Why TOD residents still use car? A study on factors affecting the automobile ownership and use of residents living near transit stations of Bangkok

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This study aim to find the factors affecting automobile ownership and use of residents near transit stations within 1 kilometer mentioned as transit-oriented development (TOD) residents. Reducing parking requirement in TOD area is a TODs' key concept. It would decrease car usage and encourage residents to use transit. However, Thai building control regulation has not been revised. It requires minimum one-car parking slot / one-room residence in high-rise buildings. Developers build parking spaces more to attract customers. It increases cost of condominium units near transit stations which low-income people cannot afford. In 2014-2015, the prices of land and property around transit station in Bangkok's Central business area are much higher, around 130%. Obviously, only middle and high-income people live there. They can afford to have their own car. Of total 322 respondents, 77% are transit users and 23% are car users. Car ownership rate of car users is higher than transit users. The estimation results clearly show that gender, car ownership, station-workplace distances, residences situated in Soi, free car parking at workplace, rail travel cost, commuting during peak hours affect car use decision.

Key Words: *car users, TOD residents, parking availability, automobile ownership, Transit-Oriented Developments (TODs)*

1. INTRODUCTION

Recently, rail transit and transit-oriented development (TOD) have been promoted to reduce auto dependence and traffic congestion. In Bangkok, there is a plan to complete 10 routes of rail transit expansion, with 556 km operating distance and around 500 stations in operation within 2029. The expected number of passengers is 5.36 million per trip a day. Building the compact city around transit station according to the Transit-Oriented Development concept is necessary. The compact city here means the city with walkable, pedestrian-use, mixed-use communities around high quality transit stations.TOD probably helps create any attracting places in cities around. People can live, work, and spend free time near transit station so it is comfortable to make a short trip. Since 2012, TOD is used in urban planning regulation but it is not seriously practiced, especially the increase of mixed land use development, transit accessibility development, car parking space limitation and car sharing campaign in TOD areas. Hopefully, if TOD becomes more effective, it obviously solves traffic congestion problem in Bangkok, which ranks the 12th most congested city in the world. The drivers in Bangkok spent averagely 64.1 hours a year in traffic jams. 23% of overall time and an average 33% of their time during peak hours are concluded here[1)]. There are many inverse results from the concept after completing transit routes expansion , for example; increasing the number of cars in Bangkok around 5% from 2015[2)], gradually higher number of transit passengers and morning/afternoon congestion during peak hours. Public transport use, especially the train, could be higher if central business centre, offices, parks are near railway stations. However, it seems that people still depend on car even though their residences are near transit stations (TOD residents). TOD residents are expected to walk and use transit but built environment around transit stations is not

attractive enough, particularly the far distance from/to home, workplace, commercial buildings, and low transit accessibility around transit station, even the high number of car parking space availability which directly attracts people to drive car. In past decades, the real estate market in Bangkok was booming. The growing number of high-rise residential buildings around transit station grew rapidly. Seemingly, developers had condominiums built with a number of rooms for their own benefit. The number of car parking spaces in residences and office buildings becomes competitive strategy of real estate market, especially areas near transit station because people prefer residence with enough car parking space, therefore, developers attract them by providing spacious parking spaces. Car parking space building is under the parking requirement regulation. It mentions that any residential buildings must provide one car parking slot per one room in minimum (more 60 sq. m.). This policy encourages people near transit station to own a car. It increases the land and property prices, too. In TOD areas, only people in above middle income group can afford to live. These kinds of built environment highly affect TOD residents' travel choice and car ownership. In this study, we survey TOD residents' travel behaviors near transit station within 1 kilometer. Then, we assess the validity of these premises. We analyzed in details how socio-economics, distance from/to station, residence location, car parking availability at home and workplace, and travel behavior characteristics affect TOD residents' car use and ownership.

2. BACKGROUND

(1) Literature review

This paper aims to contribute to our understanding of the role of car ownership as specifically in relation to daily car use of TOD residents. About previous researches, it can be seen that no past studies have been investigated the factors affecting the car usage and ownership in Bangkok. However, there are many empirical studies in the developed countries, especially the US, examined the factors influencing the automobile ownership and use.

