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Trends of driving demand to inner Bangkok in situation of a congestion charging

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Abstract

Traffic congestion to inner Bangkok needs to be relieved by some kind of a toll charge. The paper investigated whether and to what level the congestion charging will help to solve the congestion problem of inner Bangkok. A travel demand model is estimated and the factors influencing the driving demand for inner Bangkok, where most intensively used mass transit network exists during the years 2012-2014, are reported. The objective is to understand the drivers and investigate the degree of decreased traffic if the congestion charging scheme is implemented and also report other relevant variables. The results show that such the reported acceptable charge has a significant statistically impact on the demand with increasing degree of impact as well as other price-related variable such as fuel costs. Quantity effects such as higher income, more cars in household, more travel time spent to work, and having a parking space at office are used to increase the demand; however, these quantity factors do not have impact on the demand. Conversely, the number of dropping person used to has no impact. Spatial effects, such as the distance from home to office, the distance from office to the metro station, and price effects such as parking fees are not statistically significant. Some personnel factors were not relevant to changes in the number of trips but recently they are reducing factors; these are age, education and urgency of the trip. Factors such as toll charge, income level number of cars in household, travel time to work and parking space are factors increasing the demand. Fuel costs and the occupation officer lower the travel demand.

Keywords: *Travel demand, Driver survey, Inner Bangkok, Congestion charging, Toll*

1. Introduction

This paper reports a driving demand model if congestion charging scheme exists. The work is part of the project of finding on optimal toll value for a congestion charging scheme in inner Bangkok, supported by Thailand Research Fund.

For many decades, traffic congestion in Bangkok is a significant problem. It is apparently seen from the low travel speed (below 20 km/h) of passenger cars on the main roads on AM and PM peak within the inner ring road (area of 80 square kilometer approx. in Bangkok) in the last 5 years. Moreover, some main roads in the business

area (covered by this study) have speeds lower than 15 km/h. (Office of Transport and Traffic Policy and Planning, 2014). Such congestion has many impacts on community. The impacts include air pollution, wasted time, higher travel expense, stress, and a low quality of life. Moreover it brings about a more expensive fuel expense with less worth for the country (Marshall et al., 2000).

Before the first sky metro rail in 1996, the works by the planning and construction government agencies mainly were to increase the network capacity by constructing, expanding, changing the road alignments and building new expressways. These days, new roads are rarely found because space is now limited. Although in 1996 the first sky-rail transit line was built, the situation did not improve. There still appears to be a highly increasing number of driving vehicles every year (Office of Transport and Traffic Policy and Planning, 2013) as well as a discerning lower speed in the evening, even on the road under the mass transit line till the present (Office of Transport and Traffic Policy and Planning, 2014).

The serious consequence of driving at low speed is air pollution. Panich (2004) reported that the World Bank pointed out that the air pollution in Bangkok in 1998 is in a serious condition with the high number of small particles (smaller than 10 micron) at that time exceeds the acceptable level that can lead to 4,000-5,000 earlier death rate per year for Bangkok residents. Panich (2004) showed that the statistical data is still serious to year 2004.

Based on above situation, planning direction should be sustainably developed not in the way of permitting traffic to grow freely, but should be controlled at some point. Economists also pointed out several decades ago that increasing road space was proved no efficient and that drivers must pay for the externalities (congestion and pollution) they put on others (Vickery, 1994; Gärling and Schuitema, 2007).

Having an idea of the magnitude of urban car travel demand would help us understand what the level of traffic maybe like at different cost level. The paper also investigated the influence of other factors which can describe the car demand. To introduce the scheme to public, it is necessary to have information on user responses to be able to plan and to inform the public on the expected results. Therefore, it is worthwhile investigating the issue of changing driving habit through a congestion charge. This paper identifies not only the impact of the toll but also explain all significant factors influencing the demand so that it is clear to understand the environment of current drivers to the area.

The travel data in Bangkok were surveyed by various government agencies over the last 25 years. The survey can be reviewed here. Four major studies were conducted. The aim is to build a demographic database and model the trip generation model for different zone system. Table 1 below showed the previous works. All are in forms of household travel survey. The questions asked are quite similar among the four projects. The works beyond the survey are similar in the structure, as they include a pattern of trip generation, trip distribution, mode choice and trip assignment. The different between models are as the results of different techniques used in each stage of transport model. One feature which often differentiates between models is an area coverage (within inner ring road, or in Bangkok metropolitan

region (BMR) which includes Bangkok and five surrounding provinces (Bangkok=1500 sq.km., BMR=7700 sq.km. approx.). The other different features are level of trip detail and how up-to-date the data on which it is calibrated.

