measure attractiveness of use of transport modes. Then, a research method is specified to measure the indicator of attractiveness to use transport modes by quantitatively examining preferences for a range of attractiveness factors with the data of a questionnaire survey. Finally, for the case study of Bangkok, road-oriented development and rail-oriented development are assessed with the attractiveness indicators.

2. A LITERATURE REVIEW

Attractiveness to use of travel modes can be measured directly with Stated Preference (SP) data and indirectly with Revealed Preference (RP) data. Although it is not easy for developing countries to collect such data, whichever type of research it is for, the latter has been conducted more, using data of actual transport-mode choices. They are mostly not intended to measure attractiveness itself but model transport-mode choice behaviours. Travel survey data is not generally available in Asian developing countries, and it needs to be constructed from partially available data to develop transport-mode choice models. Simple models of them have been developed for Asian developing cities to examine the impacts of improvement of mass-transit services (Seki, 2012; Undrakh, 2011) on transit use, but variables to account for mode choice are limited to travel time and cost.

The SP analysis is more advantageous for capturing attractiveness factors with a questionnaire directly asking respondents about their preferences to each factor. In Asian developing cities, a behavioural model of transport-mode choice using the SP data may be more feasible with an individual survey rather than extensive database construction. Such analysis on the effectiveness of public transport improvement has been conducted in Asian developing cities (Satiennam *et al.*, 2011). However, it also limits its focus to policies assessment to affect travel time and cost for modal shift to public transport use, fixing residual attractiveness attributed to each transport mode.

There are studies on a transport-mode choice model incorporating various attractiveness factors along with time and cost, which has been developed more in developed cities. Morikawa and Sasaki (1993) modelled subjective preferences for attractiveness factors in transport-mode choice based on their causal relationship of latent consciousness. This model has been empirically applied to testing the impacts of various attractiveness factors of travel in mode choice, such as fun, flexibility, reliability, habit, deliverability, safety, and connectivity, as well as fastness and cheapness (Muto, 2004).

The analysis on attractiveness factors of transport-mode choice is more limited in Asian developing cities. It is pointed out that the analysis for developing countries should be carefully designed to reflect their local contexts. Upala (2007) assessed the mode choice between passenger van use and bus use in Bangkok with the SP data, taking account of the factors of comfort and safety. However, it did not clarify the details of comfort and safety factors of each mode, and, as a result, its applicability to choices for other transport modes and that to other cities are questionable.

In assessing future transport systems for Asian developing cities, it is important to analyse the modal-shift impacts of attractiveness factors on a range of transport modes, as a transport system consists of various modes and the future system might have a new mode which is yet to be available. Nevertheless, as previous studies are likely to focus on the choice between specific modes, mode-choice behaviours are hardly generalised at a comparable level between types of modes and between different development stages. Moreover, future preferences may change according to changes in lifestyle attributed to economic growth. Although it is difficult to track lifestyle change in a long term, the change can be captured by comparing values of residents in cities at different economic stages, in terms of their preferences for key factors in travel. This study pays more attention to analysis on examining attractiveness in mode choice in Asian developing cities with more generic indicators of attractiveness factors for travel, despite specific modes, in order to be applicable to long-term assessment for their future transport systems at the matured stage of economic growth.

3. A METHODOLOGY TO MEASURE ATTRACTIVENESS IN MODE CHOICE

This study measures attractiveness to use transport modes in Asian developing cities. First, attractiveness is measured with disutility of a trip by weighting the levels of respective preferences for various attractiveness factors. These attractiveness factors are set to be applicable to types of transport modes with a questionnaire survey. Then, the attractiveness of a trip is aggregated by residential location to assess changes in the spatial distribution of attractiveness in scenarios of future transport development.

3.1 Attractiveness of a Trip

Mode choice is generally analysed with a logit model where a mode is chosen more if its utility is higher based on the random utility theory. This study captures the utility as attractiveness of travel with transport modes. The utility is measured with a linear function of attractiveness factors in mode choice. The levels of preferences for each attractiveness factor are represented by parameters of the utility function, as below. The preference parameters β_l are calibrated with SP survey data, details of which are explained in the next chapter.

$$P_m = \frac{\exp(U_m)}{\sum_k \exp(U_k)} \tag{1}$$

$$U_m = \sum_l \beta_l \cdot X_{m,l} + \varepsilon \tag{2}$$

where,

P_m : possibility to choose transport mode *m*,

U_m : attractiveness (utility) to use transport mode *m*,

$X_{m,l}$: the levels of attractiveness factor *l* to use mode *m*,

β_l : preference parameters for attractiveness factor l, and

ε : an error term.