As for the socio-economic and demographic differences in car use and ownership behaviors, Shwanen[3] and Stead[4] found that the characteristics of the individual and the household are associated with the car usage and ownership. Factors of age, gender, income level are important variables. Car ownership and car use tend to be lower among older persons (aged above 65 years) and male. Moreover, if older persons travel by car, they are likely to travel shorter distances. Women are inclined to commute more often by public transport, by bike or on foot, whereas car use tends to be higher among men for work trips. Jou and Chen[5] found that the factors related to modal and demographic characteristics had different impacts on the usage of public transport, car and motorcycle in Taiwan. They also find that when 'the number of city bus routes' was in increased by 50% in areas with high population density and high public transportation usage, car usage decrease by 1.4%, which corresponds to 300,000 vehicles. Dargay and Hanly[6] mentioned that household size is positively associated with car ownership. The need to own more than one car increases within larger households. Households that own several cars are likely to use their cars more often. Furthermore, because of their possibly stronger car dependency, members of larger households tend to travel longer distances. Additionally, single households and childless couples tend to obtain longer total daily travel times more than households with children. The increase in the overall car park moves ahead of the rate of increase in per capita car owenership as populations expand. Sanko et al[7] studies the household car ownerhsip behaviors in Asian Big Cities and they investigated that the income level has influenced to the car ownership. Car ownership is higher among high income households, whereas motorcycle ownership is higher among low-income households. Shen[8] studied the factors affecting car ownership and mode choice in rail transit-supported suburbs of a large Chinese city and he found that proximity to metro station has a significant positive association with the choice of rail transit as primary commuting mode. Additionally, the factors of income, job, status, and transport subsidy are all positively associated with the probabilities of owning car and driving it to work. Several studies use car ownership as an independent variable in order to explain travel behavior. Kockelman[10] studied the travel behavior of people living in San Francisco Bay Area and he found that car ownership is influenced by socio-economic variables, especially income, age, status and household size. Car ownership is generally higher among high-income groups. Cao[11] studied the neighborhood design affecting auto ownership around light rail transit developments in Minneapolis-St.Pail metropolitan area, USA. He found that several demographic variables play a

significant role in auto ownership. Household income and the number of drivers in a household are associated with increased auto ownership, while women tend to own fewer autos than men.

As for the built environment factors affecting the car ownership and use, Cao et al., Scheiner and Holz-Rau[12] found that travel behavior is directly determined by car ownership and the build environment (land use diversity, distance from home and employement place to railway station), and car ownership itself is also influenced by the built environment. Dieleman et al.[13] found that an equal influence of the distance to/from railway station and personal travel behavior characteristics statistically significant influence on car use and ownership.

As for the catchment area and walking distance, some previous studies have mentioned some definitions for the catchment area of rail stations. It is generally defined as the maximum walking distance or acceptable walking distance. Mostly, it is a type of stated distance for which rail passengers are willing to walk between home and station. The acceptable walking distance is associated with features of manmade or social environment including proximity to destinations as well as social features (safety or the presence of other walkers). Several studies define the pedestrian radius as a one-way walking distance of 500-1000 m to rail station. Vuchic[14] and Rood[15] define the catchment area as a circular surface with a radius of maximum walking distance that is possible in 5 min from the center of activities or a 10 min walk from rail station. A 5 minute-walk is equivalent to a 400 metre-distance. Thus, a 10 minute-walk is equivalent to 800 m. There are still any other definitions of maximum walking distance, e.g., in Great Britain, over 70% of all one-way walks are shorter than 1600 m[16][17] found that the average maximum walking distance of rail passengers in Toronto's Canada, is approximately 1200 m. Rastogi and Rao[18] studied the maximum walking distance of rail passengers in Mumbai, India. They reported that 85% of people are comfortable with the maximum walking distance of 1250 m. Lee et al. [19] studied the subway accessibility of people in new towns of six metropolitan areas of Korea, finding that 93.7% accept the maximum walking distance of 732-762 m, equivalent to a 10 minute-walk with an average walking speed of 1.22-1.27 m/s. Pongprasert and Kubota[20] studies the transit station access of residents living near transit within 1 km. and they found that the average acceptable walking distance and time of walkers to transit station are 494 m and 9.29 min, respectively. However, the acceptable walking distance was different, depending on geographical condition, climate, land use characteristics, and walking preferences[21]. Based on these studies, the catchment area in this study is within a radius of 1000 m of rail stations.

(2) Transit systems in Bangkok

Figure 1 shows the map of three systems of mass transit systems in Bangkok Metropolitan Region (BMR). First, the Bangkok Mass Transit System (BTS), referred to as the “green line sky train”. It is an elevated heavy rail system consisting of two lines, 34 operational stations, and running for a length of 36.45 km. It began operations in 1999. Second, the Mass Rapid Transit Authority (MRT), referred to as the “blue line subway,” which is an underground heavy rail system, with 18 operational stations along 20 km; the operations began in 2004. Third, The Airport Rail Link (ARL), referred to as the “red line,” which is a partly elevated, partly underground rail system, having eight operational stations along 28.6 km; it began operation in 2010. BTS and MRT aim to serve travels of relatively short intervals, between 800-1200 m. However, ARL is mainly for commuters traveling to the airport with a distance of 2-5 km between stations. In 2015, the number of daily commuters of the BTS, MRT, and ARL were approximately 630000, 255000, and 47000 respectively[22]; however, currently, it is much lower than the targeted ridership of 680000, 570000 and 95900 passengers, respectively. In addition, the annual growth rate of passengers in BTS service has not increased according to the plan. In 2015, it showed only 7% which is less than the plan over twice of 15%. In this paper, we study with all three transit systems because they have been in services for many years and there are many new residential projects established along the rail corridors especially around transit stations. As for the data collected from Chalermpong[23], in 2004, there were around 3,000 condominium units located within 1 kilometer-radius distance of stations. However, in 2009, the numbers of condominium unit became almost 48000 units as equivalent almost 12 times higher within 5 years. In 2029, the transit systems are expected to complete with 10 routes in total and, surely, the number of condominiums will be much higher.