Table 1: Household Travel Survey in Bangkok

Project name	Year	Agency	Consultants	Coverage	Survey
STTR	1990	BMA	BMA	Inner-ring road (80 sq.km. approx.)	Major source of data 15,053 household 48,000 respondents approx.(0.9% of coverage)
UTDM	1995	OCMLT	MVA	BMR (7,700 sq.km.approx)	8,000 household No report on the number of respondents
TTID 2	2002	OTP	TDRC	BMR	20,330 household 47,974 respondents (0.5% of coverage)
TDML 2	2010	OTP	PCBK	BMR	3,018 household No report on the number of respondents

Remarks:

STTR=Short Term Urban Transport Review, BMA=Bangkok Metropolitan Authority, JICA= Japan International Cooperation Agency, UTDM= Urban Transport Database and Model Development Project, MVA= MVA Consultants Ltd., TTID 2= Transport and Traffic Information Development period 2, OTP=Office of Transport and Traffic Policy and Planning, TDRC=Transport Development Research Center, King Mongkut's University of Technology Thonburi, TDML2= Transport Data and Model Integrated with Multimodal Transport and Logistics, PCBK= PCBK International Company Ltd.

Recently, there have been no reports in the literature explicitly investigating the reaction of the public to such a change in travel cost. Therefore, it is necessary to collect the new data especially for this study. Data from above sources are not used in the study because of different objectives, and therefore they provided not enough information for this study. The paper also investigated at the influence of other factors describing the car demand. To introduce the scheme to public, it is necessary to have information on user responses to plan and inform the public on the expected results. Therefore, it is worthwhile investigating the issue of changing driving habit through a congestion charge. This paper identifies not only the impact of the toll but also explain all significant factors influencing the demand so that it is clear to understand the environment of current drivers to the area.

There are numbers of literature on the estimation of urban car travel demand. 1) For the price effect, McFadden (1974) has revealed that price affects driving demand; the demand increases when the user cost of the car falls. Goodwin (1992) pointed out that considering the elasticity of demand with respect to fuel prices can improve our understanding of the price effect, showing that rising fuel prices reduce car travel. 2) For an income level, Mogridge (1967) used the distribution of incomes and expenditures to estimate the number of cars

there would be thirty years later. Dargay and Hanly (2002), and Bresson et al. (2004) have shown there to be a positive relationship between income and car use. One of the difficulties of attempting to investigate income is that the effect of income is even more correlated with socio-demographic variables than the effect of the other variables (Garcia-Ferrer et al., 2006). These variables include household size (Lyons et al., 2002) and the economic situation (Gakenheimer, 1999). These works proved the influences of price effect on car demand which appear as well in this study.

Schafer and Victor (2000) considered the effect of income on travel practices; they brought in the concept of Travel Time Budget (TTB) developed by Zahavi (1973) and Roth and Zahavi (1981). Zahavi showed that ''on average, humans spend a fixed amount of their daily time budget travelling'', the travel time budget (TTB). Moreover, the per traveler travel time budget is typically higher for the lowest incomes (Roth and Zahavi, 1981). 3) For quality effect, Mogridge (1967, 1989) showed that demand is also affected by quantity available of goods and services, measured in terms of the number of car trips and car ownership rates (Jansson, 1989). More generally, an increase in the amount of a good that is available (cars or public transport) has a positive impact on demand. 4) Lastly, urban travel demand is also affected by spatial factors. In this paper, we also investigate the direction of origin of drivers in terms of distance and direction. Other papers investigated different aspects. Kain and Fauth (1977) have considered urban development as measured by the population density in each zone and the socioeconomic characteristics of the households and the location of their jobs and residences in order to explain their modal choice. In Small and Verhoef (2007), travel decisions are influenced by the density of buildings and the type of activity. Button et al. (1993) have demonstrated that there is a positive relationship between car ownership rates and the level of urbanization. But this relationship applies only up to a point. Beyond this point, the infrastructure becomes so saturated that the higher the urban density the more car use, car ownership rates, the number of trips and energy consumption are reduced (Camagni et al., 2002). Moreover, Handy (1996) has shown that the urban activities mix has a negative effect on car use, while emphasizing the complexity of this finding. This complexity is also apparent when it is considered the form of the city, even if a polycentric structure seems to result in lower energy consumption by traffic.

This paper investigated price effect, time budget effect, quantity effect and spatial effect on car demand. Variables maybe the same or some are different from other works based on available data obtained. The paper aims to modeling trips per week based on their personal characteristics and travel information in particular on their acceptable toll level before they change modes or desire not to travel. We also report the estimated value of time based on the choice experiment set, and identity others factors explaining the level of trips. Section 2 details the empirical survey conducted and is followed by Section 3, which discusses the results of our data analysis. Section 4 presents the conclusions.

2. Methods: Data collection and the study area

The data were obtained by conducting an interview survey among drivers in the

study area. Since the survey is aimed at respondents who use a car and face traffic congestion, we select respondents only who drive to work regularly on day-to-day basis into the study area.

To scope the area of Bangkok to a smaller study area. In this study, the area of Bangkok was defined to be a study area of 9.1 sq.km. This chosen area characteristics are considered as follows: Being business or dense area with high income level; Having severe traffic problem, Having high level of air pollution, Having rapid transit lines as travel alternatives. The scope of the paper is not to specify the optimal congestion area, but only to consider reasonably the above information available together on the map of economic area with the most-dense ~~three~~ mass rapid transit lines. Figure 1 shows the area with an average household income (in 2011) for zones. From the figure it is observed that two areas have high values appearing along the lines. One at the area above Rama IV Road and under Petchaburi Road where the area cover high-rise building, high-class shopping centers, and tourist shopping streets. The other is along the transit line at the other side south west of the river with full of luxurious hotels and condominiums along the river.