In this study, attractiveness of a trip is measured as a composite function of attractiveness factors weighted by the preference parameters as disutility which is negative to the utility. The measurement is standardised as a unit of travel time by dividing the preference parameters of attractiveness factors by the parameter of travel time. The measurement scale also needs to be standardised to be comparable between different development scenarios, as the levels of factors may significantly change depending on development. This study uses the average level of year 2005 as the standard and measure changes in disutility from development in 2050. Accordingly, the disutility is measured based on the changes from the 2005 level, standardised to the unit of travel time, including car use and railway use, as below.

$$DUT_{i,j,m} = \bar{t} + \sum_{l} \beta_l \cdot (X_{i,j,l,m} - \overline{X_l}) \quad (3)$$

where,

- i :an origin of a trip,
- j :a destination of a trip,
- $DUT_{i,j,m}$: disutility of trip *i* to *j* to use mode *m*,
- $\bar{t}$: the current average trip time,
- $X_{m,l}$: the levels of attractiveness factor *l* of trip *i* to *j* to use mode *m*,
- $\overline{X}_l$: the current average level of attractiveness factor *l* among all car and rail trips.

3.2 Attractiveness Factors

Although there are many attractiveness factors to affect mode choice, factors to be analysed should be minimised to make the model more generic and data collection easier. This study focuses on attractiveness factors of convenience, comfort and safety, and selects 11 key factors as in Table 1. These factors were mainly chosen by a pre-survey in Bangkok which asked about key factors from the list of potentially important factors taken from previous studies in developed countries to make the results comparable. Although privacy seems similar to space, it is designed as a factor to represent how secure the space is with the level of privacy. Accordingly, privacy is categorised for safety.

Table 1. Specification of attractiveness factors

Element	Factor	Description
Convenience	Travel Time	Travel time of a trip (minutes)
	Delay	Possibility of delay from expected arrival time (dummy)
	Flexibility	Possibility to choose departure time (dummy)
	Access	Travel time of access to a primary transport mode (minutes)
Comfort	Space	Space of travel per person (m^2)
	Protection	Possibility of protection from the weather or pollution (dummy)
	Transfer	Number of transfers
Safety	Accident	Possibility of accidents in travel (dummy)
	Crime	Possibility of crime in travel (dummy)
	Privacy	Level of Private space in travel (dummy)
Cost	Travel Cost	Travel cost (baht)

There may also be other factors to do with local contexts of Asian developing countries. Particularly, one of them is for a local climate issue in some of South Asian cities where the hot weather may make people reluctant to walk outside. To take account of it, this study introduces the factor of protection from the weather, such as roofs and air conditioning equipments in transport modes. The preference parameters for each attractiveness factor to be analysed are identified with the SP data taken from a questionnaire survey.

While the generic preference parameters are chosen in this study, preferences for each transport mode can be represented by setting a differentiated combination of attractiveness factors by transport mode. The characteristics of each transport mode in attractiveness factors are set based on typical characteristics of transport modes (Table 2). Some of the factors are set with values from model estimation for travel time, access time and travel cost, and from statistical references for travel space, accident rate and crime rate. However, some others, such as delay, flexibility and privacy, are hardly quantified, as they depend on perception of travellers. Therefore, the levels of attractiveness factors for each transport mode are basically differentiated in terms of whether which mode is better or worse for the factor.

Table 2. Setting Characteristics of Attractiveness factors by transport mode

Factors	Car use	Rail use
Travel Time	Estimated	Estimated
Delay	Likely (worse)	None (better)
Flexibility	More (better)	Less (worse)
Access	None (better)	Estimated (worse)
Space	$0.81m^2$/person (better)	$0.21m^2$/person (worse)
Protection	Yes	Yes
Transfer	None (better)	Twice (worse)
Accident	0.6% (worse)	0.06% (better)
Crime	0.0125% (better)	0.125% (worse)
Privacy	Little passenger contact (better)	Much passenger contact (worse)
Travel Cost	Estimated	Estimated

3.3 Attractiveness by Residential Location

Transport-mode choice is made not only by trip but also by a set of trips generated by a traveller. Therefore, it is important to assess the attractiveness of transport modes by residential location to represent spatial accessibility, although conventional accessibility indicators do not usually consider the impacts of various factors of attractiveness. This study assesses the attractiveness by residential location as accessibility of residents. It can be used as part of residential utility in location choice. In this study, the attractiveness by residential location is measured as a composite function of the disutility of trip, using the part of a log-sum function. While the log-sum function is often used to measure expected disutility in transport modelling, accessibility is rather measured in such a way that better accessibility is measured with more positive values. As a scale parameter to represent the attractiveness of travel destination, the number of employees in each location is used, divided by the number of total employees in the study area for standardisation.

$$UL_{i,m} = \sum_{j} A_j \cdot \exp(\alpha \cdot DUT_{i,j,m}) \tag{4}$$

where,

$UL_{i,m}$: attractiveness (utility) of location i to choose transport mode m,
A_j :standardised scale parameters of trip destination j,
$DUT_{i,j,m}$: disutility of a trip from i to j by transport mode m, and
α : a decay parameter.

To measure the attractiveness by residential location, this study analyses spatial distribution of intra-urban travel time and cost by car and by railway and the residual attractiveness factors of access and transfer. These spatial factors are estimated with an urban transport model developed in a previous study for Bangkok (Nakamura et al., 2013), which models intra-urban transport OD demand, modal split and travel time with a 4-step model. The model is developed with the data for 2005, and is designed to examine the impacts of future transport systems from road-oriented development and rail-oriented development by differently distributing population and employment depending on the different balance between development of road and rail networks. It outputs the spatial factors by a 3km by 3 km mesh zone which are divided from the whole city.

