Travel behaviour change under introduction of congestion charge in Hanoi

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Abstract:

One of political solutions recently proposed to reduce a serious congestion in Hanoi is the congestion charge. The study examines the impact of a congestion charge scheme on individual travel mode choice behaviour in congested areas. Since a congestion charge scheme has not been implemented in practice, we conduct a stated-preference survey where respondents are asked to choose their preferred travel mode among car, motorcycle, bus and rail under condition that the congestion pricing is applied for private motorised modes. The inclusion of refund variable as an attribute of the charging system aims to improve the acceptability of people. A multinomial logit model is developed to analyse the survey results. The results suggest that the charge has a significant impact on changing drivers behaviour especially motorcycle drivers. However, the fact that some people seems have a tendency to ignore refund issue may result from the diversified values of travel time savings estimated from the model.

Keywords: *Road pricing, Congestion charge, Travel behaviour, RP and SP, Transport demand management*

1. INTRODUCTION

For 25 years of the renewal process, Vietnam has achieved many great successes in the socio-economic development. From a poverty, stagnant and backward nation, Vietnam has become a new emerged developing country with constantly high growth rate in recent decades (at yearly 7-8% according to General Statistics Office 2009). Poverty rate in the country has been sharply reduced since 1991 - the percentage of Vietnamese people living below the global poverty benchmark of $1 per day have reduced from 51% to 8% (General Statistics Office 2009). It is even called a new "Asian Tiger" as a result. However, beside those achievements, Vietnam is confronting with remarkable challenges especially on urban transport. Economic growth tends to be coupled with increased private vehicle ownership and traffic volumes especially in Hanoi and Ho Chi Minh city (in Hanoi, private vehicle ownership increase rate is about 12-15% per year, Hanoi Transport Service 2009). In conjunction with traffic vehicle increase, demand for road space is going up much faster than the climb in capacity, particularly in the fastest growing metropolitan areas. As big cities have developed and grown, the ability to service the continued growth in travel has been increasingly limited by strict approval processes, the scarcity of land and traditional

sources of funding to build additional highway capacity. In addition, public transport system is considered inadequately as well as lack of parking space plan. As the result of this situation, traffic accidents and congestion frequently occur in large cities (according to statistics, 31 deaths per day due to traffic accidents in recent 5 years) seemingly at all hours of a day, urban air is polluted by emissions and noises from traffic vehicles. All these badly affect the economic development of Vietnam, threatening civilian living standard seriously.

For years, it has been considered that the solution to the rising issues in urban transport is to build and improve transportation facilities. Obviously, road improvements will continue to be an important strategy for providing mobility. However, for developing countries like Vietnam, it is hard to have sufficient financial resources to construct more roads. Therefore, it is high time that the authorities had to look for alternative ways to satisfy mobility needs of the nation.

Urban road pricing has been promoted by transport economists for decades as a mean of solving congestion problems in big cities. Various urban areas around the World where have been applied successfully this transport management measure to alleviate congestion, reduce travel times, and increase accessibility can be listed as Singapore, London, Stockholm, Oslo and Trondheim, etc. However, there is a limited number of studies examining the impact of this scheme on cities in developing countries where two-wheel vehicle is a dominant travel mode. Therefore, this paper aims to explore how a hypothetical congestion charging scheme influences on travel behaviour in Hanoi, Vietnam.

2. LITERATURE REVIEW

Singapore is considered the most successful example of implementing congestion charge to reduce traffic congestion in central city since it was first introduced in 1975 as Manual system and over 20 years later as Electronic one. The scheme had a huge impact on traffic situation with a 45 percent reduction of traffic demand within the morning peak, number of cars entering the restricted area decreased by 70 percent (Willoughby 2000), and another 15 percent after introducing Electronic system. The success of Singapore has encouraged other countries around the world to apply this scheme to tackle their traffic problems such as UK, Sweden, Norway, and some others. Among them, London has recently emerged as the second successful example. On February 17, 2003 the London congestion charging scheme came into effect. After one year of implementing the project, it was reported that a decrease of 18 percent of traffic entering the charged zone was seen together with 30 percent decline of traffic jams within the cordon zone. The scheme not only affected on traffic as a whole but it also influenced on travel mode change in the city. Taxi and bus use increased by 20 percent and over 20 percent in the zone, respectively because of being exempt from paying the congestion charge. (Transport for London, 2004)

