Analysis of Location Choice Behavior and Urban Railway Commuting of Bangkok's Households

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The inventory of housing near train stations is rapidly expanding along the urban railway corridor after a decade of its first operation in Bangkok, Thailand. There is still no clear reason why people buy or rent property near the stations. Past studies claimed that one important aspect in assessing housing location decisions is its relation with travel choice. The objective of this study is to understand the relationship between location behavior and travel patterns of residents living in close proximity to public transport. This research seeks to model the relationship between residential location and mode choice within a behavioral analysis framework, focusing on the self-selection question.

A discrete logit model is employed to jointly estimate the probability individuals residing near a rail station will commute by rail transit, using the interview data of station-area residents. The empirical results reveal that the inclusion of travel-related attitudes in the model can significantly explain travel behavior through residential choice. The parameter estimation shows a positive attitude toward the rail transit in that choosing to live within the station area can strongly influence rail commuting decision of the residents. This states that Bangkokians could develop more pro rail attitudes after experiencing convenient travel by train when living near a rail stop. However, in case of Bangkok, distance to the nearest station has limited impact on transit ridership and therefore has less influence on travel choice behavior.

***Keywords**: Residential location choice, Urban railway commuting, Travel-related attitudes, Residential self-selection, Bangkok*

1. Introduction

Bangkok is seeking to reduce the growth of car-based travel by developing public transport networks. The first two rail transit systems known as BTS and MRT were introduced to serve the central business district and inner city area in 1999 and 2004 respectively. After a decade of their operations, transit-based housing development widely known as transit oriented development (TOD) has been introduced to promote sustainable development to meet the public-policy goal on public transit. Transit-oriented living is thought to lower automobile ownership level, further inducing transit ridership, enhancing urban mobility and relieving peak-hour traffic congestion[1),2)]. Therefore, the increasing demand for transit-based living will likely increase the city's smart growth movement. It is well recognized that the city suffers from some of the most severe road-based traffic congestion in the world. Congestion increases commuting costs, which in turn likely draws households to rail-served locations that wish to economize on travel costs[3)]. Therefore, both BTS and MRT have become alternative modes of transport for residents living near these mass transit routes to daily commute to workplaces and

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to avoid heavy congestion. However, it is still not clear why people buy or rent property near the station, whether the decision to live near the station is due to the decision to commute by rail as well as whether or not residents choosing to reside near the railway station mainly are regular users of the railway.

Past studies on residential location and mode choice showed that people with a preference for traveling by public transport have a strong tendency to choose a residential location well-served by transit[3),5),6),7),8)]. These studies provided some empirical supports for the self-selection debate. They claimed that people do not always adjust their travel behavior in accordance with the opportunity available in selecting residential location, but many instead select the location that facilitates their travel preferences. For example, residents who prefer driving over using public transport may choose remote and spacious neighborhoods, while households with a preference for public transport may opt for more urban residential locations within walking or cycling distance of a railway station[9)].

Several studies on residential choice using different research methods have indicated that travel-related attitudes and preferences indeed influence residential choice[9), 10), 11)]. For example, one study of residents living near Santa Clara County's light-rail line in the San Francisco Bay Area in the U.S. state of California found that they patronized transit as their predominant commute mode five times as often as residents countywide; self-selection was evident in the 40 percent of the respondents who moved close to rail stops saying that they were influenced in their move by the presence of light rail [12)]. Many studies have included attitudes towards travel behavior in their analyses of the influence of the built environment on travel behavior since the mid-1990s. These results exhibit that attitudes influence travel behavior both directly and indirectly through residential choice[13), 14)]. Most households select a residential location that complies with their travel-related attitudes at least to some degree, and therefore attitudes influence the relation between the built environment and travel behavior through residential self-selection[15)]. However, it can be claimed that the studies of the role of residential self-selection are still limited, due to such issues as the use of different methodologies, different attitude measures, the difficulty of measuring attitudes and limited data availability[4), 9)]

The main objective of this study is to understand the multi-dimensional relationship between location behavior and travel patterns of residents living in close proximity to public transit within a behavioral analysis framework, focusing on the self-selection question. We examine the behavior of station-area residents and their choices in order to explain the hidden or underlying mechanisms affecting residential location and mode choice decisions. In this paper we argue self-selection may hold keys to a better understanding of people's location choices that are relevant for travel behavior. Self-selection with respect to residential location refers to as "the tendency of people to choose locations based on their travel abilities, needs and preferences" [4)]. The preferences for travel modes may be correlated to residential choice: people with a preference for traveling by train will, on average, live closer to railway stations. Ignoring this preference generally leads to an overestimation of the impact of the distance to railway station on travel behavior[15)]. Specifically, we examine the impact of residential self-selection concerning the distance to the rail station on the rail commuting of the residents within rail transit area in Bangkok.

It is important to note that the relationships between residential location and commute pattern could also be two-directional[16)]. For example, after people move to a location with good public transport access, they might experience the advantages of travelling by public transport,

which might influence their attitudes. This means attitudes towards modes could influence residential choice, but a reverse relationship is also possible. For example, after moving to a dwelling near a station people could have more positive attitude toward using rail. The self-selection with respect to locations and with respect to travel modes and travel behavior are in some cases strongly related: self-selection with respect to location choices might be the result of preferences with respect to travel. And even the opposite can happen as in the example above: attitudes towards travel might be influenced by location-based experiences[16]. Several residential self-selection studies explicitly including attitudes have shown that attitudes add to the explanation of travel behavior by built environment characteristics and socio-demographic variables[17), 18), 19)]. However, the definition, modeling and measurement of attitudinal variables vary considerably between studies, their results are hardly comparable[9)].

