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Deriving Accident Costs using Willingness-to-Pay Approaches - A Case Study for Singapore

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Abstract

This paper reports on an innovative study where for the first time in Singapore accident costs have been derived using a willingness-to-pay (WTP) approach.

In order to carry out evaluations of road safety projects and transport infrastructure investments, it is necessary to use a true value of accident cost that would reflect the community willingness to pay. Singapore has been using the traditional human capital approach, which derives a valuation of fatalities based on the discounted value of future income of an average fatal traffic accident victim.

Over the last two decades, a number of countries have derived values of accident cost based on a WTP approach by applying Contingent Valuation (CV) methods. Recently, researchers in Chile and the Netherlands have pioneered the use of Stated Preference (SP) methods to derive the WTP values of statistical life and severe injury. Our work built upon this and provided the WTP value of accident costs in Singapore.

This paper describes the survey, which involved more than 4,000 interviews of Singaporean residents, and included both CV and SP methods to derive accident costs in the context of urban travel. The CV and SP results were then compared. Finally, the WTP values were compared against those obtained from using the human capital valuation method, and also against other WTP accident cost values from other developed countries.

1. Introduction

The Land Transport Authority (LTA) of Singapore employs a project appraisal framework which incorporates an economic evaluation procedure to facilitate decision-making on investment in transport infrastructure projects ensuring the efficient use of resources and timely investment in projects. The economic evaluation procedure uses outputs from LTA’s Strategic Transport Model (STM) in combination with monetary unit values for relevant parameters to estimate social benefits.

The principal benefits from transport projects include the savings of travel time, vehicle operating cost, accident cost as well as environmental cost such as air pollution and greenhouse gas emissions. In some cases, wider economic benefits that were not captured in the conventional economic analysis approach were also calculated.

In 2008, LTA commissioned a comprehensive study to update the value of time (VOT), vehicle operating costs (VOC) and accident costs (AC) by undertaking the necessary surveys, data collection and analysis, as well as reviewing and recommending a methodology to quantify the environmental cost and wider economic benefits.

This paper focuses on the study methodology, survey design, and derivation of accident costs. It presents a brief review of existing WTP methodologies, and describes the survey design that involved both CV and SP methods to derive accident cost values in the context of urban travel. The CV and SP results were then compared. Finally, the WTP values were compared against those from using the human capital valuation method, and also against other WTP accident cost values from other developed countries.

2. Overview of accident cost valuation approaches

Generally, accident costs can be estimated using either the avoidable costs approach or the WTP approach. The avoidable cost approach incorporates a valuation of fatalities based on the discounted value of future income of an average fatal traffic accident victim. This human capital valuation plus other costs such as hospital, police, and property damage costs forms the basis of the avoidable costs approach historically used by LTA. The human capital estimate is usually the largest proportion of avoidable cost estimates.

Alternatively, a WTP approach can be used to derive a value of statistical life and serious injury, or to estimate values of WTP to avoid accidents. However, other unperceived costs usually still need to be added to determine comprehensive WTP based accident costs.

WTP values can be determined using contingent valuation and stated preference surveys or by analysis of revealed preference data. Contingent valuation and stated preference methods involve surveys to determine the willingness of people to pay for products or attributes in hypothetical situations. Revealed preference methods derive values from people’s actual purchases and actual real-life decisions and choices.

While an approach based on revealed preference was considered potentially worthwhile, studies of the value of statistical life using revealed preference data have tended to produce widely varying values depending on the particular situations for which data was analysed, and consequently such an approach was not considered for this study. Contingent valuation and stated preference survey approaches were preferred because the context can be controlled and the responses are therefore more likely to be consistent and relevant to the application for which the value is being derived.

Over the last two decades, in a number of countries, surveys to derive WTP based value of life estimates have typically used a contingent valuation technique (Viscusi and Aldy, 2002). Contingent valuation is a survey-based economic technique for the valuation of non-market resources such as environmental preservation or in this case the value of avoiding the death of an unidentified person. Questions in contingent valuation surveys have typically sought to determine how much people value hypothetical reductions in risk and these valuations are then aggregated across the population to determine the value of a statistical life.

