Road user Benefits Transfer: the Case of Contingent Valuation Method and Vehicle Operating Cost

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Abstract

Poor road maintenance is a major cause of highway capacity reduction, an increase of travel time and accidents, and so on. The Bangkok Highway Bureau is selected as a study area to research into improvements in ride quality. The Contingent Valuation Method (CVM) is used to elicit road user preferences expressed in terms of Willingness to Pay (WTP) and Willingness to Accept (WTA). Results from questionnaires found that road users are aware of the highway deterioration problem and the study showed that they are willing to sacrifice their resources to improve their standard of living. It is now up to the government to appropriately respond to this demand in the most efficient and effective way.

This research focuses on the development of benefit estimation models for the pavement network-level application. An estimation of user benefits helps engineers schedule the proper maintenance activities at the proper time. The regression models are developed based on the benefit estimation (WTP and WTA bids) and International Roughness Index (IRI). Benefits derived from CVM are sensitive to road users comparing there benefits with Vehicle Operating Cost (VOC). VOC estimates the benefits on the disaggregate level, which excludes the total delay costs, total accident costs, and other indirect benefits when the total benefits can be captured by CVM.

Keywords: Contingent Valuation Method, Vehicle Operating Cost, Road User Benefit

1. Introduction

This paper focuses on deriving road user benefits that are based on the concepts of Willingness to Pay (WTP) and Willingness to Accept (WTA). Road users quantify benefits as savings on vehicle operating costs, reduction in accidents, and reduction in travel time, as well as other factors that are not easily quantifiable, such as better ride quality, comfort, and convenience. Non-users benefit from reductions in accidents and environmental degradation. This study estimates the willingness of road users to pay for improving ride quality and to accept using poor roads by conducting a contingent valuation (CV) survey. This study will determine road user benefits that can be used in life-cycle cost analysis.

2. Vehicle Operating Cost

Vehicle operating costs are estimated based on the International Roughness Index (IRI). The tool for estimating life-cycle costs on roads in Thailand is based on the Highway Design and Maintenance Standards Model (HDM-III) developed by the World Bank. Research that is conducted in various countries over the last 15 to 20 years has demonstrated that road roughness has a significant impact on vehicle operating cost (VOC). HDM-III contains a set of relationships, which estimate the various components of VOC, for example fuel consumption, tire wear, maintenance and depreciation, as a function of road roughness. Roughness, in turn, is measured in terms of the IRI. The following relationship was developed for estimating the additional VOC incurred by road users [1, 2].

$$VOC_{PC} = 3.40 - 0.0707IRI + 0.0232IRI^2$$

$$VOC_{LT} = 3.03 - 0.0687IRI + 0.0221IRI^2$$

$$VOC_{LB} = 3.72 - 0.0864IRI + 0.0254IRI^2$$

$$VOC_{MT} = 4.32 - 0.0600IRI + 0.0184IRI^2$$

$$VOC_{HT} = 5.57 - 0.1543IRI + 0.0411IRI^2$$

$$VOC_{HB} = 17.11 - 0.1522IRI + 0.0570IRI^2$$

Where VOC = vehicle operating cost in Baht/veh/km

IRI = roughness (m/km)

3. Contingent Valuation Method

The contingent valuation method (CVM) is carried out to estimate the road user willingness to pay a fee for ride quality improvement based on the analysis of data obtained from standardized questionnaires through interviewing the sampled respondents. The CVM involves the use of survey questionnaires to elicit hypothetical willingness to pay (WTP) information. The CVM is presented in the following formulation [3]:

$$WTP = \frac{\sum_{i=1}^{N} n_i P_i}{\sum_{i=1}^{N} n_i} \quad (1)$$

Where:

WTP = road user willingness to pay;

P_i = ride quality improvement fee at level i;

n_i = frequency of P_i;

N = number of road users.