2. Transit-based housing development in Bangkok

In 2011 metropolitan Bangkok had well over 11 million inhabitants resulting in a density of 6,377 persons/sq km and leading to persistence of severe transportation problems. About a decade ago, Bangkok launched its first two rail transit systems known as BTS and MRT to serve central business district and inner city area in 1999 and 2004 respectively. The former is elevated rail system comprising two main lines with the total of 36.8 kilometers in length, 35 stations, a fleet of 35 three-car trains totaling 105 cars. And the latter is the subway line on the 20 kilometer-service length with 18 stations, a fleet of 19 three-car metro trains totaling 57 cars. The first railway line, BTS, initially had lower-than-predicted ridership, with 200,000 passenger trips per day. However, the number of daily passengers has steadily increased since then.

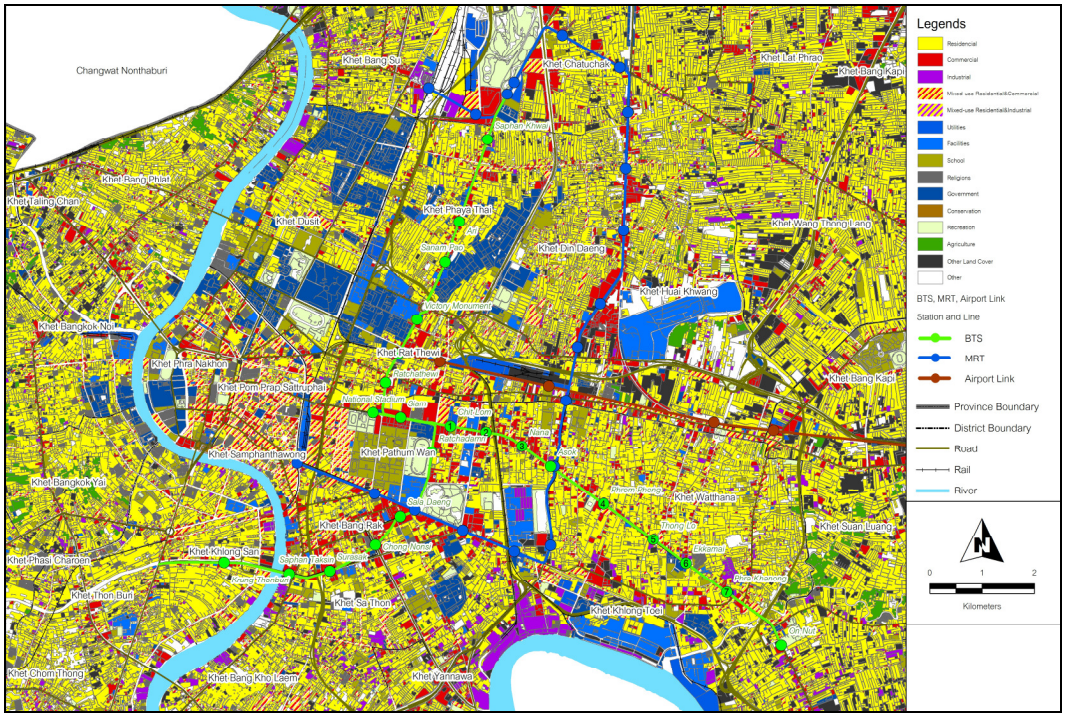

Figure-1 Land use characteristics along the rail transit lines

The BTS was built in the middle of some of the city's most congested and highest rental rate areas along arterial roads. These include Silom Road, the backbone of one of Bangkok's Central Business Districts, and Sukhumvit Road, lined with hotels, shopping centers, and high-priced condominiums. There is a horizontal mix of commercial and residential land use along the transit corridors as seen in figure 1 above. Many planners have predicted that Bangkok's real estate and housing developments would follow patterns previously established in Asian mega-cities such as Hong Kong and Tokyo. In these two major cities, the mass transit lines and especially the areas near or adjacent to mass-transit stations have become key new-development areas, both for office buildings and housing. Presently, many station areas of the BTS and MRT have become some of the most desirable areas to live and work for Bangkok residents. The mushrooming of high-rise residential and commercial buildings along the rail corridor can be seen in figure 2.