Recently, researchers in Chile (Rizzi, L et al., 2003 and Hojman, Ortuzar & Rizzi, 2005) and the Netherlands (de Blaeij et al., 2002) have experimented with stated preference surveys to derive values of statistical life and severe injury. The stated preference survey method involves a series of scenarios requiring people to choose between two routes with different levels of safety, travel time, and other characteristics. Statistical analysis is then used to derive the value of statistical life.

Following a review of previous studies, using the stated preference approach has several advantages as follows. Applying this method at the same time as the travel time and vehicle operating cost stated preference surveys would improve the consistency between the accident cost estimates and the other values. Using this method would also provide the opportunity to contribute to the latest research in this field. However, as this method has not been widely applied, there was a greater risk associated with relying only on this method to derive values. There might be unanticipated pitfalls when applying it in Singapore that would only become apparent during the actual surveys or even in the subsequent analysis. For this reason, it was considered prudent also to include some contingent valuation questions as part of the survey design.

The contingent valuation method had been much more widely used to determine value of statistical life estimates in a greater number of countries and situations and hence could be used with greater confidence that it would produce usable estimates. However, from previous international experience it was also known to result in relatively high accident cost estimates and some concerns had been expressed that these might not be consistent with the valuation approach of travel time savings and vehicle operating cost savings and hence might unduly skew transport infrastructure investment in favour of safety projects.

In order to strike a balance between using a reliable yet up-to-date method, it was proposed to include both methods in the survey. Survey respondents would first be asked contingent valuation questions that probe WTP for risk reduction in two different scenarios. Following this they would then undertake a stated preference choice. It was anticipated that using both methods would increase the certainty of obtaining usable results and enable comparison of the accident values derived from both methods.

As part of this study, the AC by the avoidable cost approach was also updated (LTA, 2009). While the process of deriving AC by this approach will not be presented here, the results will be extracted and compared against the WTP values.

3. Survey Methodology

The overall study objectives were to derive the VOT, VOC, and AC for a cross section of Singapore residents by mode. A sample of more than 4,000 interviews was conducted in Singapore by using mainly household interviews. These were then supplemented by an intercept survey, that involved interviewing respondents at tertiary institutions, food courts, and shopping centres, and that was spread throughout Singapore. The sample was segmented into five travel modes: car, taxi, motorcycle, bus and mass rapid transit (MRT) and four trip purposes: commuting, education, leisure and social, and business. The AC were derived from the sample of 1,350 interviews of car passengers and 150 motorcyclists.

The survey questionnaires to derive WTP accident cost (AC) values included two parts: Contingent Valuation (CV) questions; and Stated Preference (SP) questions.