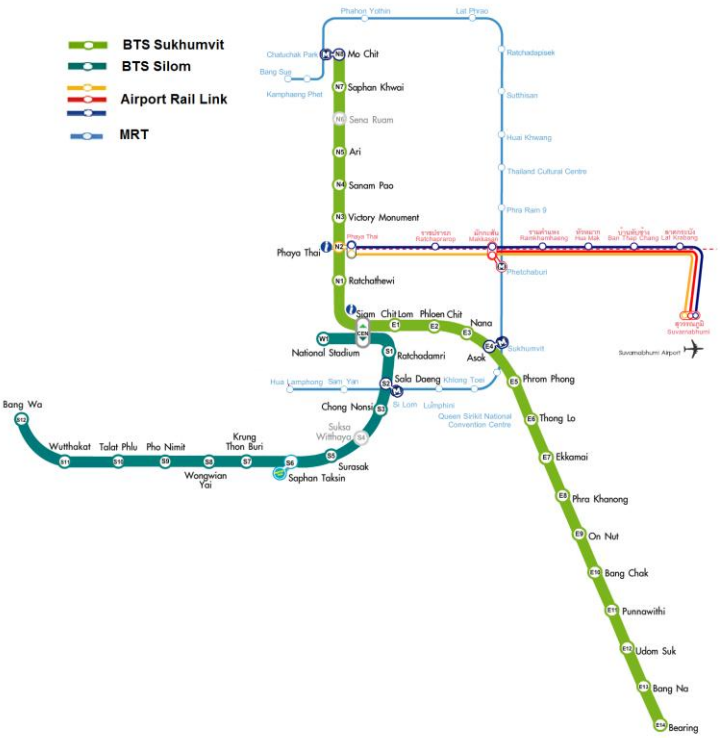

Fig. 1 Map of mass transit systems in Bangkok (Source: www.bangkok-maps.com)

(3) Parking requirements and Price of residential developments near transit station in Bangkok

a) Parking requirements in Bangkok

According to parking reguirements in Bangkok's building code24), the required number of parking stalls in residential building is one car parking slot per one room in minimum (more than 60 sq.m). For example, if developers build condominium with 100 rooms (more than 60 sq.m), they must provide 100 car parking slots at least. That is the reason why TOD residents use auto vehicles even though they live close to transit stations. Then, the minimum parking requirement promotes car ownership as well. But, developers comments that they need to set the room price higher because of higher cost per unit. Then, they can attract only middle income people. Raising IDEO, the condominium projects by Ananda Development company, for example, 10 condominiums in the nearest transit stations provide car parking space 51% of the number of condominium units approximately. Moreover, the top ten condominiums in Bangkok in 2016 ranked by buyers all are close to transit station, 450 m in average. They provide car parking spaces 56% approximately. According to ADB's report, comparing the car parking slots per 100 sq.m. with other Asian countries, small and medium residential buildings in Bangkok have 0.62 parking slots per 100 sq.m. in average, 3 times higher than Tokyo (0.28 parking slots per 100 sq.m). As for buildings for commercial uses,Bangkok city is outstanding from the other cities , especially in terms of the requirements. (averaging above 2 spaces per 100 sq.m. of floor space for building types examined) while the requirement of Tokyo is only 0.36 sq.m., less than Bangkok for 6 times25). The cost of residential developments near transit station in Bangkok.

b) Price of residential developments near transit station in Bangkok

Figure 2 shows the impacts of new mass transit systems on land values of residential development in Bangkok Metropolitan Region. It was found that the mass transit stations proximity is spatially correlated with residential land price increase. The land price slope of residential development within 0-5 kilometers distance slope is steeper than the 5-10 kilometers