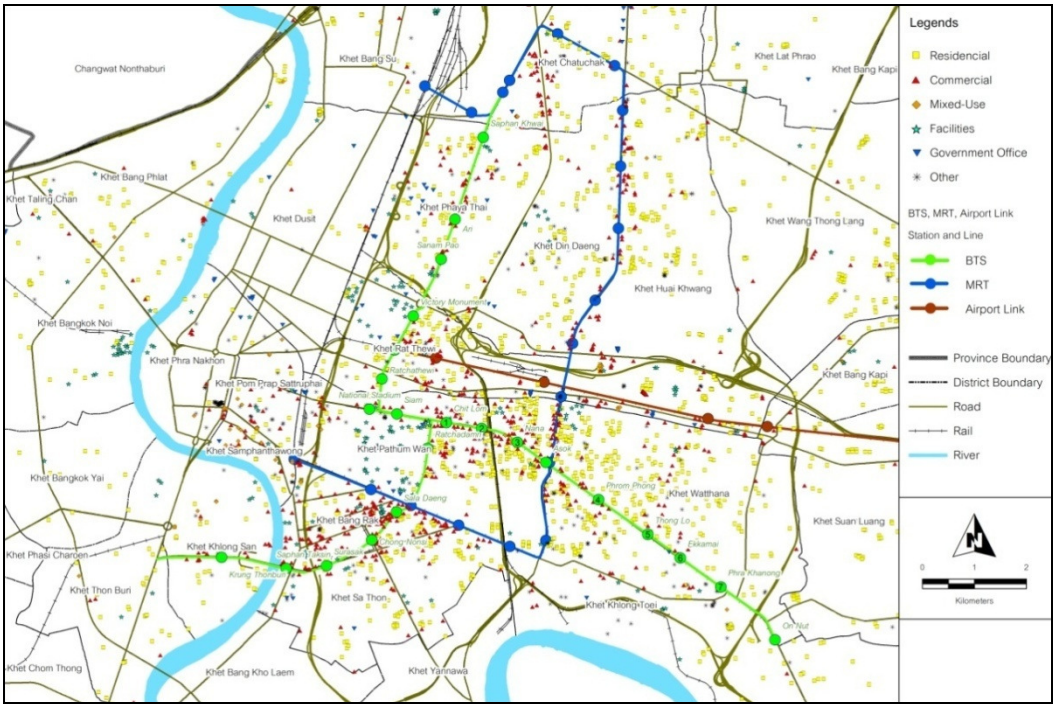

Figure-2 The distribution of high-rise residential and commercial building along the rail transit lines

3. Analytical Framework

The research framework covering three hypotheses is examined, i.e. (1) there is a relationship between residential location and mode choice decision; (2) the decision to live near the station is due to the decision to commute by rail (3) the travel pattern is partly a result of the decision where to live. The hypotheses of this study must have some connections with the theoretical background. Based on a literature review, this research basically hypothesizes that the complex relationship of location choice and travel behavior could be simplified fundamentally into three elements, i.e. travel-related attitudes, residential location choice and travel behavior as shown in figure 3.

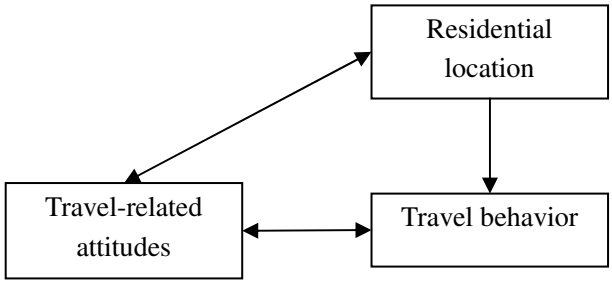

Figure-3 Multi-directional relationship between residential location and travel behavior

Firstly, it can be assumed that travel-related attitudes affect residential location through the evaluation of housing alternatives when searching for a new house. It is thus assumed that residential self-selection takes place and that people select where to live according to the built-environment characteristics of a new house that at least to some degree conforms to their attitudes towards travel behavior. Secondly, and consequently, it is assumed that travel-related attitudes and built environment characteristics of the residential location influence travel behavior. Finally, it is assumed that attitudes towards travel behavior influence travel behavior indirectly through residential choice.

For Bangkok, firstly, we set assumption that households select a residential choice complying with their travel-related attitudes at some degree. Secondly, people who have a positive attitude toward rail transit and have a preference for traveling by train will live closer to railway stations. Thirdly, after moving to a house near a station, attitude toward using rail will be more developed after people have experienced travelling by train. The definition of proximity to the station for Bangkokians is defined by the distance between their house and the nearest station within 5 minutes traveling. Generally, there are paratransit modes, i.e. van pool or golf cart, provided by the condominiums located within 2 kilometers rings of the station for their residents to conveniently commute between dwelling and the station. Also, motorcycle taxi is another common choice for the station-area residents to access the station. The 5 minutes travelling time by these paratransit modes can be referred to the distance within 1 kilometer. Thus, we define the station-area resident as people residing within 1 kilometer distance rings of the rail stations.

Our decision to model mode choices binomially was based not only on sample-size considerations but also a desire to frame the analysis to best support public policy- making. As discussed earlier, recent policy interest in transit oriented development (TOD) has focused almost exclusively on rail transit systems. And given that the main public benefit of TOD is transit riding, travel demand is best treated as binary as part of an integrated analysis of residential location and commute choice [1), 2), 20)]. Furthermore, there are too few bus transit trips among those living near the rail stops to support a modal model of motorized commute choice. Thus, bus trips are excluded from the final analysis. Our study therefore represents mode choice between rail transit and automobile (drive alone and shared-ride) alternatives.

In this paper we will widen the residential self-selection argument by considering the specificity of attitudes, travel behavior and built environment characteristics. We discuss the influence of travel attitudes at the time of residential choice. We include attitudinal variables like preferences to account for residential self-selection in model that analyzes the relation between the built environment concerning the distance to the rail station and travel mode

choices behavior. This paper will use the broad definition by Eagley and Chaiken[21] in that an attitude 'is a psychological tendency that is expressed by evaluating a particular entity with some degree of favor or disfavor[22]. The definition of evaluating refers to affective responses[23] (e.g. I like using a train). In this residential self-selection study, the specificity of travel-related attitudes is defined in general (e.g. attitude towards driving a car or using a rail transit).