This research will use another concept which is willingness to accept (WTA). A variation is the question on how much compensation road users are willing to accept to endure a poor road. WTA is widely regarded as the conceptually correct procedure in cost benefit analysis. It assesses costs in terms of what users are willing to accept as compensation for any inflicted cost.

The following simple conceptual model describes a road user's decision whether or not to agree to pay for ride quality improvement. Let V be an individual's indirect utility function, the arguments of which are: attributes of the willingness to pay for ride quality improvement including fee (Q), income (Y), the prices of other goods and services (P), and other socioeconomic characteristics and attitudes of the road user which may affect (or serve as proxies for) tastes (SE). Consider a change in an individual's pavement roughness from Q_0 to Q_1. The individual's willingness to pay (WTP) for this change is derived from his/her indifference between the following two indirect utility functions [4]:

$$V(Y_0 - WTP, P, Q_1, SE) = V(Y_0, P, Q_0, SE) \quad (2)$$

This implies that an individual's WTP for ride quality improvement is a function of the proposed change in Q and of all the other factors that influence the individual's valuation of a change in Q:

$$WTP = f(Q_0, Q_1, Y_0, P, SE) \quad (3)$$

This research focuses on the development of benefit estimation models for the network-level application. An estimation of user benefit helps engineers schedule the proper maintenance activities at the proper time. The regression models are developed based on the benefit estimation (WTP and WTA bids) and the individual's pavement roughness (IRI values).

3.1 Questionnaire Design

Over the past two decades, the use of the contingent valuation method (CVM) in policy analysis academic research has grown rapidly. CVM is used to elicit road user's preference expressed in terms of WTP and WTA. It basically asks people about what they are willing to pay, for a benefit, and accept, for a detriment. It is the most widely used method for estimating non-market values. Pavement maintenance work is non-market values of service. This value does not involve market purchases and may not involve direct road users' participation [5].

The questionnaire contains three sections. The first section deals with the road users highway use practices and attitudes. This first section is intended to measure respondents' concerns about ride quality, to be familiar with the ride quality attributes that are being evaluated, and to elicit information about their past experiences with the attributes.

The second section contains the willingness to pay for ride quality improvement. This section determines how much the road user will pay for ride quality improvement. This section consists of open-ended format, dichotomous choice and a bidding game. The final section elicits demographic information. Characteristics of road users are considered as personal and social factors. These factors include age, education level, gender, occupation, monthly income, car ownership, and mode of travel.

3.2 Survey Design

The design of the CV survey is based on experience with a pilot survey. The pilot survey was conducted in early 2001 in the Bangkok Metropolitan area. The CV design for the survey was clarified and revised from the pilot results. The results from the pilot survey showed that WTP for highway maintenance work receives mach protest from respondents because they have never purchased or never thought of purchasing as ride quality improvement. So, WTA was adopted as another option to elicit their preferences.

3.3 Data Collection

In order to evaluate the road user's attitude towards WTP and WTA, a questionnaire survey is conducted in order to determine the road users' opinions. Road users are asked about their willingness to pay for better roads and willingness to accept for poorer road. Road users refer to anyone who travels on the highway system. The area considered for the analysis in this study is in the Bangkok Highway Bureau (Highway Bureau No.11). This bureau consist of 5 Highway Field Districts, which consist of Bangkok, Thonburi, Ayuthaya, Pathum Thani, and Samut Prakan Districts.

The survey was carried out in late 2001. There were a total of 1700 questionnaires that were distributed randomly in different government offices, private offices and public places. The return rate of the total 1700 sets was approximately 83.2% (or about 1415 sets). For about 285 questionnaires, known as unit nonresponse, the road users failed to respond to the questionnaire. This occurs when road users accept to answer the questionnaire, but they cannot complete it, or those sampled in a mail survey fail to return the questionnaire. Since the questionnaire requires the knowledge of the vehicle and road conditions, it was found that only 1220 were completed and met the research requirements. For about 195 questionnaires, which were called item nonresponse, a respondent answered some or most of the questions on a survey, but failed to answer a particular question of interest such as the WTP or WTA question.