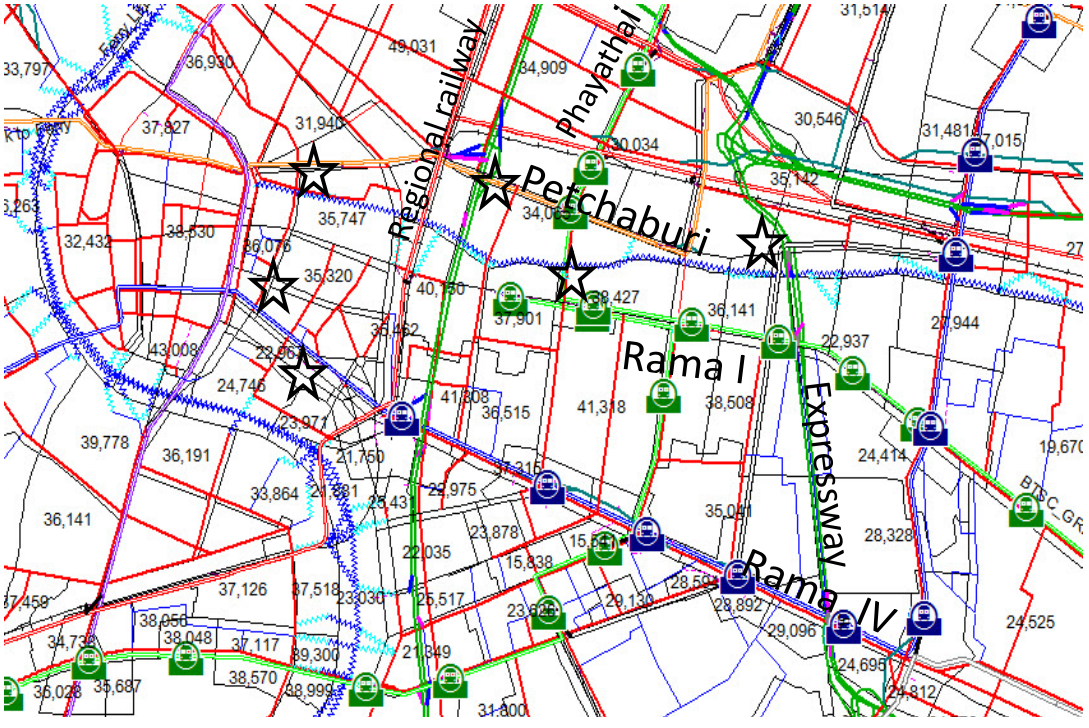

Figure 1. Economic area with income level, transit line and severe pollution points

In term of traffic, the average speed in the morning (6-9am) and evening (4-7pm) peak hour summarized in table 2.

Table 2. Average Speed in the Morning and Evening Peak Hour in Economic Area (OTP, 2014)

Road	Distance km.	Morning speed (km/hr)			Evening speed (km/hr)		
		2007	2010	2013	2007	2010	2013
Phayathai	17.25	16.5	16.7	18.1	17.9	16.5	13.9
Rama I	14.07	15.0	14.2	17.8	17.5	17.4	17.0
Rama IV	8.89	17.6	16.7	14.9	19.4	13.6	13.2

From Table 2, it is found that in the evening peak period, the speed along the transit lines decreased in general, which is not a desirable result considering in term of the effectiveness of planning. Considering the morning peak, on the first two roads, it can be seen that the speeds improve 1.0-3.5 km/hr. because the surrounding places are schools and a university, so some people arrive more early and some who only go to do business can travel outside the morning peak period. This situation does not occur in the evening where most use the road at the same time.

Considering pollution, the air quality data from Pollution Control Department indicated that BMR is facing a severe pollution problem mainly from a large amount of particles, not CO or SO_2. The number exceeds the standard acceptable level. The marks 'star' in figure above shows the measured locations. All points detected the higher value than the standard (Pollution Control Department, 2014). The marked locations are the intersections where detectors were installed. Having considered information on income, speed pollution and rapid transit system available, the study area is therefore the area of the following four roads: Petchaburi Road in the north; The 1st stage expressway in the east; Rama IV Road in the south; Regional Railway from central station up along the northern rail track in the west

Finally, the study area appears in the following figure 2. It is shown as a part of inner ring road (80 sq.km. approx.) in fig. 2.