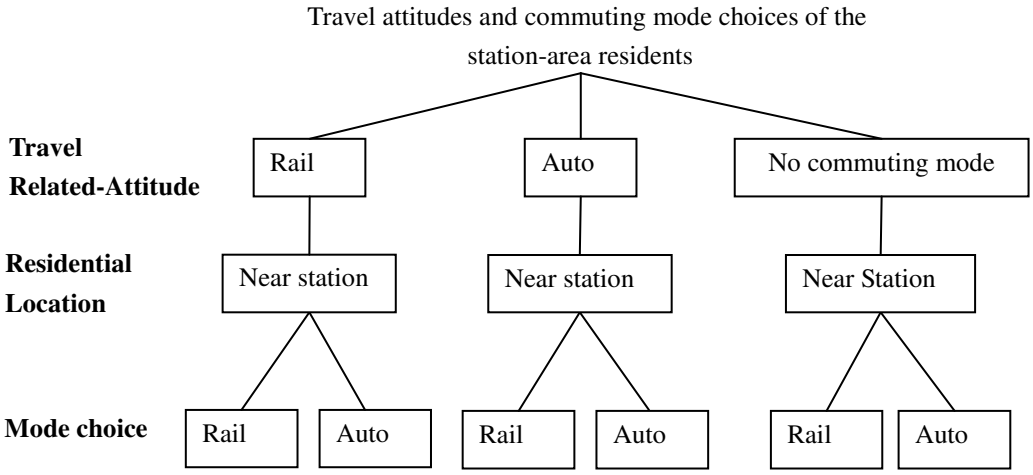

Figure-4 The conceptual framework of the influence of attitudes on travel behavior through residential self-selection

Figure 4 summarizes the assumed relationships investigated in this paper. Mode choice is chosen normally just before the start of the trip. Commuting mode can be pre-determined just before the decision of residential location. It is differentiated from mode choices as normal meaning. Furthermore, some people predetermine the commuting modes but others not. In this context the first stage must have three categories such as 1) I would like to commute by rail hopefully, 2) I would like to commute by auto hopefully and 3) I am not considering about the commuting mode at the time of residential choice decisions. Then, after moving to live near the station 1) I will go to work by rail or 2) I will go to work by auto. Finally, a multidimensional approach is also offered to examine that relationship, i.e. involving several factors consisting of socio demographic, location characteristics, travel characteristics and attitudes factors affecting mode choice decisions.

4. Data collection

To collect the residential location and travel choice behavior data, we conducted surveys in May, 2013. We formulated a set of questionnaires to ask residents who living in condominium/apartment located within 1 km rings of the BTS/MRT stations. The questionnaires were designed focusing on self-selection questions by asking the residents why they move to live near the station and how they go to work at their presence residence. There are 4 parts in the questionnaire including location characteristics, travel behaviors, travel attitudes, and individual characteristics. Since we measure travel attitudes at the time of residential choice, retrospective questioning on the attitudes that individuals held at the time of making the residential choice is required. To obtain more reliable results of the exact role of travel attitudes in residential choice because of the complexity of such decisions, the questionnaires were distributed to residents by door to door home interview survey. Mainly, we

conducted field survey on weekend as the respondents had more time and were willing to fill out the questionnaires. The total 469 respondents of 28 condominiums/apartments from 5 prime residential zones along the railway corridor were randomly selected.

Note that one of the well-known residential area namely "Sukhumvit" zone is excluded from our scope since the previous study on TOD in this city using this area as the case study indicated the failure of TOD outcomes to increase attractiveness of transit use in this zone[19]. This area was proved to be unique from other residential zones because most of the residents are the elite high income people and foreigners who are car dependent. Most of residents in this area use the car rather than the rail transit[24].

Furthermore, we focused solely on journeys to work since classic location theory holds workers trade-off commuting and housing costs when choosing a residential location[25]. In the case of multi-worker households, only the primary worker earning the highest income of the household was interviewed. The respondent characteristics are described in table 1.

The typical characteristics of the station area-resident are female workers, single-persons, middle income, and car-owning households. From the previous study on travel behavior in this city, the income groups are categorized into three groups including (1) low income – those who earn less than THB 10,000 a month, (2) middle income- those whose income are THB 10,000-20,000 and (3) high income- those who obtain revenue more than THB 20,000 [26]. Bangkok, in similar fashion to other Asian cities, has a relatively young middle-income population. The housing provision towards housing affordability targets these middle-income earners as main buyers. This group will relatively create significant demand for smaller unit sizes in exchange for high quality condominium and housing units in quiet locations but with access to mass transit lines. There are very few low income respondents in this study. They live in the low cost apartment built before the development of rail transit system. The average price of condominium in this zone seems to be unaffordable price for low income residents. Therefore, they tend to be unable to afford houses near the station and have to move far away[24].

Most of respondent made the decision to move to live near the railway after the first operation of rail system in 1999. The size and cost of their dwelling are lesser as compared to their prior house. In the past, both high-end and the middle-income condominium developers have launched successful projects along the railway line. The Real Estate Information Center's (REIC) statistics shows the average home size in Bangkok had fallen. More people were choosing to purchase smaller-sized condominiums, many of which were located near or adjacent to mass-transit lines rather than purchasing more-costly single family homes. This new trend for city condominium living is also creating a new type of owners who wish to live in condominiums during weekdays and in their homes outside the city on weekends. They can save commuting cost and time during weekdays and live with family on weekends.