3.4 Distribution of Individual WTP

This study successfully implements contingent valuation studies for measuring the WTP and WTA for ride quality improvement. The outcome of this study has made it quite clear that deteriorating ride quality is one of major problems. In addition, about two-thirds of the respondents in the survey indicated their willingness to pay for ride quality improvement, to drive in a more perfect condition. This information bridges the gap in data collection for highway planning, design & maintenance. The conclusions based on the survey results are that most of the road users are not satisfied with the ride quality of the present road network.

On the quantitative side, the mean values of the fee for ride quality improvement at high and medium severity condition are found to be 76.81 and 45.91 baht/month, respectively. The majority of those who are unwilling to pay the fee have been found to be either protesting the bid or too poor to pay. The implication of these findings is that if they are more aware of the problem and understand its importance, they might be more willing to support and even to pay the necessary fee to better the road conditions. Analysis of data collected from source observations indicates that the road users information provided by the respondents in the questionnaire survey is reasonably accurate. The mean values of the willingness to accept for road deterioration, at high and medium severity condition, are found to be 492.48 and 307.96 baht/month, respectively.

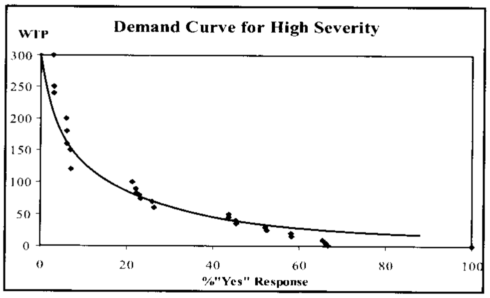

Fig 1. WTP Function

In deciding whether to undertake a road tariff, a policymaker may be more interested in the distribution of benefits from a changed policy changed than the actual aggregate comparison of cost and benefits. This would be particularly true if it is readily apparent that the change being contemplated and the desired distributional information is directly available from a contingent valuation survey. One of the most understandable ways of summarizing this information is to prepare a graph of money amount by the percentage of the public willing to pay each amount or more for the level of ride quality. This is simply a plot of one minus the cumulative distribution function for the willingness-to-pay responses at high severity as shown in Fig 1.

4. Benefit Estimation Model

This part presents the results of the benefit estimation model development. The data used in the model formulation, the pattern of the developed model, the model validation and verification, including the comparison of benefit estimations between the developed model and the current HDM-III model, are discussed in the following sections.

4.1 Regression Model Formulation

The regression models are developed based on the benefit estimation (WTP and WTA bids) and IRI values. The regression equations are developed to show the relationships between the benefits and the IRI values of the pavement. The benefits of the pavement construction and maintenance are derived from savings of the road user costs which consist of vehicle operating cost (VOC), discomfort and accident cost, and travel time cost. Without road user cost components (i.e., cost of user delays, discomfort and accident cost, and travel time cost), it is difficult to capture the benefit/savings in numerical terms [6].

Although they represent real situations, they are omitted in cost calculation by the current HDM-III model. The traditional benefit calculation includes VOC savings over the analysis period. VOC is the cost that is required to run a vehicle in a given section of a pavement which includes fuel and oil consumption, tire wear, vehicle maintenance and depreciation. Road roughness which is measured in terms of IRI, has a significant impact on VOC. Traffic volume is another factor that is included in the calculation of VOC. The VOC saving is equal to the difference between VOC values before and after the application of maintenance alternatives [2].

Contingent valuation is a method that is used to measure the benefits of public goods which are pavements in this study. In this chapter, the researcher reviews the nature of the benefits, which the pavement engineer needs to value and compares this with an existing benefit method. In this study, an elicitation question in a contingent valuation survey is phrased in terms of willingness to pay and willingness to accept.