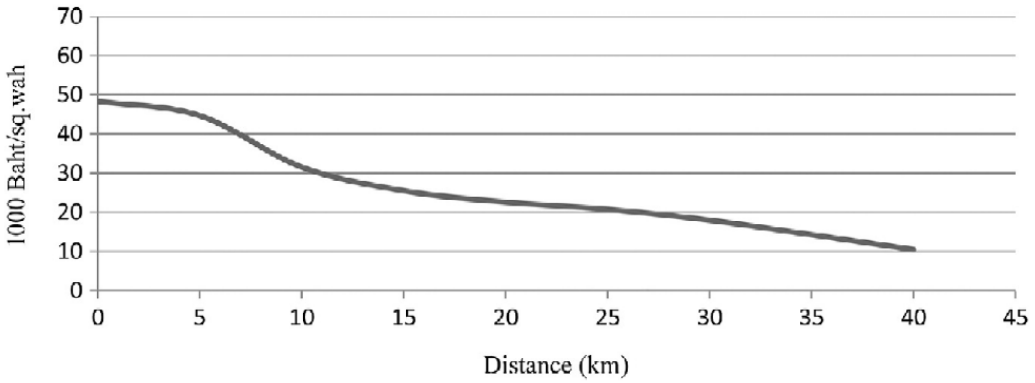

Fig. 2 Average land price by distance to mass transit station in the BMR (Anantsksomsri and Tontisirin[26])

As for current residential unit price in Bangkok, Corrier mentions that the selling rates of condominiums within 200 m distance from transit station was 70% , the highest in 2016 first quarter. CBRE mentions that the average price of high-end condominium units near transit stations in Central Business District (CBD) rises up to the highest of 219000 THB/sq.m, 130% higher than 2015. The data obviously proves that parking space increases condominium price so highly that only above middle income people can afford. In addition, parking space availability is one of the main factors for travel mode choice. Hence, developers now competitively attract customers by providing enough parking spaces inside buildings.

(4) The growth of Car ownership in Bangkok

Car driving is the most popular transport mode in Bangkok. Some say that owning a car upgrade their social and income status. However, the increasing number of automobile vehicles in such a limited-space city is unsuitable. During 2009-2015, the number of private cars in Bangkok continuously grows (Figure 3) from 2393061 to 4013519 (around 68.4%) Generally, the number of private cars increases around 8% year by year. However, Bangkok's private car increase rate in 2012 was rapidly high, around 12.1%[27], because of the first-Time Car Buyer Tax Rebate Scheme in Thailand. This program was launched to help automotive industry recover from 2011 flood, to decrease unemployment rates and to boost car ownerships. The high growth in both manufacturings and sales sector in 2012 boosts the car production industry[28]. However, after 2012, traffic jam problems become critical. Road capacity began to be increased. This is not related to current number of automobile vehicles at all. In comparison with car ownerships in Bangkok and Tokyo, car ownership average in Bangkok is 100 people for 77.46, 4 times higher than Tokyo, 23.46 per 100 people[29]. Apart from disorganized transit route networks, parking lot decrease in TOD areas, residents' travel behaviors and car use habit influences their decision to use transit instead of driving car.

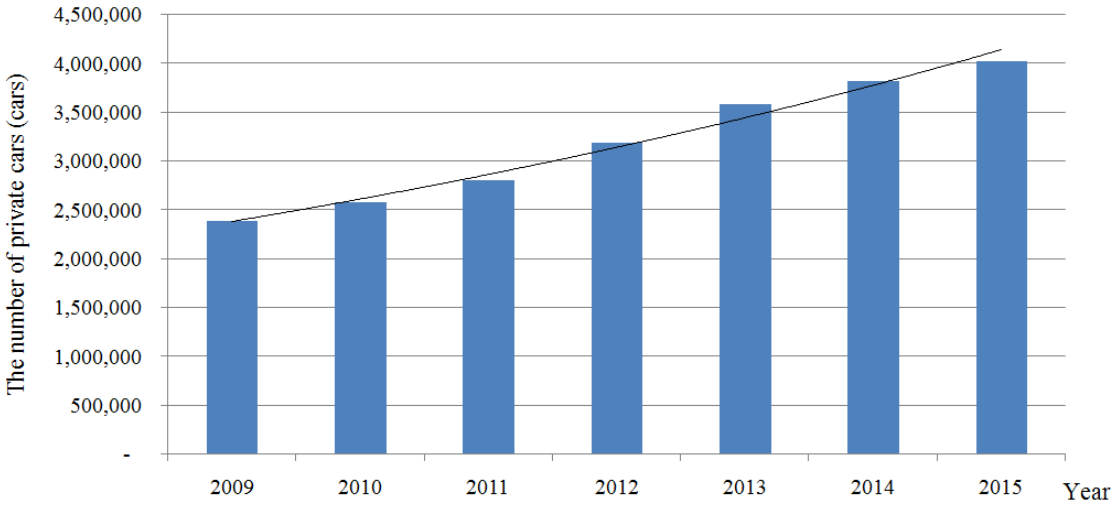

Fig. 3 The number of private cars in Bangkok from 2009 to 2015

3. RESEARCH METHODOLOGY AND DATA COLLECTION

In this research, we hypothesize that automobile use and ownership of TOD areas are dependent not only on their socioeconomic characteristics, but also on their built environment around home and workplace especially proximity to transit station, car parking availability, and home location. Furthermore, the factors of travel characteristics are included in the model of car use. Specially, we focus on the tendency to use and own automobile of residents who live near transit station within 1 km. To test this hypothesis, we estimate the logistic regression model as shown in equation (1) and (2), respectively.