4. A QUESTIONNAIRE SURVEY

This study conducted a SP questionnaire survey in Bangkok as the case study of Asian developing cities. Bangkok is a typical example of Asian developing megacities which have pursued road-oriented development. Bangkok's planning in the 1960s was designed for a car-dependent city based on American-style development by constructing wide roads with many lanes, while railway development was almost ignored. However, despite extensive road development, the road capacity could not meet the growth of traffic demand. As a result, traffic congestion became so serious that the average speed of cars drastically decreased from 15 km/h to 7 km/h from 1986 to 1993 (Hayashi et al., 2011). Recently, public transport development has started in Bangkok, with the opening of Skytrain (1999), the underground (2004) and the airport rail (2010), and this investment has amounted to approximately 80 km of new routes. This is a different situation of a transport system from ones in developed cities where people are familiar with mass-transit use. While the urban railway development has increased the ridership in Bangkok, many people may still prefer car use.

A questionnaire survey needs to be conducted to collect the SP data to examine preferences for attractiveness factors in mode choice. This study uses a conjoint analysis to identify the preference parameters. For each attractiveness factor, better and worse choices are set (Table 3). The questionnaire does not show specific figures of the choices for some of the factors, such as accident, crime and privacy, but shows their subjective levels, as their figures are not straightforward to respondents. In the interview survey, the difference of choices about each factor is first explained to respondents by local interviewers in Thai language. Then, choices for each factor are combined among a set of attractiveness factors to be a choice set to represent characteristics of a transport mode (Figure 1, Figure 2 and Figure 3). Respondents are asked to choose one of the 2 modes to capture the trade-off relationship between factors. A set of the questions is asked to them for a range of the trade-off relationship between factors, which is designed based on an orthogonal array. Accordingly, the number of questions in the questionnaire depends on the number of attractiveness factors. Such data collection could be extensive and complicated, and is thus not easy in Asian developing cities, where survey resources are much more limited than developed cities. The interview survey is the most common method of their surveys, but it is hard to collect the large number of data samples, as respondents cannot answer many questions in a short time. Therefore, this study conducted an interview survey, splitting the questionnaire into 3 parts to ask about respective factors for convenience, comfort and safety. The factor of travel cost is included in all the questionnaire parts to make all the results of preference parameters comparable.

Table 3. Choice pairs of attractiveness factors for a trip in the questionnaire

Element	Factor	Better choice	Worse choice
Convenience	Travel Time	20 minutes	35 minutes
	Delay	Arrival on time	Arrival likely late
	Flexibility	Any departure time	Scheduled departure time
	Access	0 minutes	10 minutes
Comfort	Space	Size of a sitting space in car	Size of a standing space
	Protection	Protected	Not protected
	Transfer	No transfer	Twice
Safety	Accident	Safe	Normal
	Crime	Safe	Normal
	Privacy	High	Low
Cost	Travel Cost	25 baht	50 baht

	1	2
Travel time	35 min	20 min
Punctuality	Late	On time
Departure time	Cannot choose	Can choose
Access to main mode	0 min	10 min
Travel cost	25 Baht	50 Baht

Figure 1. An example of choices in the questionnaire design (convenience)

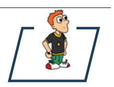
	1	2
Riding Space		
Protection		
Transfer	Yes	No
Travel cost	25 Baht	50 Baht

Figure 2. An example of choices in the questionnaire design (comfort)

	1	2
Accident	Safe	Normal
Crime	Safe	Normal
Privacy	Low	High
Travel Cost	25 Baht	50 Baht

Figure 3. An example of choices in the questionnaire design (safety)

The survey took 180 samples each for one part of the questionnaire from 26, November to 1, December in 2012. Mode choice behaviours may vary by socio-economic characteristic. In this interview survey, to analyse the difference in mode choice by income and age, data samples were collected for a range of socio-economic types of respondents. The interview areas were chosen to cover various socio-economic types of respondents, such as business areas for higher-income ones and public parks for elderly ones. Respondents are divided by income into high-income ones with more than 40,000 baht per month of household income and low-income ones less than that. They are also divided by age, depending on whether they are older than 40 years old or not. The survey was conducted both in an urban area and a suburban area, to avoid the spatial bias of respondents. The descriptive table of samples are summarised in Table 4.