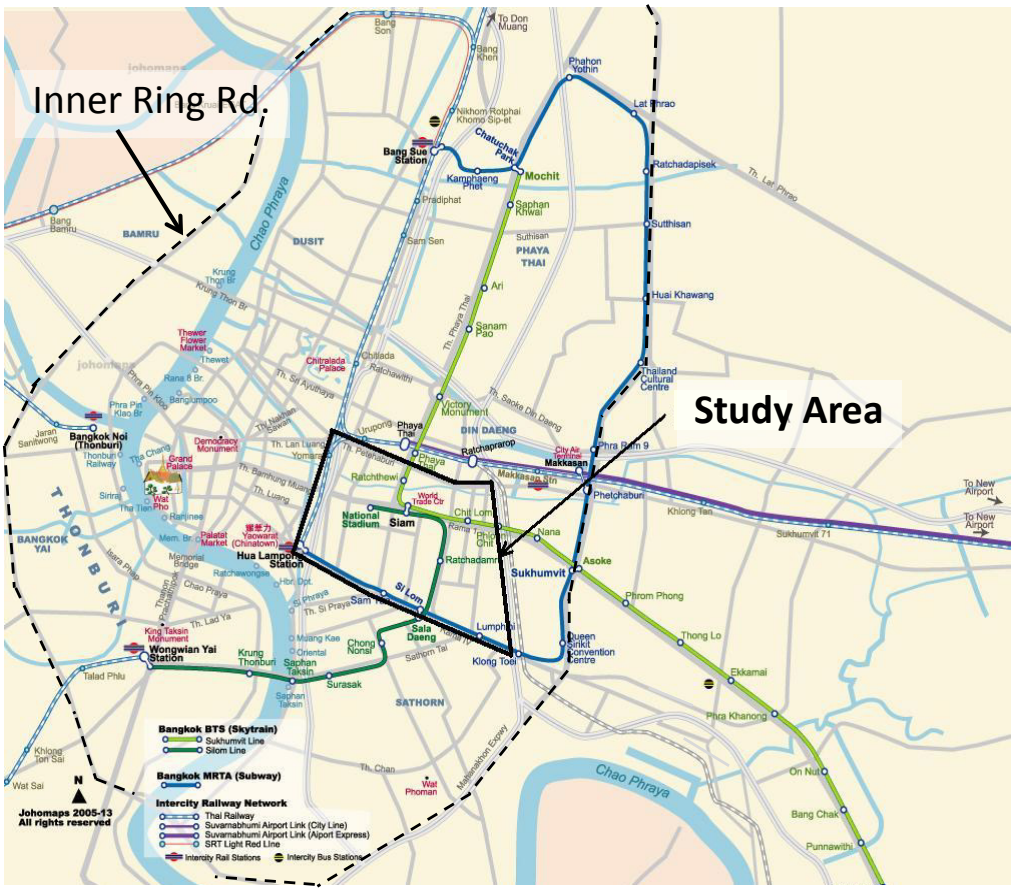

Figure 2. The study area as a part of inner ring road

After the sampling area was defined, the sampling was based on a random technique. The area was divided roughly into 10 portions, of which four portions around the mass transit stations on Petchaburi Road, four portions around four stations on Rama IV road, one portion around Ratchathewi station and another portion at Pratunam shopping area. An equal number of respondents were surveyed in each of 10 portion covering the total area in each block. The survey procedure ensured that each of the 500 total respondents answered all questions completely. The sample size was greater than the number required by Israel (1992) that for 5% precision level where confidence level is 95%, 400 samples required for > 100,000 population. The survey was conducted for 3 years in 2112, 2013 and 2014 over 3 weeks during late April to mid May.

The survey started with questions regarding general characteristics and the travel background of the respondents. The questionnaire asked about some socio-economic characteristics (such as education and income). In the second part, we asked about travel behavior which may be indicators in making response decisions to the experiment. Responses were sought on fuel expense; whether the respondent was urgent, the purpose of each trip, the number of persons dropped off/picked up, information on parking, distance to an existing mass

transit station, the accessibility and their willingness to walk to mass transit station. In the third part, respondents were asked for their reaction to a toll to reduce travel time caused as a result of reduced traffic congestion. The objective is to make a new independent variable associated with the decisions in paying the extra charge to save some travel time in return, in other word the value of time saved. The value of time for home to-work trips in the whole of the Bangkok and metropolitan area, as used by OTP, Ministry of Transport in 2011 (Office of Transport and Traffic Policy and Planning, 2011) was 1.254 baht/minute (or 75 baht/hour). Given this value, we have identified the following intervals: A. 0–40 baht, B. >40–80 baht, C. >80–120 baht, D. >120 baht.

In order to allocate responses to one of above categories, the following choices were offered and presented to the respondent in this format.