$$\ln\left(\frac{p_1}{1-p_1}\right) = X\beta + L\alpha + Y\delta + \varepsilon \qquad (1)$$

where p_1 is the probability with which TOD residents use their own car; X is the vector of the socioeconomic characteristic variables of the residents; L is the vector of the built environment characteristic variables of the residents; Y is the vector of the travel characteristic variables of the residents; ε is the logistically distributed error; β, α and δ are the vectors of the model parameters.

$$\ln\left(\frac{p_2}{1-p_2}\right) = X\beta + L\alpha + \varepsilon \qquad (2)$$

where p_2 is the probability with which TOD residents preferably own the car; X is the vector of the socioeconomic characteristic variables of the residents; L is the vector of the built environment characteristic variables of the residents; ε is the logistically distributed error; β and α are the vectors of the model parameters.

To estimate the logistic regression models, we collected the data of residents living near transit station within 1 km by an on-line and survey questionnaire in April, 2016. After completed data selection process, we have 322 respondents in total. 60 respondents were from online questionnaire and 262 from online questionnaire survey. All questionnaires were completed by TOD residents of 51 transit station areas. For the online data collection, the questionnaires were distributed to only the respondents living within 1 km of stations. As for the survey, all respondents were given the questionnaire in the residential areas near transit stations such as department stores, coffee shops, restaurants and parks. These can confirm that they are our real research sample. As for the questionnaire, it consists of three parts: 1) socio-economic data; 2) built environment characteristics; 3) travel characteristics. In the part of built environment characteristics, questions of distance from home, workplace to transit station, home location, parking availability and its free of charge are included. The actual distance between respondent's home to nearest transit station, key station to workplaces and home to main streets are measured using Google maps based on the shortest route. Although, the online questionnaire could not meet the respondents, the results collected from them are not more different than that of on-the-road questionnaire. Based on literature reviews and collected data, the variables used in the model of automobile use will be three groups: socio-economic, built environment, travel characteristics. While the model of automobile ownership will be two groups: socio-economic and built environment characteristics. Automobile use and ownership are the dependent variable in each model.

As for the literature reviews, the age group is divided into four: (1) young age (lower than 23 years old, students); (2) mid young age (23-40); (3) mid adult age (40-64); (4) old age (65 or older). They are following to the age group classification by Feldman[30]. As for the income group, we divided into three: (1) low income (less than 20,000 baht/month); (2) middle income (20,001-50,000 baht/month); (3) high income (more than 50,000 baht/month). These data are obtained from Thai's minimum wage rate[31] and research on monthly income of people in Bangkok[32].

4. RESEARCH FINDINGS

(1) Descriptive data

In this paper, there used two estimation models to find factors affecting TOD residents to use and own the cars. Therefore, descriptive data from respondents were separated and shown in 2 tables. The summarized characteristic data of respondents who are car users and transit users and Table 2 shows a group of people owning the car and those who do not. According to Table 1, 23% of respondents are car users while 77% are transit users. 56% of respondents are female. Obviously, female prefer rail to car, while male choose car. The largest group of respondents is middle-young ages (23-40 years old), 63%, while those younger groups (under 23 years old) and

middle-adult ages (40-64 years old) are 25% and 12%. Evidently, middle-young aged people prefer rail to car. Young people prefer transit to car, but middle-adult ages people prefer car to transit. There were no elderly (over 65 years old) here. In terms of household size, respondents with 2 family members are the largest, 35%, while respondents with 3 members and the non-married are 33% and 32%. Most of respondents with 3 members prefer car to transit, while those with 2 members prefer transit to car in their daily life. In terms of income, 46% of respondents are from middle-income household (20000-50000 THB/month), while people with high (over 50000 THB/month) and low income (lower than 20000 THB/month) are 30% and 24%. Most of middle-income respondents depend on transit service in their daily travel more than car. High-income group prefer car to rail, while those with low income prefer transit to car. Although the respondents access the transit services easily because of short distance from home, 45% at least need a personal car. They often drive their own car, while respondents with no car prefer transit. 15% of car users own 2 cars at least. The highest numbers of car possession is 5, while transit users own 2 at most. This data proves the high rate of TOD residents' car ownership. As for home ownership, 63% of respondents own a home, while 37% rent it. Respondents owning a home use car more than transit, while home renters use transit more than car. The average transit access distance of respondents is 452 m, while the average distance from terminal station to workplace/school is 809 m. approximately. 85% of respondents work near transit station (within 1 kilometer). 64% of car users live and work within 1 km from transit station. Obviously, car users travel in the farther distance to/from transit station than transit users. 58% of respondents live in narrow streets (Soi). They choose to drive their own car. In terms of car parking availability, car users are provided car parking space at home and workplace so they prefer car. On the contrary, transit users are provided free parking space at workplace less so they prefer transit. As regards for travel characteristics, 82% of respondents usually travel during peak hours. If car users use transit service, their average travel cost is higher for two times than transit users.