Table 4. A descriptive table of respondents

	Convenience		Comfort		Safety	
	samples	%	samples	%	samples	%
Gender						
Male	80	44	91	51	76	42
Female	100	56	89	49	104	58
Age						
<20 years old	19	11	3	2	16	9
20-29 years old	65	36	37	21	93	52
30-39 years old	43	24	40	22	37	21
40-49 years old	26	14	42	23	25	14
>50 years old	27	15	58	32	9	5
Household income						
<10,000 baht	2	1	4	2	6	3
10,000-20,000 baht	28	16	33	18	36	20
20,001-30,000 baht	27	15	35	19	52	29
30,001-40,000 baht	26	14	35	19	22	12
40,001-50,000 baht	34	19	21	12	14	8
50,000-75,000 baht	31	17	30	17	29	16
75,001-100,000 baht	20	11	14	8	12	7
>100,001 baht	2	1	8	4	9	5
Car ownership						
yes	74	41	118	66	105	58
no	106	59	62	34	75	42

5. RESULTS OF THE SURVEY

With the SP survey data, the preference parameters for attractiveness factors are estimated. The survey results show some patterns of the preferences for attractiveness factors, which understandably reflect demand for travel by socio-economic characteristic in a way generally applicable to Asian developing cities. Although the likelihood ratios of the models are not as good as similar studies in developed countries, the level of reliability reflects the difficulty of data collection about potential preferences in developing countries. This study pays more attention to how the results can be interpreted under the limitation of data in developing countries than to examine whether the results can meet the strict statistical reliability test. Considering these, this section discusses the result interpretation and the possible methodological improvement.

5.1 The Results of All Respondents

The parameters estimated with samples of all respondents are shown in Table 5. To make the levels of preferences comparable among all factors in convenience, comfort and safety, these parameters are first divided by the parameter of travel cost for standardisation. However, the perception of monetary cost may significantly vary by socio-economic group, particularly by income group. Thus, they are converted to the unit of travel time as a primary indicator of travel disutility by dividing their parameters by the parameter of time, as shown in Figure 4. Accordingly, the unit represents equivalent travel time saving to improve each attractiveness factor, in which the improvement of travel time factor is fixed with 15 minutes as set in the questionnaire survey. These indicators are designed as a relative value to be used for comparing the levels of preferences for different attractiveness factors within each socio-economic group. Although the scale of the indicator depends on the unit, their absolute values are not directly comparable as the difference of the preference levels between socio-economic groups because the perception to the unit indicator may vary by socio-economic group.

Table 5. Preference parameters of all respondents

		All		All		All	
	Factor	Coefficient	(t-value)	Coefficient	(t-value)	Coefficient	(t-value)
Convenience	Travel time	-0.29	(-14.0)	-	-	-	-
	Delay	-0.18	(-8.57)	-	-	-	-
	Flexibility	0.04	(1.80)	-	-	-	-
	Access	-0.06	(-2.75)	-	-	-	-
	Travel cost	-0.16	(-7.89)	-	-	-	-
Comfort	Space	-	-	0.07	(3.66)	-	-
	Protection	-	-	0.25	(12.9)	-	-
	Transfer	-	-	-0.22	(-11.3)	-	-
	Travel cost	-	-	-0.26	(-13.3)	-	-
Safety	Accident	-	-	-	-	-0.23	(-9.69)
	Crime	-	-	-	-	-0.07	(-3.74)
	Privacy	-	-	-	-	0.20	(8.45)
	Travel cost	-	-	-	-	-0.23	(-9.13)
Likelihood ratio		0.09		0.12		0.05	
Samples		180		180		180	

While the results show the significant preferences for travel time and cost, the equally significant preferences are shown for some of the residual attractiveness factors, such as delay, protection, transfer, accident and privacy. People prefer more protection, less transfer and more privacy. This reflect current transport situations in Asian developing cities in which people shift travel modes from public transport use to car use due to the insufficient quality of public transport services against motorisation. On the other hand, it also shows the potential advantage of mass-transit use according to more preferences for less delay and less accident.