Details	Option A	B	C	D
Extra minutes in-congestion	45	30	15	0
Arrival time	T_A	T_A	T_A	T_A
Additional cost (baht)	0	10	30	60
umber of trips	_____ +	_____ +	_____ +	_____ = 10 Trips

Four alternatives are presented. Each of them offer a level of charge corresponding to extra travel time. Then, we asked how they would split a nominal 10 trips into the 4 alternatives. If they chose alternative B over A, it can be inferred that they would be willing to pay 10 baht to save 15 minutes (implying a value of time of at least 40 baht per hour). Also If they chose alternative C over B, it can be inferred that they would be willing to pay 20 (=30-10) baht to save 15 minutes (implying a value of time of at least 80 baht per hour). Again, If they chose alternative D over C, it can be inferred that they would be willing to pay 30 (=60-30) baht to save 15 minutes (implying a value of time of at least 120 baht per hour). We analyzed the value of time saving by the weighted average of the toll and the number of trips for each interval. For instance, when a respondent allocates 5 trips to B and 5 trips to C, therefore, a value of time point estimate of 60 results (=(5*40+5*80)/10)). To survey the value of time, we adopted the method by Ubbels and Verhoef (2006). The next question asked them to identify the charge level at which the cost became unacceptable. And the later question, we asked (based on question 2 in appendix 1) how they would split their 10 trips into each mode including not travelling. In the fourth part, we asked the respondents to rank the transport developments in the area (such as pavement improvement, mass transit network extension, intelligent bus information monitor at bus stops and bus quality improvement. The questionaire's responses can be summarized as the variables in Table 3. All the independent variables were tested.

Table 3. Description of Variables

Variable	Description	Min	Max	Mean	SD
TripPerWk	Car trips per week (Dependent variable)	2	20	10.758	2.913
Age	1 - 18-25 years, 2 - 26-35 years, 3 - 36-45 years, 4 - 46-60 years, 5 - more than 60	1	5	2.980	0.906
Edu	1 - Lower than secondary, 2 - Secondary, 3 - Undergraduate, 4 – Postgraduate	1	4	2.964	0.579
OccEmployee	Occupation: employee 0 - no, 1 - yes	0	1	0.622	0.485
OccGovernment	Occupation: officials 0 - no, 1 - yes	0	1	0.178	0.383
OccOwner	Occupation: status owner 0 - no, 1 - yes	0	1	0.186	0.390
IncomeInterval	1 - less than 10,000 Baht, 2 - 10,000-15,000 Baht, 3 - 15,001-20,000 Baht, 4 - 20,001-25,000 Baht, 5 - 25,001-35,000 Baht, 6 – more than 35,000	1	6	4.780	1.258
CostTimeIncomePerTrip	Income/workinghour* traveltime/trip, in baht per trip	19.35	818.45	230.581	131.765
CostTimeIncomePerWk	Income/workinghour* travel time/trip* trip/week, in baht per week	77.40	9,821.43	2,519.67	1,681.019
CarInHH	Number of car in household 1 - 1 car, 2 - 2 cars, 3 – more than 2 cars	1	3	1.840	0.712

Variable	Description	Min	Max	Mean	SD
VehicleTypeCar	0 - no, 1 - yes	0	1	0.860	0.347
VehicleTypePickup	0 - no, 1 - yes	0	1	0.138	0.345
DistanceToWork	Distance from home, km.	0.2	56.4	15.607	11.396
DirectionE	Living in the east side of the study area. 0 - no, 1 – yes	0	1	0.066	0.249
DirectionN	Living in the northern side of the study area. 0 - no, 1 – yes	0	1	0.302	0.460
DirectionW	Living in the west side of the study area. 0 - no, 1 – yes	0	1	0.064	0.250
DirectionS	Living in the south side of the study area. 0 - no, 1 – yes	0	1	0.092	0.289
DirectionNE	Living in the N-E side of the study area. 0 - no, 1 - yes	0	1	0.174	0.379
DirectionNW	Living in the N-W side of the study area. 0 - no, 1 – yes	0	1	0.070	0.255
DirectionSW	Living in the S-W side of the study area. 0 - no, 1 - yes	0	1	0.082	0.275
DirectionSE	Living in the S-E side of the study area. 0 - no, 1 - yes	0	1	0.038	0.191
FuelPerTrip	Fuel cost per trip, In baht per trip	11.2	595.24	109.345	475.024
Urgency	Normally drive urgently to work 0 - no, 1 - yes	0	1	0.788	0.409

Variable	Description	Min	Max	Mean	SD
TimeToWorkPerWk	The go-to-work hours time the (H to W and W to H) trips per week, in hours per week	1	36	12.169	6.207
PersonDrop	Number of person dropped 0 - 0 person, 1 - 1 person, 2 – 2 or more	0	3	0.342	0.629
ParkSpaceAtOffice	Having a parking space at office. 0 - no, 1 - yes	0	1	0.810	0.393
ParkCost	Baht per day	0	100	13.511	24.403
Move	Tendency to change job to outside area. 0 – No, 1 - May be in 3 years 2 - 3-5 years 3 - less than 5 year	0	3	0.585	0.894
MetroFar	Metro station near office. 0 - no, 1 – yes	0	1	0.546	0.498
MetroNotUse	Driver is not willing to use metro. 0 - no, 1 - yes	0	1	0.070	0.255
ValueOfTimeChoice	Value of time calculated from the chosen tolls from the four alternatives, in baht per hour	0	80	28.004	22.870
CostTimeChoice	Time costs calculated as the multiple of ValueOfTimeChoice and the travel time per trip, in baht per trip	0	240	32.916	33.026