Table 1 Summary of respondents' characteristics (Car users vs. Transit users)

	Overall	**Car users**	**Transit users**
Number of observations	322	73	249
Share (%)	100	22.7	77.3
Gender			
Male (%)	44.1	64.4	38.2
Female (%)	55.9	35.6	63.9
Age			
Young age (%)	25.2	19.2	26.9
Middle young age (%)	63.0	60.3	63.9
Middle adult age (%)	11.8	20.5	9.2
Elderly (%)	0.0	0.0	0.0
Household size			
1 person (%)	32.0	31.5	32.1
2 persons (%)	34.8	23.3	38.2
3 persons (%)	33.2	45.2	29.7
Income			
Low income (%)	23.9	21.9	24.5
Middle income (%)	45.7	37.0	48.2
High income (%)	30.4	41.1	27.3
Car ownership			
No car (%)	56.2	16.4	67.9
1 car (%)	36.0	64.4	27.7
2 cars (%)	4.3	4.1	4.4
More than 2 cars (%)	3.4	15.0	0.0
Home ownership			
Owns (%)	63.0	79.5	58.2
Rents (%)	37.0	20.5	41.8

Distance from home to nearest station			
Average (m)	452	529	428
Distance from key station to workplace			
Within 1 kilometer (%)	85.1	64.4	91.2
Average (m)	809	1552	591
Home saturated in Soi			
Yes (%)	57.8	86.3	49.4
No (%)	42.2	13.7	50.6
Car parking availability at residence (%)			
Yes (%)	84.5	89	83.1
No (%)	15.5	11	16.9
Free parking at residence (%)			
Yes (%)	93.8	85.9	93.2
No (%)	6.2	14.1	6.8
Car parking availability at workplace (%)			
Yes (%)	56.8	91.8	46.6
No (%)	43.2	8.2	53.4
Free parking at workplace (%)			
Yes (%)	19.3	49.3	10.4
No (%)	80.7	50.7	89.6
Travel during peak hours (%)			
Yes (%)	82.3	67.1	86.7
No (%)	17.7	32.9	13.3
Travel cost in transit use (baht)	53	76	46

Respondents' characteristics between those who have 1 car at least and those with no car in household family are shown in Table 2. According to Table 1, 45% of 322 respondents own 1 car at least. TOD respondents owning the car are female, middle-young age, and middle-income. If they are from bigger family, car possession is necessary. 80% have their own home, while those who without car possession rent it. Obviously, respondents owning the car travel in farther distance between home and workplace to/from station than that of those without a car. 85% of respondents work near transit station (within 1 km of transit station); however, 45% need 1 car at home at least. In addition, respondents whose residence located inside narrow streets where car parking is permitted choose to own a car.

Table 2 Summary of respondents' characteristics (TOD residents who own car and those who do not)

	Overall	**Residents who own car**	**Residents who do not own car**
Number of observations	322	141	181
Share (%)	100	43.8	56.2
Gender			
Male (%)	44.1	47.5	41.4
Female (%)	55.9	52.5	58.6
Age			
Young age (%)	25.2	10.6	36.5
Middle young age (%)	63.0	66.7	60.2
Middle adult age (%)	11.8	22.7	3.3
Elderly (%)	0.0	0.0	0.0
Household size			
1 person (%)	32.0	27.7	35.4
2 persons (%)	34.8	34.0	35.4
3 persons (%)	33.2	38.3	29.3
Income			
Low income (%)	23.9	14.2	31.5

Middle income (%)	45.7	49.6	42.5
High income (%)	30.4	36.2	26.0
Home ownership			
Owns (%)	63.0	77.3	51.9
Rents (%)	37.0	22.7	48.1
Distance from home to nearest station			
Average (m)	452	499	414
Distance from key station to workplace			
Within 1 kilometer (%)	85.1	79.4	89.5
Average (m)	809	996	663
Home saturated in Soi			
Yes (%)	57.8	66.7	50.8
No (%)	42.2	33.3	49.2
Car parking availability at residence			
Yes (%)	84.5	90.8	79.6
No (%)	15.5	9.2	20.4
Free parking at residence			
Yes (%)	93.8	95	92.8
No (%)	6.2	5.0	7.2
Car parking availability at workplace			
Yes (%)	56.8	93.6	28.2
No (%)	43.2	6.4	71.8
Free parking at workplace			
Yes (%)	19.3	36.2	6.1
No (%)	80.7	63.8	93.9