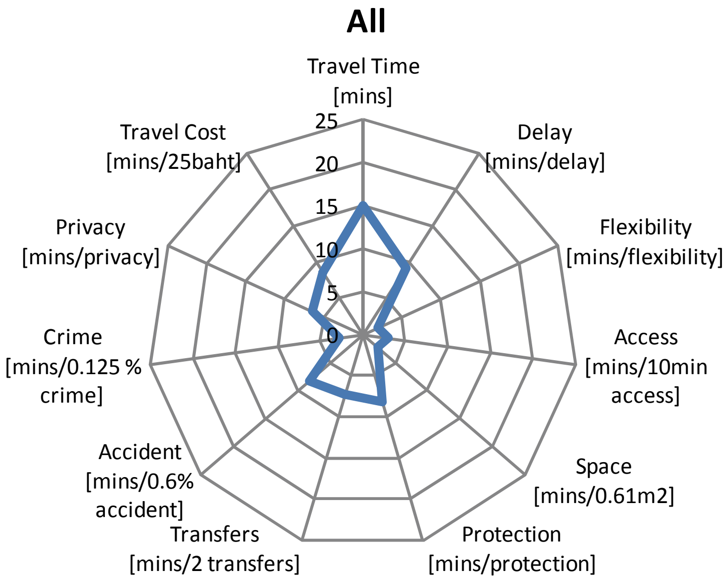


Figure 4. Comparison of preferences of all respondents

5.2 The Results by Income Group

Table 6. Preference parameters by income group

		Low-income		High-income		Low-income		High-income		Low-income		High-income	
	Factor	Coeff	(t)	Coeff	(t)	Coeff	(t)	Coeff	(t)	Coeff	(t)	Coeff	(t)
Conveni	Time	-0.20	(-6.76)	-0.36	(-13.1)	-	-	-	-	-	-	-	-
	Delay	-0.16	(-5.37)	-0.19	(-6.85)	-	-	-	-	-	-	-	-
	Flexibility	0.04	(1.39)	0.03	(1.19)	-	-	-	-	-	-	-	-
	Access	-0.12	(-3.98)	0.00	(-0.06)	-	-	-	-	-	-	-	-
	Cost	-0.28	(-9.15)	-0.06	(-2.32)	-	-	-	-	-	-	-	-
Comfort	Space	-	-	-	-	0.05	(1.96)	0.10	(3.40)	-	-	-	-
	Protection	-	-	-	-	0.20	(8.13)	0.32	(10.6)	-	-	-	-
	Transfer	-	-	-	-	-0.21	(-8.50)	-0.23	(-7.65)	-	-	-	-
	Cost	-	-	-	-	-0.35	(-13.9)	-0.13	(-4.30)	-	-	-	-
Safety	Accident	-	-	-	-	-	-	-	-	-0.28	(-9.39)	-0.15	(-3.68)
	Crime	-	-	-	-	-	-	-	-	-0.06	(-2.35)	-0.10	(-3.11)
	Privacy	-	-	-	-	-	-	-	-	0.20	(6.80)	0.20	(5.05)
	Cost	-	-	-	-	-	-	-	-	-0.28	(-8.89)	-0.15	(-3.41)
L-ratio		0.13		0.09		0.12		0.09		0.04		0.06	
Samples		97		83		73		107		64		116	

The difference of the preference parameters and the preference levels by income group are shown in Table 6 and Figure 5. While higher-income people prefer travel time, the preference for travel cost is more significant for lower-income people. This may reflect higher time value for higher-income people and more cost burden for lower-income people. Lower-income people also prefer the residual attractiveness factors more, such as less delay, better access, more protection, less transfer, less accident and more privacy. The result suggests that lower-income people suffer from poor public transport services, such as low-quality buses and paratransit, and live in locations less accessible to bus stops and stations, which makes them demand more for the availability of better public transport services.

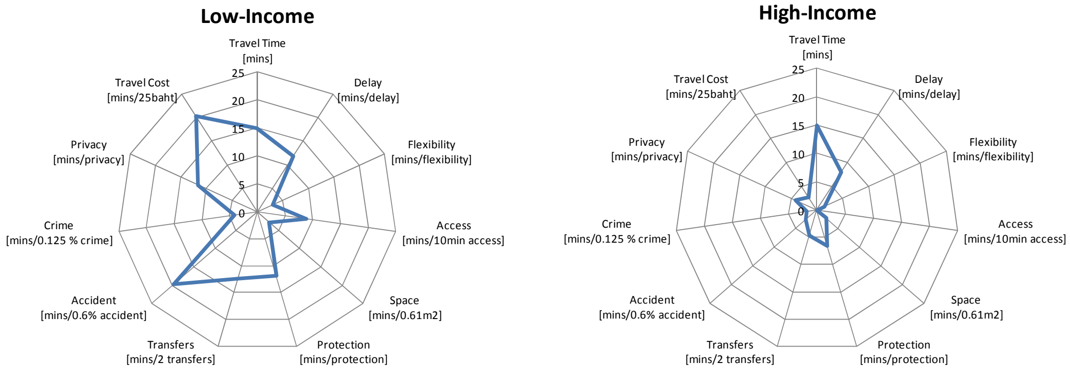


Figure 5. Comparison of preferences by income

5.3 The Results by Age Group

The difference of the preference parameters and the preference levels by age group are shown in Table 7 and Figure 6. While younger people care more about travel time, the residual attractiveness factors are more important for older people. This may be because older people are more flexible for their working time or work less, and they therefore care less about time but more about residual attractiveness of travel. Particularly, the significant preferences for more protection, less transfer and less accident may reflect the demand of elderly people for more comfortable and safe travel.