The WTP and WTA bids are converted into baht/veh/km on the same basis as VOC units. The conversion process is done by dividing these bids by daily transportation distance and duration in months (30 days). This was done by excluding the data representing the cases of protest zeros. Protest zeros are perhaps the most troublesome, It is necessary to distinguish them from the bids given by the respondents who prefer to forego ride quality improvement rather than pay for it. In addition, outliers are also identified and excluded from the benefit estimation process. In the CV studies, outliers are typically from very low-income respondents who gave WTP amounts representing an implausibly large percentage of their income or very low WTP amounts even though their answers to other questions in the survey indicated a strong demand for the ride quality improvement. The data is filtered in order to prevent certain data points from dominating the outcome of the entire equation. Three types of regression models are included in the analyses, which are linear, logarithmic and polynomial regression. The general forms of the regression equations are presented as follows:

- Linear regression:
  WTP or WTA bids = a + bIRI
- Logarithmic regression:
  WTP or WTA bids = a + b*ln* IRI
- Polynomial regression
  WTP or WTA bids = a + bIRI + cIRI^2

The WTP or WTA bids are the dependent variables and IRI values are the independent variable. The parameters *a*, *b*, and *c* are regression constants. Other factor such as vehicle type are not included in the developed models, but the grouping approach is applied.

4.2 Model Validation

From the results of regression analysis, the developed equations that are the best fit are selected. The best fit of the formulation is explained by the value of R^2 (coefficient of determination). The higher R^2 indicates higher correlation of variables of the developed equation. The R^2 values of different equations vary depending on the appropriate mathematical forms. The R^2 is one validation method. Another validation approach is to observe the coefficient of each variable in the developed equations. The trend of the dependent and independent variables of this study must be the same. The WTP and WTA bids are increased as the IRI values increase. This can be observed by the sign of coefficients. It can be observed that the WTP and WTA bids of the polynomial regression are decreased as the IRI values increase. Therefore, the polynomial equations are excluded from the estimation process.

The WTP and WTA bids model for all vehicles are developed by a regression equation. These two models are compared to determine the best-fitted model for passenger cars. The benefit of the existing model, that is the additional VOC incurred by road users at different IRI levels from new pavement, is plotted to compare with the developed model. The WTA bids model can predict road user benefit for passenger car, light truck, medium truck and heavy truck to be very close to the existing VOC models and closer when the differential IRI locates in the lower portion. In the overall picture, the WTA bids model yields better prediction than WTP bids because the WTP bids curve estimates the benefit in the lower boundary. VOC represents one component of benefit estimation, but the benefits derived from CVM are the total benefits. Therefore, the lower boundary estimation is not appropriate in this case.

The developed models for heavy bus show the same pattern as light bus. The WTA bids model predicts more road user benefit than the WTP bids model, and the difference between predicted values from the two developed models are very high. The WTA bids model presents a very high road user benefit. WTP bids model can predict the closest to the existing VOC model. The WTP is used to calculate the actual benefit for public transportation mode because the benefit should reflect individual road users.

The selection of the model for further analysis in the network-level application is based on the result of the model validation. It should be noted that from the result, the WTA bids model should be used as the benefit estimation model for passenger car (PC), light truck (LT), medium truck (MT), and heavy truck (HT). For light bus (LB) and heavy bus (HB), the WTP bids model is adopted for determining road user benefits. This contingent valuation method is used as the benefit estimation model in network planning for the Department of Highway (DOH) in actual practice. The following relationship was developed for predicting road users benefits as a function of roughness.

$$WTA_{PC} = -0.217 + 0.117IRI$$

$$WTA_{LT} = -0.110 + 0.059IRI$$

$$WTP_{LB} = -0.215 + 0.320\,ln\,IRI$$

$$WTA_{MT} = -0.327 + 0.151IRI$$

$$WTA_{HT} = -0.715 + 1.031\,ln\,IRI$$

$$WTP_{HB} = -2.436 + 3.634\,ln\,IRI$$

Where WTP = willingness to pay for ride quality improvement in Baht/veh/km

WTA = willingness to accept for road deterioration in Baht/veh/km

IRI = the roughness (m/km)

5. Case Study

In quantifying road user benefits associated with higher overall pavement performance, this benefit assessment method makes the fundamental assumption that individual preference can be used as a basis for evaluating benefits. The WTP and WTA bids of individuals have been found to be most appropriate for benefit assessments. The stated preference approach is suitable for evaluating the monetary values associated with different levels of pavement serviceability. Road users values for higher ride-quality pavements are measured by their WTP and WTA bids for the service provided.