(a) Car ownerships in TOD areas

Car ownership in TOD areas Figure 4 shows the car ownership data from 322 respondents who use car and transit regularly. Their residence is located in different ranges within 1 km-distance from transit station. Exactly, transit users' car use habit is 50 m-distance from transit station, while the car users is 100 m-distance. The highest rate of car ownerships among regular car users is 250-300 m-distance while transit users' is 700-750 m. The number of TOD respondents' car ownership is up to 100-150 km. To conclude, TOD residents' car ownership is not lower in closer distance to transit station but it seemingly grows higher at some areas around transit station. In addition, the average rate of car ownership among 73 car users is 1.5 ones per household, while the rate from 249 transit users is 1.14. It can be said that TOD respondents need to own 1 car at least even if they live or work near transit within 1 km-distance for 85%. This is directly caused by unregulated parking requirements in the Bangkok residential buildings near transit station.

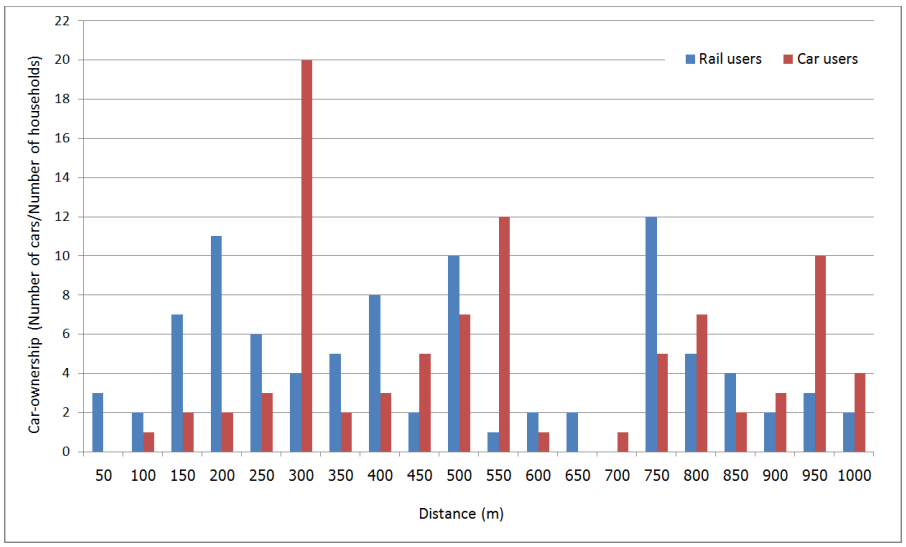

Fig. 4 The number of cars of TOD respondents located at different ranges of distance from rail transit station

(2) Factors affecting car use and car ownership

There are 3 variables; socio-economic, man-made environment around residential area and workplace, travel behavior in the binary regression model analysis. In the survey, 24.22% in total valid respondents (n =322) use car in daily travel. 43.8% of respondents in total own at least 1 car. The estimated values of coefficients of 2 models are shown in Table 3 and 4. They show the estimation results of logistic regression models of tendency to own a car. The coefficient values are estimated by the maximum likelihood method, calculated from the collected data. Table 3 is the factors affecting car use consisting of gender, car ownership, distance from station to workplace, residential areas in narrow streets (Soi), free parking availability at workplace, and rail transit service cost. All are statistically significant at $p<0.05$. Furthermore, car ownership shows major determinant of car use as the highest odd ratio at 8.527. It means that if 1 car increases corresponding to TOD residents' household, the odds of car use increase for 8.527 times. All else is equal. However, traveling during peak hours corresponding to car use's lower rate is statistically significant at $p<0.05$. It means that if other factors are equal, more people commuting during peak hours use car less.

Table 4 shows the factors corresponding to TOD residents' car ownership. It shows that middle young age (23-40 years), middle adult age (40-64 years), home ownership, distances from home to station and key station to workplace, car parking availability at workplace are statistically significant at $p<0.05$. Moreover, car parking availability at workplace shows the highest odd ratio at 88.065. It means that if 1 more car parking is provided at TOD residents' workplace, the odds of owning a car increases for 88.065 times.

Table 3 Binary regression model: Car use of TOD residents

	B	S.E.	Wald	Sig.	Exp(B)
Socio-economic characteristics					
Gender	1.461	.415	12.390	.000**	4.312
Middle young age	-.211	.592	.127	.722	.810
Middle adult age	-.738	.802	.846	.358	.478
Household size	-.164	.276	.355	.551	.848
Middle income	-.926	.575	2.598	.107	.396
High income	-.515	.637	.656	.418	.597
Car ownership	2.143	.578	13.762	.000**	8.527
Home ownership	-.158	.513	.094	.759	.854
Built environment characteristics					
Distance from home to nearest station	.000	.001	.013	.909	1.000
Distance from key station to workplace	.000	.000	9.013	.003**	1.000
Home in Soi	1.741	.493	12.458	.000**	5.703
Car parking availability at home	-.052	.622	.007	.934	.950
Free parking at home	-.731	.844	.749	.387	.481
Car parking availability at workplace	1.044	.652	2.564	.109	2.840
Free parking at workplace	1.109	.446	6.175	.013*	3.032
Travel behavior characteristics					
Travel during peak hours	-1.414	.479	8.701	.003**	.243
Travel cost in transit use	.014	.006	4.406	.036*	1.014
Constant	-3.880	1.350	8.260	.004	.021
Number of observation (N)	322				
Model Chi-square	5.970				