Table-1 Summary of respondent characteristics

Variables		% / Mean	SD
Individual characteristics			
Sex	male	37.2	
	Female	62.8	
Household type	Living alone	54.6	
	married couple only	5.9	
	married couple with child	7.8	
	living with family	21.9	
	unrelated house sharers	9.7	
Education	low level	4.1	
	medium level	60.2	
	high level	35.7	
Income	low	3.7	
	middle	54.4	
	high	41.9	
Car ownership	no	23.4	
	yes	58.7	
Location characteristics			
Distance to nearest station		482.99	280.254
Move after 1999	no	3.3	
	yes	96.7	
Dwelling type	Condominium	84.4	
	Apartment	14.5	
Parking availability	no	35.8	
	yes	64.2	
Parking fee	no	26.8	
	yes	73.2	
Workplace near station	no	36.1	
	yes	59.9	
Two houses living	no	78.4	
	yes	21.6	
Travel-related attitude			
Mode preference	I would like to commute by rail hopefully	86.2	
	I would like to commute by auto hopefully	7.4	
	I am not considering about the commuting mode	6.3	
Travel behavior			
Frequency of transit use (per week)		3.54	2.230
Train total travel cost (Baht)		44.22	34.996
Train in-vehicle travel time (minutes)		25.32	14.479
Train out-vehicle travel time (minutes)		9.20	7.466
Car total travel cost (Baht)		111.12	48.884
Car in-vehicle travel time (minutes)		50.41	23.460
	N=469		

5. The Relationship between Travel Attitudes and Mode Choices

This section explains the relationship between mode preferences, commuting choices, and respondents' characteristics using crosstab analysis method. We describe the existing situation on whether the Bangkok residents who move to live near train stations tend to be rail-commuters. The simple statistics of travel attitudes on Table 1 suggest that living near the rail transit has become the alternative choice for residents who would like to commute by rail at the time of residential choice decision. There are very few people who would like to commute by car or who did not decide on their choice. Figure 5 shows that rail transit has become the most popular commuting mode choice for the station-area residents. It is overwhelmingly selected as mode choice to go to work while the car is used nearly as half of the transit use. Particularly, the residents those dwelling in the condominium or apartment within 500 m from the station select rail transit more than car as their mode choice. On the contrary, car and paratransit such as motorcycle taxi are preferable among the residents living further away as seen in figure 6.

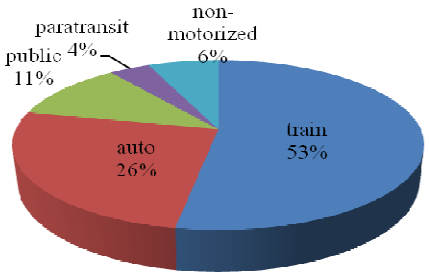

Figure-5 Mode shares of respondents

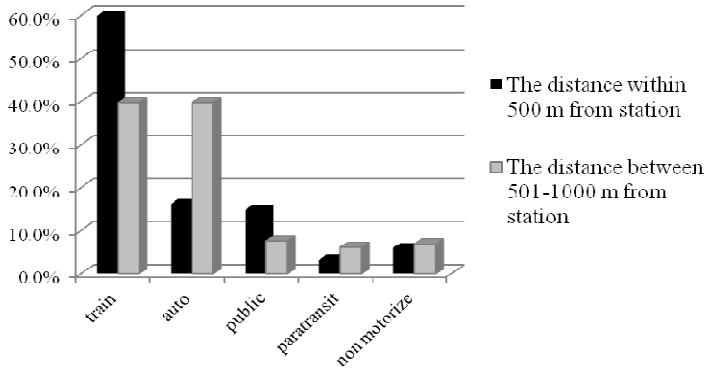

Figure-6 Mode choices of residents those living within and beyond 500 m ring of the rail station

Figure 7 explains that most of residents who have the preference for traveling by train choose to commute by rail after moving to reside near the rail except married couple both with and without children. They are auto users. Although there are very few low income respondents, all of them have the preference on rail and commute by rail. In contrary, nearly all residents who like to use auto highly select to travel by auto. But if they live closer to the station, they select rail transit as their commuting mode choice as seen in figure 8. Even though some of residents didn't decide on mode choice, they chose to be rail passengers after living near the rail stop. Nevertheless, the residents being men, being married couple with children, being car owner as well as working and living further become auto users rather than rail users as shown in figure 9. It is noted that there are very few respondents in some categories as mentioned in Table-1. Therefore, there are no respondents in some categories of crosstab table, for instance, the respondents of married couple with and without children as seen in Figure-8 and Figure-9.

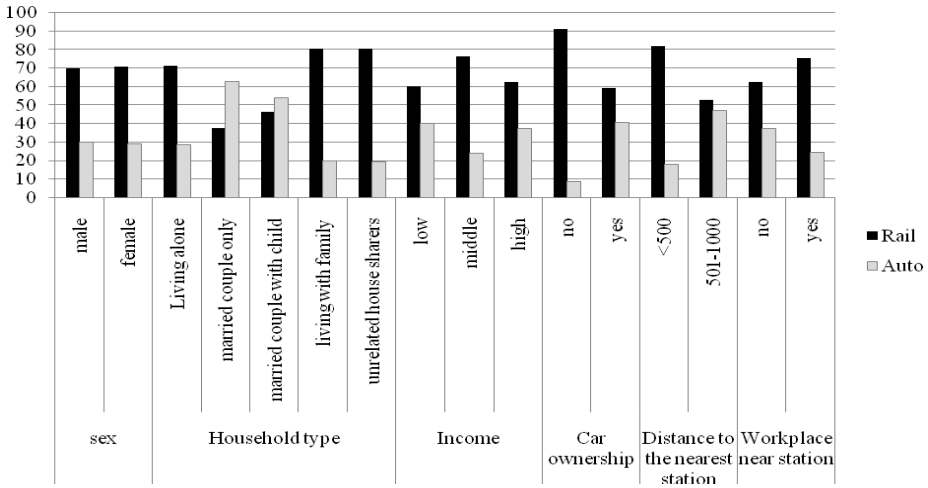

Figure-7 Mode choices of respondents whose attitude would like to commute by rail