The developed benefit estimation models are used to predict the road user benefits. These benefits consist of direct and indirect benefits. The direct benefits are those that are resulted from savings in vehicle operating cost. Indirect benefits such as land values, employment, and other social effects are considered in this method. The network-level application of this study focuses on pavement maintenance planning [6]. This task is one of the main components in the pavement management system. The goal of the system is to maintain the pavement network in an acceptable condition. Prioritization and optimization techniques are applied to identify which treatment should be implemented for the selected pavement section [7].

Several routes in the Bangkok Highway Bureau were selected for detailed study. The following sections present the results of benefit estimation calculations that use the CVM and VOC approach to capture several maintenance scenarios, in which the type and timing of maintenance activities are varied, respectively.

Case Study 1: Benefit Estimation for Different Traffic Compositions

A case study of the comparison of traffic composition is described. In general, the traffic volume has the most significant effect on the maintenance planning based on the current model used by DOH. The traffic volume is expressed in Annual Daily Traffic (ADT). The benefit of maintaining a high traffic pavement is more than for a low traffic pavement. However, traffic composition plays an important role in road user benefits. Two routes in Pathum Thani district are selected to illustrate the effect of traffic composition in benefit estimation. The characteristics of the two selected routes are presented in Table 1.

Table 1 Pavement Characteristics for the Selected Sections

Control Section	Km. Start	Subsection	IRI	ADT	Benefit (Baht/km)	
					VOC	CVM
31110100	005	01	2.82	13278	559.25	2258.05
32150101	004	01	2.84	12638	442.92	1462.64

Table 2 Benefit Estimation of Two Routes

Vehicle Type	31110100					32150101				
	ADT	VOC Benefit		CVM Benefit		ADT	VOC Benefit		CVM Benefit	
		Per veh	Total	Per veh	Total		Per veh	Total	Per veh	Total
PC	7578	0.034	255.54	0.096	727.03	8774	0.035	306.51	0.098	862.31
LT	3477	0.031	107.84	0.048	168.22	2568	0.032	82.54	0.050	127.27
LB	456	0.030	13.47	0.110	50.14	245	0.031	7.52	0.112	27.49
MT	645	0.024	20.00	0.124	79.86	545	0.024	13.30	0.127	69.13
HT	188	0.036	6.75	0.354	66.60	294	0.037	11.02	0.362	106.29
HB	934	0.100	93.85	1.249	1166.20	212	0.104	22.02	1.274	270.15

The pavement condition and traffic volume of the two routes are similar. It can be seen that VOC savings of route 31110100 are close to route 32150101. Using the CVM method, route 31110100 has a higher benefit than route 32150101. According to Table 1, benefit estimations are presented for the traffic composition of both routes. Table 2 illustrates the effect of traffic composition on benefit estimation. This table demonstrates that the benefits of heavy vehicles are much more sensitive to roughness than light vehicles

Case Study 2: Effect of Early Maintenance

A case study of section 31110201 is presented to illustrate a pavement section which is maintained earlier than an appropriate intervention level. The effect of this situation is analyzed through a life-cycle cost analysis. The comparison of two maintenance planning approaches is presented in Table 3.

In these maintenance approaches, Seal categorized as routine maintenance is used on roads that are in good condition to provide localized repair and to prevent accelerated deterioration. Roads that are starting to show the first signs of deterioration can benefit from preventive maintenance such as thin overlay (Overlay 25 mm: OL-25), which increases the road's service life and slows down deterioration caused by weather-related aging. Overlay 25 mm is ultra thin, so it does not provide structural improvement. It should only be applied to pavements that have adequate structure to carry the anticipated future traffic loading.