Initial -2Log Likelihood	344.713
Step1 -2Log Likelihood	182.628
Cox & Snell R Square	.396
Negelkerke R Square	.602
Percentage correct	88.5%

**Significant at p<1% *Significant at p<5%

Table 4 Binary regression model: Car Ownership of TOD residents

	B	S.E.	Wald	Sig.	Exp(B)
Socio-economic characteristics					
Gender	-.477	.385	1.532	.216	.621
Middle young age	2.509	.562	19.945	.000**	12.297
Middle adult age	4.524	.862	27.557	.000**	92.241
Household size	.077	.269	.081	.775	1.080
Middle income	-.010	.516	.000	.984	.990
High income	-.402	.568	.501	.479	.669
Home ownership	1.113	.452	6.067	.014*	3.042
Build environment characteristics					
Distance from home to nearest station	.003	.001	16.463	.000**	1.003
Distance from key station to workplace	.000	.000	7.491	.006**	1.000
Home in Soi	-.402	.397	1.024	.312	.669
Car parking availability at home	.770	.541	2.027	.155	2.160
Free parking at home	-.838	.788	1.132	.287	.432
Car parking availability at workplace	4.478	.557	64.551	.000**	88.065
Free parking at workplace	.068	.514	.017	.895	1.070
Constant	-7.430	1.312	32.089	.000	.001
Number of observation (N)	322				
Model Chi-square	9.647				
Initial -2Log Likelihood	441.405				
Step1 -2Log Likelihood	200.590				
Cox & Snell R Square	.527				
Negelkerke R Square	.706				
Percentage correct	86%				

Significant at p<1% Significant at p<5%

5. CONCLUSION AND SUGGESSTION

Traffic congestion problem in Bangkok exists for so long mainly because of overwhelming personal car use in Bangkok Metropolitan Region (BMR). This problem became more critical after 2012 first-Time Car Buyer Tax Rebate Scheme in Thailand. The number of private car increased more than 12% in Bangkok whereas the road capacity does not change. Currently, car ownership rate in Bangkok Metropolitan Region is 72 cars per 100 people and 77 per 100 in average in Bangkok city. This proves that car ownership rate in Bangkok is quite high. However, to solve traffic congestion problem, mass transit system is practiced by encouraging

people to use transit more. But it is not successful because of disorganized transit route network. Not only that, people always depend on private car even though they live close to transit station. As seen from the study, almost half of respondents living near transit station own 1 car at least. People owning higher number of cars tend to drive car much more in daily travel. This results from Thailand's building control regulations which do not limit car parking space in residential and office buildings situated near transit stations so real estate developers can freely have car parking spaces built to attract customers. However, TOD residents still need their own car because of the uncompleted transit route network and difficulty in accessing transit stations. According to survey, among 322 residents near 51 transit stations (85% of total stations) within 1 km, 77% are transit users, while only 23% drive cars in their daily travel. Although some surveys were not completed around transit stations, the data is similar. In terms of respondents' characteristics, 64% of car users live and work within 1 km near transit station but still depend on car. The largest group of car users is male with middle young age (23-40 years old), non-single resident, gaining high income (above 50000 baht/month), living in narrow streets (Soi). They are provided free parking both at home and workplace, and regularly travel during morning peak hours (6.30-9.30). Almost 85% of car users own at least 1 car and 19% have 2 cars at least. As for TOD residents who is a car owner, most are female in middle-young age, gaining middle income and they are non-single resident. Obviously, car owner respondents have farther distance between home and workplace to/from station than those who do not. 15% of car users own 2 cars at least. The highest car ownership number is 5. Those who live in their own home usually drive car more, while the residence renter have lower car ownership rates. According to estimation results, male, car ownership, residence in narrow street, free car parking availability at workplace, higher travel cost in transit use, rail commuters during non-peak hours all influence car use in daily travel. Car ownership shows the highest odds of car use of residents near transit station. As for factors affecting car ownership, middle young age (23-40 years), middle adult age (40-64 years), home ownership, distances from home to station and key station to workplace, car parking availability at workplace own at least 1 car. Car parking availability at workplace factor shows the highest odds of car ownership. These factors influence TOD residents' car ownership. Therefore, to practically encourage TOD residents to use transit more, the attitude toward transit service, car use and standardized urban transportation policy should be studied in further research.

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(Received April 26, 2017)