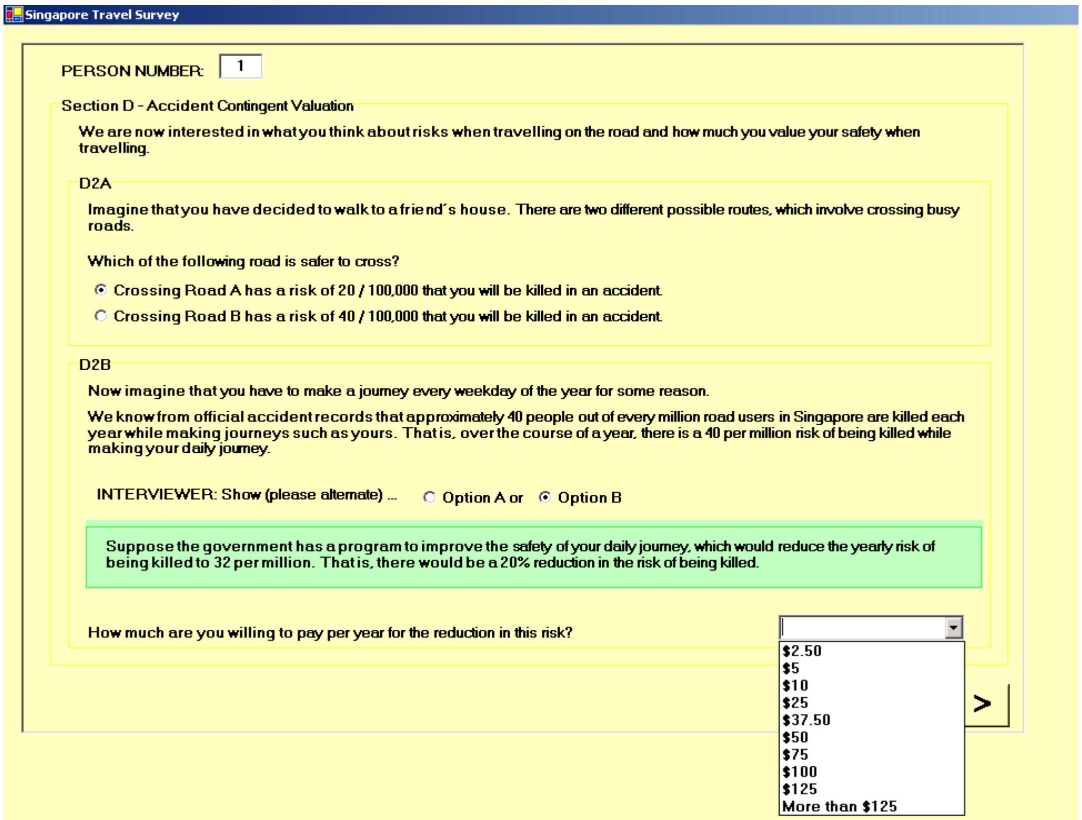
The CV approach involved direct questions. In this case, respondents were simply asked to state how much they were willing to pay for a reduction in the risk of getting killed in a road accident. SP techniques provide a more sophisticated method for obtaining individuals' valuations by presenting respondents with pairs of hypothetical but realistic scenarios, where they trade off different travel attributes such as travel time, cost and number of casualty accidents in deciding which alternative to choose. The results were used to develop choice models that were used to estimate AC values.

The following section presents the design and results of the CV approach. The SP approach was then presented in subsequent section.

4. Contingent valuation

The accident CV questions were asked only of car drivers and motorcyclists. A total of 1,549 people completed this section of the questionnaire. The questions included three parts. Figure 1 shows the first and second parts. Figure 2 shows the third part.