Table 7. Preference parameters by age group

		Under 40		Over 40		Under 40		Over 40		Under 40		Over 40	
	Factor	Coeff	(t)	Coeff	(t)	Coeff	(t)	Coeff	(t)	Coeff	(t)	Coeff	(t)
Conveni	Time	-0.31	(-12.6)	-0.24	(-6.34)	-	-	-	-	-	-	-	-
	Delay	-0.13	(-5.48)	-0.28	(-7.35)	-	-	-	-	-	-	-	-
	Flexibility	0.02	(0.97)	0.07	(1.84)	-	-	-	-	-	-	-	-
	Access	-0.06	(-2.26)	-0.06	(-1.59)	-	-	-	-	-	-	-	-
	Cost	-0.15	(-6.13)	-0.19	(-5.09)	-	-	-	-	-	-	-	-
Comfort	Space	-	-	-	-	0.03	(1.15)	0.10	(3.95)	-	-	-	-
	Protection	-	-	-	-	0.17	(5.75)	0.32	(12.3)	-	-	-	-
	Transfer	-	-	-	-	-0.15	(-5.13)	-0.28	(-10.8)	-	-	-	-
	Cost	-	-	-	-	-0.30	(-10.2)	-0.23	(-8.83)	-	-	-	-
Safety	Accident	-	-	-	-	-	-	-	-	-0.25	(-9.62)	-0.14	(-2.44)
	Crime	-	-	-	-	-	-	-	-	-0.09	(-3.99)	-0.02	(-0.38)
	Privacy	-	-	-	-	-	-	-	-	0.24	(9.02)	0.05	(0.85)
	Cost	-	-	-	-	-	-	-	-	-0.25	(-8.75)	-0.18	(-2.93)
L-ratio		0.13		0.09		0.12		0.09		0.04		0.06	
Samples		97		83		73		107		64		116	

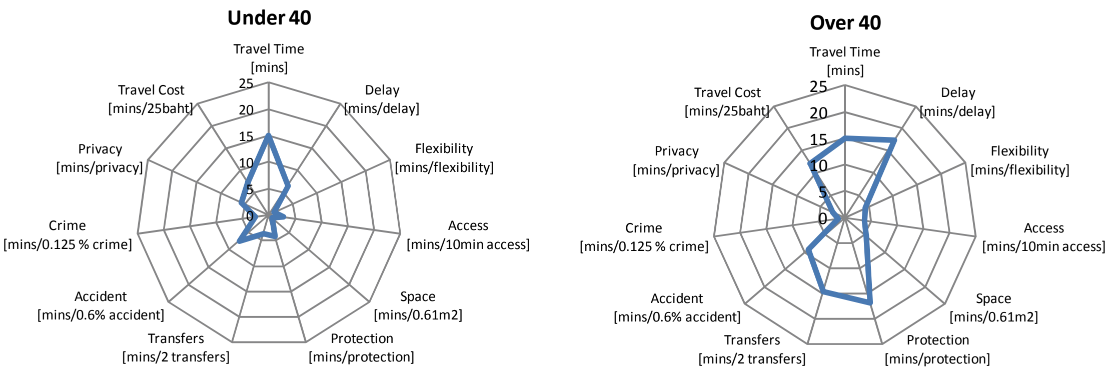


Figure 6. Comparison of preferences by age

5.4 Discussion about Improvement of the Results

The reliability of these results could be improved by questionnaire design and data screening. The questionnaire design of the conjoint analysis might be sometimes confusing for respondents as the difference of some choices is unclear. To avoid this problem, the number of factors in the choice set needs to be minimised. A pre-survey is important to choose such key factors by asking local people about it among the list of possible factors. Moreover, even though respondents understand the questions, the questionnaire repeatedly asks them about the similar questions, and could therefore cause contradictory answers particularly in the circumstance of a short interview survey. Although the former design effort was made by this study, the latter issue is hardly avoidable. This issue could be tackled by excluding contradictory data. Further improvement can be expected with such methodological improvement.

6. COMPARISON OF ATTRACTIVENESS BY TRANSPORT DEVELOPMENT

Using the preference parameters of all respondents, this study compares the attractiveness of transport modes between scenarios of road-oriented development and railway-oriented development in 2050. The road-oriented development scenario assumes that the current trend of rapid motorization would continue, as preference for car use stays high, and car use would be overwhelming. Most of transport infrastructure investment would be made in road development, assuming that no railway development would take place beyond the level of 2010. Road-oriented development would decrease urbanized density and increase car ownership. Distribution of population and employees is simply set in a way that evenly disperses them to make the level of variation of distribution smaller.

The railway-oriented development scenario assumes that the large-scale development of urban railway networks would take place, and railway use would become popular. Urban railway networks would be developed up to the level of the existing development plan. The rest of the investment would be made in road development. Railway development could calm urban sprawl and slow the pace of growth in car ownership. In setting the urban form, the dispersed amount of population and employees in the road-oriented development is moved to the nearest stations. As a result, the urban form is not mono-centric, but polycentric with more concentration of them in suburbs.

These scenarios are quantitatively set by the previous study to model the long-term changes in land-use transport systems depending on transport development (Nakamura et al., 2013). It applied a macroscopic urban model to estimating long-term motorisation and urban sprawl in economic growth and the impacts of railway development on calming them, referring to the experience of Japanese cities in the growth period. Table 8 shows the key macroscopic characteristics of each scenario in 2050. Population and railway networks in 2005 and 2050 are distributed into 3km-mesh cells (Figure 7 and Figure 8), based on the current data of Bangkok and the assumptions made by each scenarios. In this study, population distribution is simply set by changing their spatial variation to meet the macroscopic indicator of urbanised area in each scenario.