It is believed that the effects of road pricing on traffic demand will be gained by altering traveler's behaviour such as departure time choice, modal split or route choice. Some studies have dealt with this topic in countries around the world. Vrtic, Schuessler, Erath, and Axhausen (2010) revealed the impacts of road pricing on route and mode choice behaviour in Switzerland. The result showed that socio-demographic, trip and transport service characteristics have strong influences on road user's response to the road pricing scheme. Saleh and Farrell (2005) suggested that the impacts of congestion charge on travelers' departure time choice depends not only on flexibility of work schedule but also on other non-work business such as childcare or before-work activities. Therefore, policies facilitating workers to implement personal commitments should be considered parallel with application of congestion charge. However, studies about this topic mostly are conducted in developed countries where car is the dominant travel mode. In the context of motorcycle dependent cities like Hanoi, how a congestion charging scheme will affect individual travel behaviour is an issue needed to be examined.

Despite the fact that congestion charge is considered to be one of the most effective transport demand management solutions for alleviating traffic jams, the scheme still has to face its low social acceptability. There are some reasons for this problem such as car use limitation, doubts about its effectiveness and the degradation of business activities in charging zones. In an effort to improve the

acceptability of congestion pricing strategies, Miwa et al. propose an idea of a parking deposit system (PDS) in which a full or partial refund of area entry toll to drivers who shop or use parking facilities in the charged zone. The result indicated that the PDS partly improves the acceptability of congestion charge. However, this research mainly focused on how the PDS influences on attitude of respondents toward congestion charging scheme, while the alteration of individual travel behaviour was not yet concerned. As far as the author's best knowledge, there is still limited number of research, which include refund as a single variable to explore changes in travel behaviour of drivers in the situation that congestion charge is introduced. Therefore, the aims of this research is to concern about the impact of congestion charge on mode choice in the context of motorcycle dependent city like Hanoi and include refund as a factor to improve the acceptability of residents.

3. MULTINOMIAL LOGIT MODEL

Random utility discrete choice models are the standard tools to model transport behaviour (Domencich and McFadden, 1975; Ben-Akiva and Lerman, 1985) In this study, we simply apply the conventional multinomial logit model to model mode choice behaviour under introduction of congestion charge.

Under the logit model, it is assumed that the respondent chooses an alternative from a choice set that gives the highest utility. Individual i's utility for alternative j, U_{ij}, is defined as follows:

$$U_{ij} = V_{ij} + \varepsilon_{ij} \quad (1)$$

Where V_{ij} is the observable portion of the utility estimated by the analyst, and ε_{ij} is the error component of the utility unknown to the analyst. For the observable component, a liner utility function is applied as follows:

$$V_{ij} = \sum_k \beta_{ijk} X_{ijk} \quad (2)$$

Where β_{ijk} are the parameters of the k-th attributes X_{ijk} for alternative j.

Assuming a Gumbel distribution for error components, the probability that individual i chooses alternative j from a choice set J can de defined as:

$$P_{ij} = \frac{\exp(V_{ij})}{\sum_{j' \in J} \exp(V_{ij'})} \quad (2)$$

4. DATA

To collect input data for model estimation, a household survey including both Revealed Preference (RP) and Stated Preference (SP) questions was conducted in Hanoi. Various set of questionnaires are distributed randomly to different residential areas.

- Survey method: Paper-based, face-to-face interview
- Sample size: 230 respondents (Pilot survey: 30 respondents)
- Time: October 7th 2013 – November 1st 2013

RP section consists of four parts. The first part is to collect respondent information on trips that the respondent made to the charged area including data about trip purpose, travel modes, travel time, trip length, travel cost, and parking activities. The second part is questions related to residential characteristics of respondents. In the third part, respondents will be asked about their preference. Part 4 and part 5 is to collect people's opinion on transport environment and solutions, and socio-demographic characteristics respectively.

SP survey was designed to explore how people travel behaviour change in term of modification of travel mode and departure time when a congestion charging scheme is hypothetically applied. The interviewer first introduced and gave some general information about the scheme. Then, the respondent was given a set of questionnaire in which the hypothetical attributes of each travel mode, such as charge, in-vehicle travel time, refund, public transport level of services and other attributes are systematically distributed. The summary of data characteristics and summary of alternatives and attributes used in the survey are shown in Appendix A and B respectively.