In Thailand, DOH applies thick overlay (Overlay 80 mm: OL-80) or Rehabilitation with asphaltic concrete (Rehab-AC) for rehabilitation. Roads that require rehabilitation have declined to the point where less costly strategies are no longer cost-effective. Rehabilitation is used to correct specific deficiencies in the pavement, so it is important to carefully assess the pavement's current condition and predict the type and number of vehicles the road will be required to carry in the future to help select the most cost-effective repair alternative.

Based on the CVM method, the result shows that early maintenance yields more benefit and higher life-cycle costs. However, the recommended plan to rehabilite with AC every five years results in a higher benefit cost ratio. However, user travel costs will increase very mach during the time pavement maintenance or rehabilitation is carried out. While such work improves pavement serviceability considerably, it also leads to high travel time costs due to traffic delays. A traffic-delay cost consideration does not favor rehabilitation that impedes traffic flow. Future criteria to follow for prioritization should be based on the cost incurred by both the government and user during construction.

Table 3 Life-Cycle Cost Analysis for the Early Maintenance

Life-Cycle Cost Analysis				
Analysis Period	30 years			
Discount Rate	12% (No Inflation)			
Condition	Actual Condition		Planning	
Treatment every	6 years		5 years	
Treatment selection	Year 1: OL-25 84 B/m^2		Rehab-AC 314 B/m^2	
	Year 3: OL-80 249 B/m^2			
	Year 6: Seal 29 B/m^2			
No. of cycle	5		6	
Benefit Estimation	VOC	CVM	VOC	CVM
Total Benefit	1048992 B/km	3227112 B/km	1054498 B/km	2811330 B/km
Total Cost	3660776 B/km		3121424 B/km	
B/C ratio	0.29	0.88	0.34	0.90

Case Study 3: Effect of Applying an Inappropriate Benefit Estimation Model

Life-cycle cost analysis requires the determination of pavement service life, rate of performance deterioration and benefit estimation. The prediction accuracy of the benefit estimation model affects the maintenance frequency, selection, and planning [8]. A case study of section 03460200 that carries traffic of more than 10,000 veh/day is selected to illustrate the effect of applying an inappropriate benefit estimation model in the planning process by VOC and CVM methods. A life-cycle cost analysis is conducted to compare the planning with the different deterioration models by VOC and CVM methods. Table 4 shows the result of this analysis. The result shows that benefit estimation from the CVM method yields more benefits. Using the VOC method, only one component of direct benefit is estimated. VOC is the cost that is required to run a vehicle, which includes depreciation, fuel, lubrication, maintenace and so on. But the CVM method integrates different cost components arising from accidents, travel time, and indirect benefits. The result shows that, for each section, the more accurate model yields more benefits and more benefit cost ratio.

Table 4 Life-Cycle Cost Analysis for Inappropriate Benefit Estimation Model

Life Cycle Cost Analysis		
Analysis Period	35 years	
Discount Rate	12% (No Inflation)	
Treatment Every	7 years	
Treatment Selection	Rehab-AC	
Cost	314 B/m^2	
No. of Cycle	5	
Benefit Estimation	VOC	CVM
Total Benefit	1262086 B/km	3985633 B/km
Total Cost	2798906 B/km	
B/C ratio	0.45	1.42

The B/C ratio indicates the viability of different projects. When the B/C is greater than 1, the project is considered to be feasible. As shown in Table 4, the benefits derived from CVM and VOC are significantly different. Applying VOC results in the B/C ratio of 0.45, but the B/C ratio of CVM is 1.42. The maintenance project of the selected route becomes viable when benefits are assessed based on the CVM technique since the B/C ratio is greater than one. This shows that CVM is able to reflect the total benefits. Further investigation was pursued in the traffic composition of the selected route in order to confirm the results of B/C ratio. Table 5 presents the traffic composition of this route. It can be seen that heavy buses have high volume on this route. As discussed in preceding section, benefits derived from CVM are sensitive to the number of heavy buses. VOC estimates the benefits on the disaggregate level, which excludes the total delay costs, total accident costs, and other indirect benefits, while benefits estimated from CVM represent the traffic benefit.