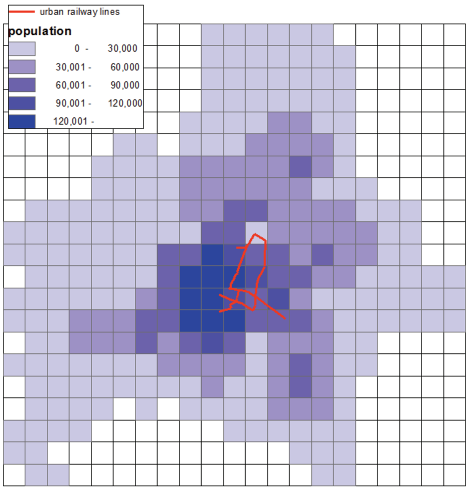


Figure 7. Population distribution and urban railway network in 2005

Table 8. Development scenarios

	Road	Railway	Urbanized area	Urbanized density	Car ownership
	km	km	km^2	persons/km^2	cars/1000persons
2005	3,541	46	1,540	5,233	189
Road 2050	16,739	81	2,094	4,941	412
Railway 2050	13,564	524	2,956	3,512	327

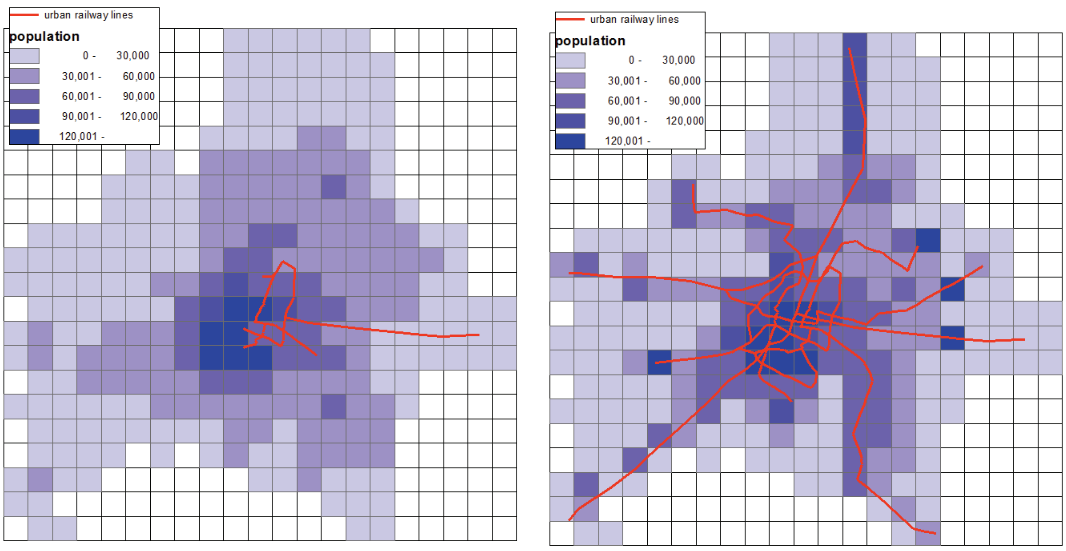


Figure 8. Population distribution and urban railway network in 2050 development scenarios (left: road-oriented development, right: rail-oriented development)

The results of the attractiveness in 2005, the road-oriented scenario and the rail-oriented scenario are respectively shown in Figure 9, Figure 10 and Figure 11. The standardised parameters of attractiveness factors for convenience, comfort and safety in Figure 4 are used to measure the composite disutility in Equation 3. Travel time and cost are estimated with a 4 step-model used in the previous study (Nakamura et al., 2013). Then, the attractiveness by location is measured with Equation 4. According to the attractiveness factors to be analysed in this study, the residual attractiveness apart from travel time and cost is higher in car use than in rail use. The road-oriented development scenario would enhance the attractiveness of road use all over the city, as the residual attractiveness factors of car use does not spatially vary. In rail-oriented development scenario, the attractiveness of rail use would be enhanced more along mass-transit corridors as it has better access to stations and the number of transfers is reduced. In the comparison between the development scenarios, it is found that, even though car use can enjoy better attractiveness factors, the impact of rail-oriented development on reducing travel time would be more overwhelming, which can make rail use more attractive.