Variable	Description	Min	Max	Mean	SD
TollPerDay	Reported acceptable daily toll, in baht per day	0	142.837	31.691	19.746
TollPerWk	Reported acceptable daily toll, in baht per week	0	1,000	221.835	138.224
NeedNetwork	More or less one needs network expansion 1 – Like the least, 5 – Like the most	1	5	4.016	1.307
NeedITS	More or less one needs ITS system at the bus stop (from raking of the 5 Need variables). 1 – Like the least, 5 – Like the most	1	5	2.254	1.119
NeedFund	More or less one needs transit fund for better bus quality 1 – Like the least, 5 – Like the most	1	5	2.992	1.214
NeedFootpath	More or less one needs better footpath quality 1 – Like the least, 5 – Like the most	1	5	2.486	1.264
NeedParkBoundary	More or less one needs provided parking space outsides the charging zone 1 – Like the least, 5 – Like the most	1	5	3.252	1.438

3. Results

All the variables in Table 3 were investigated for their impact, as shown below. Not all variables do statistically affect the demand. It is noted that before finalized the results, we analyzed in different models and found it is rather not possible to model a relationship: 1. between the number of trips after the toll and the other factors, and 2. between the number of delta trips and the other factors. The estimated model coefficients were determined using STATA software. The results of regression model for the number of trips per week in the year 2012, 2013 and 2014 are shown in Table 4-Table 6 respectively. These results can be summarized in form of directional impact as in Table 7

Table 4. Regression model including all input variables for the number of trips per week in the 1st year, 2012 (R^2 =0.6389, Root MSE = 1.7693)

Variable	Coef.	Std.Err.	t-test	P-value	[95%Conf.	Interval]
Constant	7.297	0.563	12.960	0.000	6.190	8.403
ParkSpaceAtOffice	0.542	0.219	2.470	0.014	0.111	0.972
Edu	0.450	0.158	2.850	0.005	0.139	0.761
DirectionS	0.663	0.283	2.350	0.019	0.108	1.218
CarInHH	0.280	0.120	2.330	0.020	0.043	0.516
PersonDrop	0.249	0.131	1.910	0.057	-0.008	0.506
TimeToWorkWk	0.204	0.016	12.400	0.000	0.171	0.236
IncomeInterval	0.135	0.072	1.870	0.062	-0.007	0.277
TollPerWk	0.006	0.001	8.510	0.000	0.004	0.007
FuelPerTrip	-0.017	0.001	14.460	0.000	-0.020	-0.015
NeedNetwork	-0.136	0.065	-2.100	0.037	-0.263	-0.008
OccGovemment	-0.418	0.223	-1.870	0.062	-0.856	0.021
DirectionNW	-0.950	0.319	-2.980	0.003	-1.576	-0.324

Table 5. Regression model including all input variables for the number of trips per week in the 2nd year, 2013. (R^2 =0.4575, Root MSE = 1.8183)

Variable	Coef.	Std.Err.	t-test	P-value	[95%Conf.Interval]	
Constant	10.768	0.729	14.770	0.000	9.336	12.200
DirectionE	-1.644	0.488	-3.370	0.001	-2.603	-0.685
DirectionNE	-1.013	0.280	-3.620	0.000	-1.564	-0.463
OccGovemment	-0.776	0.183	-4.250	0.000	-1.135	-0.417
DirectionSE	-1.676	0.466	-3.600	0.000	-2.592	-0.760
IncomeInterval	0.146	0.069	2.130	0.033	0.012	0.281
CarInHH	0.262	0.130	2.010	0.045	0.006	0.518
TollPerWk	0.004	0.001	10.110	0.000	0.003	0.005
FuelPerTrip	-0.011	0.002	-5.830	0.000	-0.015	-0.007
DirectionN	-0.923	0.255	-3.610	0.000	-1.426	-0.421
TimeToWorkWk	0.199	0.025	8.060	0.000	0.150	0.247
Move	0.288	0.118	2.580	0.010	0.068	0.507
DirectionS	-0.674	0.316	-2.140	0.033	-1.295	-0.054
ValueOfTimeChoice	0.021	0.006	3.360	0.001	0.009	0.033
CostTimeChoice	-0.028	0.005	-5.910	0.000	-0.037	-0.019
NeedParkBoundary	-0.186	0.079	-2.350	0.019	-0.340	0.031

Table 6. Regression model including all input variables for the number of trips per week in the 3rd year, 2014 (R^2 =0.3605, Root MSE = 3.2412)

Variable	Coef.	Std.Err.	t-test	P-value	[95%Conf.Interval]	
Constant	13.412	1.128	11.890	0.000	11.196	15.628
Age	-0.387	0.166	-2.340	0.020	-0.713	-0.062
Edu	-0.528	0.253	-2.090	0.037	-1.024	-0.031
OccEmployee	1.204	0.522	2.310	0.021	0.179	2.228
TollPerWk	0.002	0.000	5.350	0.000	0.001	0.003
NeedParkBoundary	0.253	0.117	2.160	0.031	0.023	0.484
CostTimeIncome	0.001	0.000	2.230	0.026	0.000	0.002
DirectionSE	3.198	1.499	2.130	0.033	0.253	6.143
FuelPerTrip	-0.004	0.000	-9.170	0.000	-0.005	-0.003
Rush	-0.997	0.379	-2.630	0.009	-1.743	-0.252
NeedFund	0.279	0.124	2.240	0.025	0.034	0.523
PersonDrop	1.823	0.208	8.770	0.000	1.415	2.232
Move	-0.510	0.148	-3.440	0.001	-0.801	-0.219

From the tables above, the results can be summarized in form of directional impact as in Table 7 .