Finally, the proposed CVM method can help pavement engineers to remedy the existing deficiencies and help decision makers in examining alternate strategies to increase road user benefits and allocate funds for roadway improvements. The CVM method should be integrated to assist decision makers in determining what pavement sections need some type of rehabilitation, what type and level of rehabilitation is needed, and the optimum point in time to perform the needed rehabilitation.

Table 5 Pavement Section Data for Maintenance Planning

Control Section	Width (m)	IRI	ADT						
			PC	LB	HB	LT	MT	HT	Total
03020100	11	4.34	52711	13281	6290	14877	11969	6744	105872
03050101	6	3.22	46847	5999	2864	8418	5642	2601	72371
03450100	12	2.14	19241	1432	295	4891	6554	5091	37504
03460200	7	3.48	10843	1164	961	2022	2518	1311	18819
31000100	7	3.18	11388	866	1038	3030	2510	1801	20633
31110100	7	2.80	8118	512	674	1380	712	597	11993
31110201	7	3.23	6294	759	436	1213	784	1042	10528
32150101	7	2.54	6360	173	176	1758	216	16	8699
32150103	7	2.67	8855	1271	285	6933	1437	1237	20018
33090101	5.5	2.77	4133	440	278	1027	303	137	6318

6. Conclusions

The regression models are developed based on the benefit estimation (WTP and WTA bids) and IRI values for comparison purposes. The developed benefit estimation models based on the IRI values are validated by comparing with the VOC savings. The best-developed models for each vehicle type which are defined by the model validity are selected. Based on the results of model development, the WTA bids models are used as the benefit estimation model for passenger cars, light trucks, medium trucks, and heavy trucks. For light and heavy buses, the WTP bids model is adopted for determining road user benefits.

The results show that benefit estimation from the CVM method yields higher benefits. Using the VOC method, only one component of direct benefits is estimated. VOC is the cost that is required to run a vehicle. It includes depreciation, fuel, lubrication, maintenance, and so on. The CVM method integrates costs arising from accidents, travel time, and indirect benefit. Indirect benefits mean values of land, employment, and other social effects. In addition, CVM captures both direct and indirect benefits from road users' perspective. The results show that, for each pavement section, the more accurate model yields more benefits and higher benefit to cost ratios

The results of this research provide recommendations for maintenance planning of TPMS. The benefit estimation model should be improved to reflect the total benefits comprised of direct and indirect benefits. Nowadays, DOH relies on vehicle operating costs estimated by the HDM-III model. The framework of the VOC savings model was well calibrated at the beginning stage of the HDM-III model in Thailand. However, the existing benefit estimation model should be updated since road user benefits include of travel time, vehicle operating costs and other indirect benefits. Having accurate benefit estimation is very beneficial to the organization in terms of budget allocation and maintenance planning.

7. Future Directions

Using the expressed preference approach, DOH benefits can be evaluated by conducting surveys or interviews with pavement engineers involved in decision-making. For instance, each decision maker may be presented with several hypothetical strategies having different total government costs (including construction, maintenance, rehabilitation, and administration costs). Each strategy is assigned pavement performance such that lower government costs will be associated with lower pavement performance. Comparing two strategies at a time, each decision maker is asked if he or she favors the higher pavement performance strategy. The sequence of pairwise comparisons can be planned in a systematic manner to provide benefits assessment for different pavement performance. Depending on pavement design philosophy and the maintenance and rehabilitation policy of DOH, it is likely that the governments preference for better pavement performance will be different. It is advisable for

DOH to conduct its own evaluation to obtain a set of monetary values for pavement performance that reflects its planning and decision-making criteria.

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