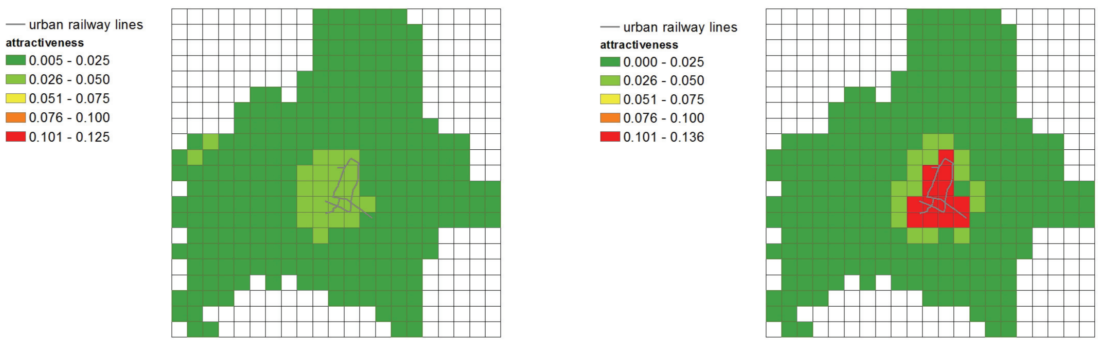


Figure 9. The attractiveness of car use (left) and rail use (right) in 2005

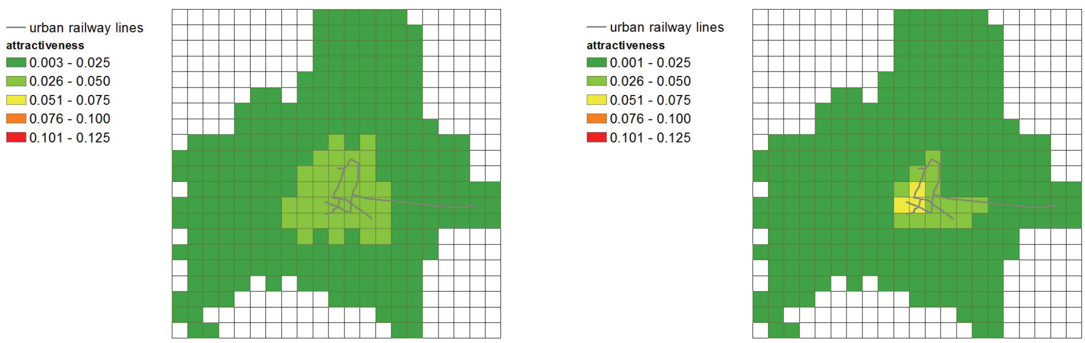


Figure 10. The attractiveness of car use (left) and rail use (right) in road-oriented development

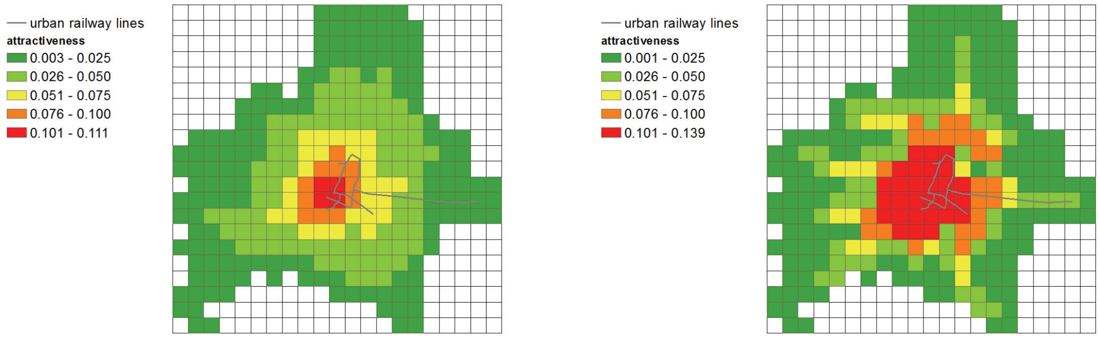


Figure 11. The attractiveness of car use (left) and rail use (right) in rail-oriented development

7. CONCLUSIONS

This study examined attractiveness to use transport modes in Bangkok in order to assess the future development of transport systems for Asian developing cities. The key findings are summarised as follows.

a) The attractiveness factors of transport modes for Asian developing cities are not only time and cost, but also delay, protection, transfer, accident and privacy. Lower-income people and older people care more about these residual attractiveness factors apart from travel time, which suggests that the current mass-transit development is not sufficient attractive for them.
b) The residual attractiveness is more significant in car use than in rail use, while the attractiveness spatially varies more in rail use. Nevertheless, it is possible to enhance the attractiveness of rail use further than that of car use with long-term rail-oriented development which can bring greater benefits by reducing travel time and enhancing the residual attractiveness.

These findings imply the necessary direction of mass-transit development to promote public transport use to realise low-carbon transport systems in Asian developing cities. To secure sufficient time-saving benefits of rail use to be more attractive than car use, extensive rail development is required. Nevertheless, rail development requires not only time saving but also quality improvement, taking account of long-term socio-economic changes. In designing the potential quality improvement of mass-transit services, it may be effective to target the demand of lower-income people and older people who are likely to be less accessible to car use and use public transport more. As many Asian developing countries enter into an aged society from 2030, the increasing number of older people suggests the large potential demand for public transport use. Moreover, as people become richer and demand more mobility improvement according to economic growth, it is another potential to keep more lower-income people to use public transport in their mobility development process.

Long-term economic growth may change people's preferences for transport modes themselves, which is not considered in this study. The comparison of the preferences between developed cities and developing cities is useful for it. Asian developing cities have significantly changed and will continue the change. Although low-carbon transport systems may not be realised in a short term in Asian developing cities, the long-term vision and the pathway to it should be attractive rather than enforcing them as burden. Further research is expected in terms of how to realise such a vision of necessary and attractive transport systems for Asian developing cities, considering long-term changes.

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