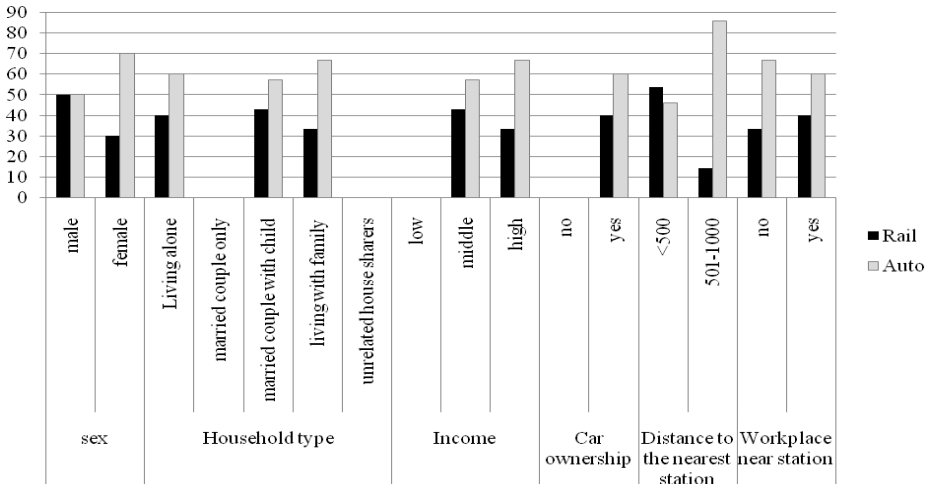

Figure-8 Mode choices of respondents whose attitude would like to commute by auto

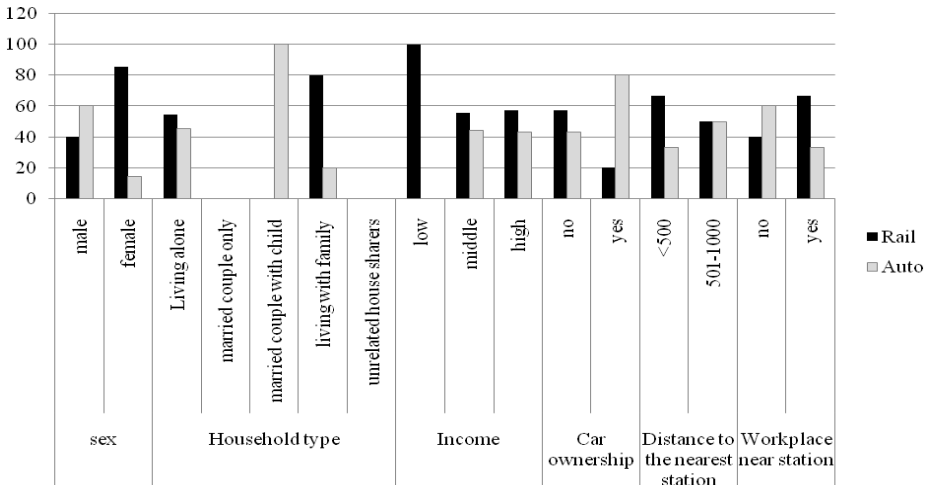

Figure-9 Mode choices of respondents whose attitude are not considering about the commuting mode

6. Location Choice Behavior and Rail Commuting of the Station Area-Residents in Bangkok

To analyze the relationship of residential choice and rail commuting, we examine the existing situation on whether the Bangkok residents who move to live near train stations tend to be rail commuters. It has been realized that households select a residential choice that complies with their travel-related attitudes. Their decision to live within the rail transit catchment area is related to the decision to commute by rail. However, to what extent the residential self-selection concerning the distance to the rail station has an impact on the rail commuting of the station-area residents is still questionable. Discrete logit model in the context of binary logit is then employed to examine factors influencing transit ridership in this city. The best set of predictors is finally found.

Table 2 shows the estimated values of the model coefficients. The coefficients were estimated by the maximum likelihood method. All explanatory variables except income variable are clearly significant at $P < 0.05$. The signs of the estimated coefficients are worthy of attention. The negative sign of the coefficients of variables such as car ownership, married with children household, distance to the nearest station, travel cost, travel time and attitude toward car use indicates that other things being equal. The alternatives with high travel time, travel cost and distance as well as that involve having car, having child and having intention to use car tend to be less preferred than alternatives that have low travel cost, travel time and distance as well as do not involve these variables. On the other hand, the positive coefficient of variables such as low income, middle income, workplace near rail station, parking fee at workplace and attitude to use rail implies that these groups are more likely to commute by the transit, other things being equal.

6.1 The influence of travel-related attitudes on mode choices

As compared to model calibration without travel attitudes, the inclusion of travel attitudes in analysis model noticeably demonstrates the set of predictors with the stronger R squared values. There are two potential attitude factors for understanding the decision-making on rail commuting of the station-area residents. To start with the travel attitude to commute by rail, it is the strongest positive predictor for the rail passenger. The odds ratio value associated with train preference explain when attitude is raised by 1 unit; the householders are as much as 6.2 more times likely to belong to rail transit users. The more positive attitude they have the more rail passengers they tend to be. Empirically, individual characteristics are significantly related to the travel attitudes as mentioned in the previous section. Being women, being single-person household, being medium education level person as well as being the residents living closer to the station significantly have a more positive attitude towards rail use. The increasing of pro rail attitude may develop as the result of the good service of mass transit system. For this reason, it is crucial to improve the service of mass transit system based on commuter satisfaction to encourage more rail patronages.