5. MODEL ESTIMATION RESULTS

The parameters are estimated using the data set described in the previous section and a multinomial logit model is applied. The estimation results for Model 1 are shown in Table 1.

Table 1 – Model 1 estimation result

Explanatory variables	Estimated parameters
Income	
Car	
Motorcycle	-0.1586 (-7.077***)
Bus	-0.3714 (-7.562***)
Rail	-0.1814 (-5.791***)
Age	
Car	
Motorcycle	-0.3003 (-2.287***)
Bus	-0.4768 (-2.274**)
Rail	-0.324 (-1.998**)
Car ownership	
Car	
Motorcycle	-1.557 (-7.796***)
Bus	-1.825 (-5.314***)
Rail	-1.702 (-6.346***)
Motorcycle ownership	
Car	
Motorcycle	0.939 (5.649***)
Bus	0.384 (1.763*)
Rail	0.596 (3.05***)
Charge (VND)	
Car	-0.0125 (-1.931*)
Motorcycle	-0.06 (-2.108**)
Fare (VND)	
Bus Rail	-0.105 (-2.776**)
In-vehicle time (minutes)	-0.053 (-4.713***)
Refund	0.01 (0.113)
Frequency (minutes)	
Bus Rail	-0.015 (-0.762)
Access and egress time (minutes)	
Bus Rail	-0.0493 (-1.632)
Constant	
Motorcycle	3.658 (6.34***)
Bus	6.579 (7.72***)
Rail	5.168 (6.024***)
Log-likehood at zero	-1.292.026
Log-likehood at covergence	-914.5744
Rho-square	0.292
Adjusted Rho-square	0.275

****, **,* Significant at 99%, 95% and 90% respectively*

Among the explanatory variables, representing characteristics related to travel modes, both charge and in-vehicle travel time had a negative sign and were highly statistically significant which indicates that those factors strongly influence on mode choice behaviour of road users. It seems that people tends to avoid to pay congestion charge and prefer travel mode supporting shorter travel time. In addition, that the value of parameter representing charge variable for motorcycle is 5 times higher than the one for car indicates that motorcycle users are more affected by congestion pricing than car users. Besides, other statistically insignificant variables such as refund, frequency, and access and egress time may illustrate that people mainly focus on cost and time attributes when they choose vehicles to travel.

Regarding variables representing socio-demographic characteristics of respondents, the result suggests that people with higher income may have higher preference of choosing car instead of other travel modes. Aging people less likely choose motorcycle, bus, and rail as their travel mode compared to cars. While people who tend to own car may prefer to choose a car as their travel mode compared to the rest, people who have higher motorcycle ownership may have higher preference of motorcycle, bus and rail than car.

The ratio of the estimated in-vehicle time and charge parameter provides the value of travel time savings (VTTS) implied by the model. The implied VTTS for cars, motorcycle and bus is 4,240 VND/min, 883 VND/min and 505 VND/min respectively that is equivalent to 254,400 VND/hour, 53,000 and 30,300 VND/hour. This estimated VTTS is significantly higher than the average wage rate in Hanoi at present, approximately 24,000 VND/hour. However, this VTTS is fixed over income group. To explore how VTTS varies over income, we refined Model 1 with another model in which charge variable was replaced by charge/income variable. The estimated result is shown in Table 2.

The second model yielded a similar result to the first model except for the parameter representing car charge variable that was statistically insignificant. This again prove that motorcycle driver is strongly sensitive to congestion charge especially for lower income group. Car users with higher income level appear to be willing to pay the congestion charge. A variety of VTTS over income group implied by the model is illustrated in Table 3.

6. DISCUSSION

Recently, Vietnamese government has been seeking various solutions in order to tackle serious traffic congestion in big cities like Hanoi and Ho Chi Minh city. Among solutions proposed, congestion charge that is conducted successfully in several cities around the world is considered a potential and effective one. Before applying this traffic management scheme into practice, a better understanding of its impact on travel behaviour is necessary. To do it, a survey including both RP and SP questions was conducted in Hanoi in 2013. A multinomial logit model was then developed to analyse travel mode choice behaviour under the presence of congestion charge. The results suggest that the charge has a significant impact on changing mode choice behaviour especially motorcycle users. The results also indicate that people seem to have a tendency to ignore refunding scheme, presumably resulting from the diversified values of travel time savings.