Table 7. Directional impact of independent variables on the number of trips to CBD for the year 2012-2014 (+ = positive impact, - = negative impact, and 0 = not being a significant variable)

Variable		2012	2013	2014	Remark
TollPerWk	price	+	+	+	With decreasing positive impact
IncomeInterval	price	+	+	0	With increasing positive and no impact
CarInHH	quantity	+	+	0	With decreasing positive then no impact
TimeToWorkWk	time	+	+	0	
ParkSpaceAtOffice	quantity	+	0	0	
PersonDrop	quantity	0	0	+	Recently having positive impact
DistToWork,MetroFar,	spatial	0	0	0	Not having significant impact
ParkCost,	price	0	0	0	
Sex,	Personnel	0	0	0	
NeedITS,NeedFootpath	quantity	0	0	0	
Age,Education,	personnel	0	0	-	Recently Having negative Impact
Urgency	quantity	0	0	-	
Move	spatial	0	+	-	
FuelPerTrip	price	-	-	-	With decreasing negative impact
OccGov	quantity	-	-	0	With increasing negative then no impact
NeedNetwork	quantity	-	0	0	
NeedFund	quantity	0	0	+	
NeedParkBoundary	quantity	0	-	+	

Remark: + = positive impact, - = negative impact, and 0 = not being a significant variable

4. Findings and Conclusions

The results are beneficial for policy implementation. One of the outcomes from the survey among Bangkok drivers analyzed in this paper confirms that drivers' responses varied based on their background and travel characteristics. Drivers with different backgrounds, opportunities and duties have different levels of driving demand.

Beyond the background and the characteristics, the insight of travelers is revealed. The analysis in 2012 identifies that increasing in a money-related factors about half cost of a meal does change the demand level. A half meal value of toll can change 8%. This degree is more than that of increasing in other money-related factor, in this case the fuel cost (i.e. Fuel cost factor can change 2%). It means that drivers who drive into this area are sensitive to a higher travel expense incurring from the charge more than they perceive the fuel costs. Thus, tolls will significantly affect driving demand. However, the toll and fuel costs are not a significant change compared to the factors of direction of travel.

Other factors also have impacts such as parking space available at workplace, number of persons dropped, occupation and the proximity of station. It means that the main portion of driver demand who drive into this area do not only sensitive to a little higher price. Moreover, it is interesting that having a parking space at workplace can increase car demand much larger compared to other factors, including the parking fee which does not affect the demand. The parking space, one of the most significant physical factors which the government can control, is a key measure to reduce the demand to the area. Thus, having the toll itself may not be an effective strategy to reduce traffic in the area. Even charging may relieve the traffic condition for a period of time, but sometime later the new cars can fill in again. The key point, therefore, is the limitation in parking space complying with introduction of the toll charge; otherwise, the result of the car decrease would not happen.

In revenue policy, the government should focus mainly on mass transit network expansion as other factors do not significantly affect. It is interesting that having a parking space at workplace can make the trips larger than the parking fee which in this study does not affect the demand. Moreover, the parking space can increase the trips at the same level as increasing the toll equal to half the cost of a meal. Therefore, having the toll itself may not be an effective strategy to reduce traffic in the area. The analysis pointed out that drivers make car trips because they have a necessity to make such trips.

Combining the results from two years later, it is found that the effect of the highest acceptable congestion charge (price effect) decreases during the period. Interestingly, the quantity effect such as higher income, more cars in household, more travel time spent to work (time budget effect), and having parking space at office used to increase the demand, but later these factors do not have impact. This presents travel saturation for these drivers. Conversely, the number of persons dropped off before has no impact; however, now it has. This shows that the accompany persons are the key trip-induced factors

However some variables for spatial effect are not statistically significant, i.e. they do not have influences from 2012 through 2014. These variables are the

distance from home to office, the distance from office to the metro station. However, the amount of parking charge (price effect), and driver's sex (personnel) also reflect the same. Some factors before were not relevant to changes in the number of trips but recently they are reducing factors; these are Age, Education and Urgency (personnel). It means that recently the higher age and the higher education drivers tend to drive less to the area, as well as the drivers in a rush. Driver's tendency of moving a workplace (spatial) has a vary effect through the year from irrelevant to positive and negative effect.