Conversely, the attitude toward car use is strongly a negative effect on the transit ridership. The vast majority groups of car users are the station-area residents who have intention to use car before moving to live near station. It is difficult for mass transit system to induce people who are pro car attitude to shift from being car user to being rail user.

Table-2 Model estimation of rail transit passenger

Variables	With influence of travel attitudes			Without influence of travel attitudes		
	Coefficient	Sig.	Odd ratio	Coefficient	Sig.	Odd ratio
Individuals attributes						
Low income	.499	.347	1.646	.508	.452	1.662
Middle income	.300	.452	1.350	.293	.460	1.341
Car ownership	-1.766	.002**	.171	-1.793	.001**	.167
Married with child	-1.003	.012*	.367	-.906	.037*	.404
Location attributes						
Distance to the nearest station	-.002	.000**	.998	-.002	.000**	.998
Workplace within 1 km of rail station	.556	.019*	1.743	.586	.014*	1.796
Parking fee at workplace	.053	.039*	1.055	.061	.023*	1.063
Transport attributes						
Total travel cost	-.001	.004**	.999	-.002	.007**	.998
Total in-vehicle travel time	-.066	.000**	.936	-.068	.000**	.934
Total out-vehicle travel time	-102	.013**	.903	-.196	.039*	.890
Attitudes						
I would like to commute by rail hopefully	1.830	.009*	6.234			
I would like to commute by auto hopefully	-.748	.011*	.474			
Constant	1.550	.039*	4.712	1.909	.020*	6.748
-2 Log likelihood			127.03			166.765
Cox & Snell R Square			.515			.417
Nagelkerke R Square			.708			.572

** Significant at .01 level

* Significant at .05 level

6.2 The relationship between travel-related attitudes and socio-demographic characteristics

The significant effect of attitudinal variables shows that they play an important role in explaining the mode share of rail trips among the transit-based residents by socio-demographic characteristics. Socio-demographic characteristics and car availability together potentially explain travel choice decisions. Firstly, car ownership variable is the strongest negative impact on the transit ridership. Evidently, all people who have intention to use car and in turn choose the car as their mode choice belong to car-owning households. Thus, mass transit system is less attractive for those who have car and lesser for those who have pro car attitudes.

Secondly, the house and workplace location also have a significant impact on transit uses. The negative sign of coefficient estimation of access distance between house and station means that the probability of mass transit being chosen decreases as the distance increases. Confirming with the previous studies, workplace location is the significant predictor to predict who is most inclined to be a rail passenger. Destination's proximity to transit tends to encourage the likelihood of rail commuting[27]. As mention above in figure 6, the respondents keep commuting by car if their house is beyond the acceptable walking distance (500m) and workplace location

is further than the transit catchment area respectively. While longer distance to access is related to inconvenience where more effort is needed to reach mass transit station. As a result, the car-availability travelers would keep using a car rather than shifting to mass transit as the distance to station increase significantly. It is because they might highly value the convenience aspect of using mass transit comparing to using car[28]. Therefore, it is more effective to encourage infrequent users who have car availability but have positive attitude toward rail use to shift from being car user to rail user than to convince people with car use preference.

Next, parking fee at workplace has positive influence on rail use decision significantly. The car park availability along the corridor seems to be the key explanation of not using transit. Some of respondents keep using car even their house and workplace are located within catchment area of the transit station. There is high percentage of car park availability at workplace among car user group. Therefore, car parking policies along the transit corridors should be carefully considered as the critical issues to control car use and encourage transit use.

Lastly, being married couple with children household is significantly meaningful to predict transit passenger. This household type is more apt to be the car user than single-person household. The high negative coefficient value of the presence of children variable supports the idea that their children' school location becomes an additional location factor that has a powerful effect on the household's choice decision. Logically, travelling trips to school of young children with immaturity and dependency on adults will encourage car oriented mode of family mobility directly, which will affect household travel patterns. Therefore, the distribution of quality school seems to strongly affect the traffic condition in Bangkok.

Apart from significant variables, Bangkok residents select to use the rail transit for their trips regardless of their income level since income variable is not a significant predictor. However, the positive sign of coefficient of low and middle income states that they are most inclined to be regular rail passengers. Not only middle income but also high income groups are the exclusive target group of residential property market along the transit corridors. Notwithstanding, by comparison with the high class, the middle class is more likely to be transit passengers as shown above in figure 5-7. Unlike the two income groups, living near station tend to be less preferred than other alternatives for the low income people because the average price of condominium in this zone seems to be unaffordable for the low income residents. As a result, being the transit residents is beyond the means of most low income group.

Even though the low income group chooses to live far from the transit corridors, they are the main group of the rail passengers as seen above in figure 5-7. Supported by the previous finding, the low income group tends to be more captive riders than the middle and high income groups. They rely on public transportation such as rail transit, bus and paratransit for their work trip. In contrast, the two other groups seem to be choice transit riders who have a vehicle but choose the transit for some trips. Also, the previous study stated that one main reason of the failure to attract transit ridership in Bangkok is the incomplete and small network that generally follows middle and high income residential areas[29]. Therefore, providing more target groups to include the low income as rail transit residents will be better to extend the number of transit passengers. Therefore, the policies to encourage the more low income group to live near the railway corridors should be promoted. The development of housing near transit that is affordable to a broader range of incomes should be carefully investigated.