Due to time limitation, this paper have only applied MNL model for data analysis, which may result in some drawbacks in the estimation results. In the future, advanced models such as a RP-SP combined model and latent class model that can explore latent individual groups will be applied.

Table 2 – Model 2 estimation result

Explanatory variables	Estimated parameters
Income	
Car	
Motorcycle	-0.189 (-7.425***)
Bus	-0.288 (-5.821***)
Rail	-0.157 (-4.625***)
Age	
Car	
Motorcycle	-0.3638(-2.685***)
Bus	-0.474 (-2.247**)
Rail	-0.331 (-2.008**)
Car ownership	
Car	
Motorcycle	-1.566 (-7.719***)
Bus	-1.876 (-5.368***)
Rail	-1.768 (-6.438***)
Motorcycle ownership	
Car	
Motorcycle	0.934 (5.636***)
Bus	0.401 (1.857*)
Rail	0.603 (3.139***)
Charge (VND)	
Car	-0.0215 (-1.264)
Motorcycle	-0.279 (-4.968***)
Fare (VND)	
Bus Rail	-0.075 (-1.855*)
In-vehicle time (minutes)	-0.053 (-4.675***)
Refund	0.016 (0.168)
Frequency (minutes)	
Bus Rail	-0.014 (-0.66)
Access and egress time (minutes)	
Bus Rail	-0.0497 (-1.633)
Constant	
Motorcycle	4.364 (7.297***)
Bus	5.685 (6.793***)
Rail	4.287 (5.387***)
Log-likehood at zero	-1.292.026
Log-likehood at covergence	-907.4018
Rho-square	0.2977
Adjusted Rho-square	0.2807

****, **, * Significant at 99%, 95% and 90% respectively*

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Table 3 – VTTS over income group

Monthly income (million VND)	Value of travel time savings (VND/min)
	Motorcycle
1	190
5	950
10	1,900
15	2,849
20	3,799
25	4,749
30	5,699

APPENDIX A

Summary of data characteristics

Individual characteristics	Percentage (%)
Age	
<20	2.58
20-29	42.92
30-39	29.18
40-49	21.46
50-59	3.00
60-65	0.86
Gender	
Male	53.22
Female	46.78
Marital status	
Single	41.20
Married	58.80
Occupation	
Government officer/ Company staff	53.22
Industrial worker	10.30
Business	12.02
Jobless/Retired	0.43
Student/pupil	21.46
Others	2.58
Education	
Master/Doctor	19.74
Bachelor	58.37
Junior College	12.45
High school	8.15
Secondary or lower	1.29
Individual Income (million VND)	
≤ 1	16.31
1+ – 3.	6.87
3+ – 5	16.74
5+ – 10	33.48
10+ – 15	10.73
15+ – 20	9.87
20+ – 30	3.00
> 30	3.00
Driver license	
Motorcycle	54.94
Both	40.77
None	4.29
Car ownership (or able to use)	
No	64.81
1	31.33
2	2.15
3 or more	1.72
Motorcycle ownership (or able to use)	
No	12.02
1	60.52
2	18.88
3 or more	8.58

APPENDIX B

Alternatives and attributes for mode choice section:

- Alternatives: car, motorcycle, bus, rail (elevated)
- Trip scenarios: purpose (work, non-work); length (20 minutes, 40 minutes)
- Attributes and their levels in SP exercise:

Attributes \ Alternatives	Car	Motorcycle	Bus	Rail
Charge (VND) (car/motor) Fare (bus/rail)	20000	5000	6000	10000
	40000	10000	9000	14000
	60000			
In-vehicle travel time (minutes) (For trip 20 minutes long)	10	10	15	10
	15	15	25	15
	20	20		
In-vehicle travel time (minutes) (For trip 40 minutes long)	20	20	35	30
	30	30	45	35
	40	40		
Frequency (minutes)			5	3
			10	6
			15	9
Access and egress (minutes)			5	8
			10	12
Refund (who shop or use parking facilities in the charged area)	No			
	Half			
	Full			
Charged area	Small area			
	Wide area			
Charged time	6.30-9am ; 4.30-7pm			
	7am-9am ; 5.30pm-7pm			
Trip purpose	Work trip			
	Non-work trip			