Fuel costs (price effect) always express a negative impact but with decreasing negative effect. The result shows that drivers who have the occupation officials (personnel) drove less than others who in this case are the owners and workers in private enterprise. Drivers, who need a more spread train network chose less drive but recently show non-significant results, i.e. currently the network expansion is no longer an obstacle to the workers in the area. Conversely, drivers, who have the opinion of using fund from the congestion charging for promoting public transport service, used to have no effect but recently this group induces more trips. However, drivers who need parking space (park and ride) at the boundary of the charging area show inconsistent results, from irrelevant to drive less and back to drive more.

For policy implementation, it is found that ability to pay a higher toll leads to more driving into inner Bangkok. It also stems from higher income and having more cars in household. Parking cost does not have an impact. Therefore, to accomplish government may deal with these high i ncome drivers by limiting the number of cars own. Another interesting point, more-travel-time driving leads to higher car trips to inner area for its advantage over other travel modes. This result also confirms because the driving also need the parking area at the boundary of charging area, conversely it is also interesting that having parking space at office currently do not have impact.

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Appendix 1. The questionnaire

Questionnaire no._____
Location code _____
Date _____/____/_____

Questionnaire for the car driver workers for the response to the congestion charging scheme in Bangkok traffic congested area.

Part 1: General questions

1. Sex ( ) Male ( ) Female
2. Age ( ) 18 – 25 ( ) >25 – 35 ( ) >35 – 45 ( ) 46 – 60 ( ) > 60
3. Education ( ) Primary ( ) Secondary ( ) Graduated ( ) Post-Graduated
4. Occupation ( ) Employee ( ) Official ( ) Owner of business in area ( ) Others_____
5. Salary + incomes (baht/month)
   ( ) <= 10,000 ( ) 10,001 - 15,000 ( ) 15,001 - 20,000 ( ) 20,001 - 25,000 ( ) 25,001 - 35,000 ( ) > 35,000
6. Cars in household ( ) 1 ( ) 2 ( ) >=3
7. Home location Sub-district _____District_____Postcode_____City_____
8. Work location Sub-district _____District_____Postcode_____City_____
9. Work status ( ) Owner ( ) Come to Work ( ) Others _____
10. Type of your vehicles ( ) Car ( ) Pick-up ( ) Others _____
11. How much is your fuel cost? _____baht/month
12. Are you traveling in a Rush? ( ) Y ( ) N
13. Time LEAVE HOME_____, ARRIVE AT WORK_____, LEAVE WORK_____, ARRIVE AT HOME_____

Part 2 : Travel information

14. Number of Trips you drive in/within/out the area _____ (Trips/week)
    Purposes:
    - Leave home in area ___A___Trips, or otherwise Go to work in area __B__ Trips (If fill in A, do not fill in B)
    - Go home (in or outside) _____ Trips - Business _____ Trips
    - Shopping _____ Trips - Others (Visits, drop off/pick up) _____ Trips
15. Number of persons you are responsible to drop off or pick up every day.
    ( ) 1 ( ) 2 or more ( ) 0 (You drive alone.)
16. Do you have your own parking space in the area?
    ( ) Yes at cost _____baht/day ( ) No, have to find an available space at cost _____baht/day
17. Your tendency to move your work outside the area
    ( ) None ( ) Maybe in 3 years ( ) Maybe in 3-5 years ( ) More than 5 years
18. The distance between your Home/Destination and the nearest mass transit station is
    (Q 18. you can tick more than 1 choices)
    ( ) in walking distance ( ) too far ( ) Not willing to use no matter how near or far

Part 3: Responses to stated choices. The government needs to deal with the increase in air pollution and traffic congestion in the inner metropolitan area. To drive a private vehicle inside the area will be charged a fixed amount per day. Let's suppose that you make a total of 10 trips/week in and out the area during the peak hour.

19. If there is an ideal system which can help you save your travel time more or less depending on your desired toll. Assume the situation in the four alternatives (A B C D) below. Please allocate your 10 trips among the four options.

    Ex. Normally you don't want to pay, and you can spare 45-minutes time for traffic congestion. But only on Monday morning, you are willing to pay 60 baht because you don't want extra minutes in the street. Then you put 9 in Alternative A, and put 1 in alternative D.

	Option			
Details	A	B	C	D
Extra minutes in congestion 45	30	15	0	0 (No congestion)
Additional cost (baht)	0	10	30	60
	_____ +	_____+	_____ +	_____ = 10 Trips

20. (Independent of 19.) If you have to pay the toll, identify the lowest charge level you would consider unacceptable. (You may want to quit some car trips, share a ride with others or switch your departure time, or use mass transit). Please tick the number below (in baht) for the lowest amount that is unacceptable.

    10 15 **20** 25 **30** 35 **40** 45 **50** **60** **70** **80** **90** **100** baht

Part 4

21. Government spending options for the revenue from the charge.

    Please rank 1 to 5 (1 = like the most).

    Expansion of mass transit network outside .....

    Intelligent transport system at the bus stops in the area .....

    New buses and good service in the area .....

    Improvement of footpaths in the area .....

    Parking garage outside the area .....