6.3 The influence of transport factors on rail commuting

The model results reveal to what extent the transportation factors in terms of travel cost and time influence on the decision mechanism of households living near the railway corridor. The time in the model was associated with the total in-vehicle travel time and out-of-vehicle travel time while the cost is referred to the total of out-of-pocket cost. In the case of Bangkok, the total travel time has slightly more impact on rail commuting as compared to the total travel cost. The transit mode is preferable due to its advantage in the term of time saving for the pair of origin and destination within transit corridors. In addition, the total cost of rail transit use is not too much cheaper than of auto use because the travelers particularly those living and working beyond walking distance to the station mostly rely on paratransit such as motorcycle taxi to access the station. Unfriendly environment conditions such as narrow road without footbath or hot and humid weather condition diminish the non-motorized mode such as walking and bicycling to access the station. They are willing to pay more travel cost in order to save the travel time. Transit system can take advantage of the existing paratransit. The previous study suggested that introduction of paratransit as a feeder for mass transit system is one of the solutions to improve mass transit patronage. The improvement policies regarding paratransit service must be carefully drawn with the purpose of enhancing the performance of mass transit[30].

The important lesson learnt from this research is that people are more sensitive about out-of-vehicle travel time than in-vehicle time to make their decision on mode choice. Lesser out-of-vehicle time or waiting time is preferable for the rail users. The passengers want to minimize their out of vehicle time due to hot weather. Although the in-vehicle time of traveling by rail is fixed, the out of vehicle time is less reliable during rush hours. At present, BTS services surpassing 600,000 passengers on average per day, with the number peaking at 715,000, and is upgrading to a fleet of 35 four-car trains on the Sukhumvit line to accommodate more passengers during peak hours. Also, MRT services 200,000 passengers on average per day. The standard capacity of BTS and MRT are 8 passengers per square meter, totally 1,490 passengers per fleet (4 cars) and 886 passengers per fleet (3 cars) respectively. The frequency of BTS and MRT are 2.40 minutes and 3.15 minutes during the peak hours 06.00 - 09.00 and 16.30 - 19.30 respectively[31), 32)]. At peak hour, the trains sometimes depart without being able to take all waiting passengers. The passengers inevitably spend more time waiting for the next train due to the overcapacity of passengers at the main stations at peak hours, particularly at the main interchange stations. This problem can reduce the positive attitude toward rail transit use.

6.4 The effect of residential self-selection on rail commuting

From model calibration, we can disentangle how residential self-selection influences on travel pattern. The inclusion of travel-related attitudes such as attitudes towards using rail transit or driving can significantly explain specific travel behavior such as using rail or driving to work. Also, the distance to the nearest station is meaningful in explaining the rail commuting of the station-area residents. This illustrates that residential self-selection has taken place and there is a significant relationship between built environment, travel attitudes and travel choice behaviors. Travel attitudes have influence on travel choice behavior through residential choice. The decision to live near the station is due to the decision to commute by rail and travel pattern is partly a result of the decision where to live. However, the low estimated coefficient of the distance factor reveals that it has less influence on travel choice behavior. The effect of living

nearer the station area has low degree to increase the rail transit use. It implies that residential self-selection concerning the distance to the rail station has limited impact on transit ridership in Bangkok. The hypothesis is then identified since Bangkok households select their residential location close to the transit that conforms to their preference with respect to travel by the rail transit at low degree.

7. Conclusion and Recommendations

All the discussions above explain the existing situation of residential location and travel behavior of Bangkok residents after the first railway system was introduced in the city. As transit-based housing is rapidly expanding along railway lines, we examine whether the residents choosing to reside near the railway station mainly are regular users of the railway. From location and travel behavior survey by using self-selection question, the simple statistics shows most of the station-area residents would like to commute by rail at the time of making residential choice and in turn choose to go to work by the rail transit after moving. This summarizes that people who have a positive attitude toward rail transit and have a preference for traveling by train will live closer to railway stations.

To analyze the relationship between location behavior and travel pattern, we employ binary logit model to estimate the probability individuals residing near a rail stop will commute by rail transit. From model calibration, the results show the influence of travel attitudes on travel choice behavior through residential choice. The low degree impact of distance to the rail station in explaining mode choice behavior implies Bangkok households select where to live according to the built-environment characteristics of the new house rather than the proximity to the mass transit conforming to their attitudes towards mass transit use. Therefore, residential self-selection has taken place but has limited impact on transit ridership in the case study of Bangkok.

Research on self-selection can shed light on the kinds of households most inclining to move to station areas and becoming regular transit passengers. The parameter estimation results indicate householders who have positive attitude toward rail use and whose workplace are well-served by transit are thought to be drawn to residences that are well-served by transit and in turn become regular transit users. The strongest positive impact of travel attitudes depicts that there is a better chance for TOD in Bangkok since the city since people could develop more pro rail attitudes after experiencing travel by train after living near the rail stop.

As people's positive attitude toward using rail transit maybe caused by the good service of rail transit, improvement rail transit system may improve their attitudes. Reducing out-of-vehicle time can be an important strategy to increase more transit users by increasing more frequency of service during peak hours and improving connection to station (such as providing shelter or better footpath) as well. The previous study suggested that increasing the quality of walking environment within acceptable walking distance could be an important strategy to make walking to station more attractive[27]. Moreover, rail transit would be more attractive to gain more ridership by adding more feeder mode for longer distance to access station. It could be combined with providing exclusive shuttle bus to connect condominium to station because some of the station-area residents are infrequent users who own an automobile but have a good attitude toward rail and choose the transit for some trips. Evidences from previous literatures as well as the results found in this research reveal that mass transit system is less attractive for people who own a car and would like to commute by it. Therefore, to

persuade more travelers shifting to mass transit or using mass transit more often, it is better to focus on transit captive users or infrequent users rather than spending too much resource to convince people who have a car preference[27)].

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