Figure 1: Contingent valuation question – Part 1 and 2

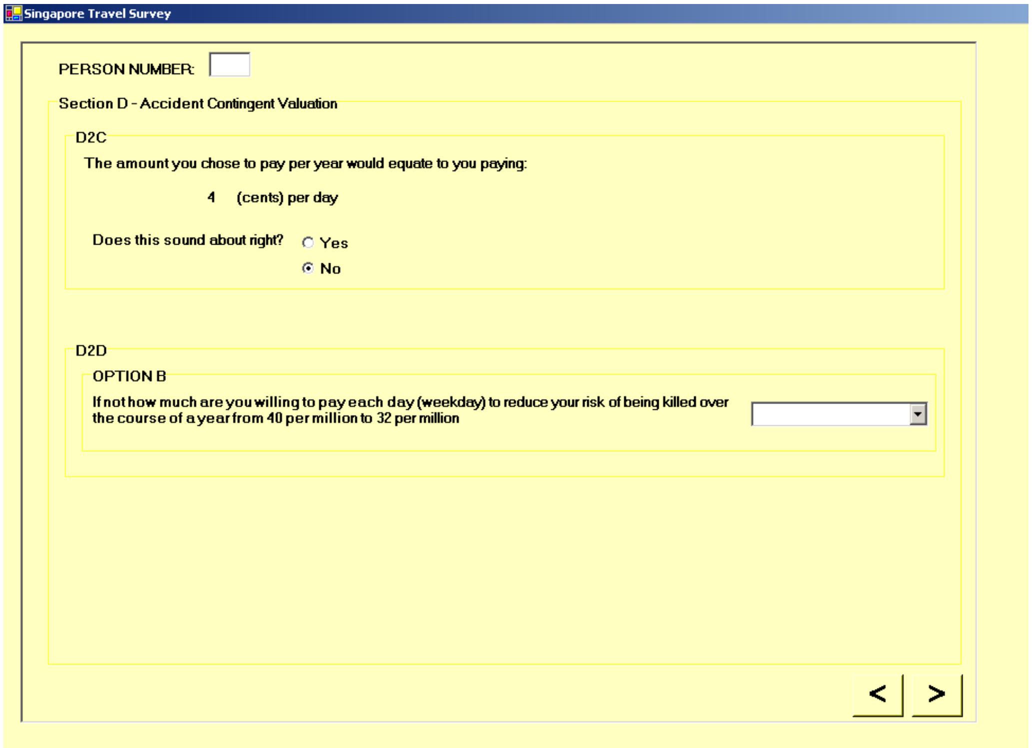


The first part (D2A) explores whether people understand risk. Clearly Route A is safer. However, 52 or 3.4% of 1,549 respondents answered this test question incorrectly. Since they did not understand the risk proposition, their subsequent answers would be unreliable. These people were therefore excluded from further analysis.

The second part (D2B) explores how much the respondent is willing to pay per year for reducing the risk of being killed in an accident. The figure of 40 people out of every million car drivers/passengers in Singapore killed each year was derived from the Police accident records over a five year period. The question was rotated between two options A and B. Option A involved a 50% reduction in the risk of being killed, while Option B involved a 20% reduction.

It was intended that approximately half of respondents would be presented with Option A and half would be presented with Option B, but in the actual survey, the interviewers forgot to alternate strictly between Option A and B. This resulted in 72% presented with Option A and only 28% presented with Option B. The reason for presenting two different risk reduction scenarios was to investigate whether this resulted in different willingness to pay values, for example if people were not sensitive to differences in low probability risks.

Figure 2: Contingent valuation question – Part 3



The third part (D2C) addresses the respondent's WTP per day for a reduction in accident risk. The idea is to check if the respondent would change their valuation if the amount is expressed as a per day amount. The amount displayed in this question is derived by dividing the answer given in D2B by 250 (working days per year), and respondents were asked if this was a good estimate of their WTP for the reduction in accident risk. A small minority of respondents (2% and 3% of those presented with Option A and B respectively) said it was not and they were asked to provide a correct daily value. This adjusted daily value was then used to calculate an adjusted annual value.

Table 1 shows the adjusted annual CV values and the corresponding number of respondents for each option.

Table 1: Annual CV Value (WTP for accident risk reduction) ($ per year)

$/year	Option A (50% risk reduction)	Option B (20% risk reduction)	
2.50	340	103	
3.00	12	8	
5.00	111	94	
10.00	178	60	
25.00	137	43	
37.50	28	14	
50.00	142	54	
75.00	34	14	
100.00	83	28	
125.00	8	9	
140.00	37	9	
Total	**1,110**	**436**	**1,546**

Mean values of annual WTP for accident risk reduction were calculated for Option A and Option B based on the responses in Table 1 after excluding the 3.4% of respondents who failed the understanding of risk question. Table 2 shows the resulting values of risk reduction.

Table 2: Value of Accident Risk Reduction $ per year

Option	Mean ($ per year)	N	Std. Deviation	Median
A (50% risk reduction)	28.72	1,086	36.18	10
B (20% risk reduction)	26.32	408	35.13	10
Total	**28.07**	**1,494**	**35.90**	**10**

The mean value of accident risk reduction (VRR) was $28.72 per year for Option A (50% risk reduction) and $26.32 for Option B (20% risk reduction). The median value was $10 for both options.

The actual risk of death in a traffic accident in Singapore is approximately 40 per million per year, therefore a 50% reduction in risk (Option A) equates to a reduction of 20 per million. Therefore to obtain the value of statistical life, the CV value ($28.72/year) is multiplied by 1,000,000/20, giving a value of $1,436,000.

For Option B the 20% reduction in risk equates to a reduction of 8 per million (20% of 40 per million). Multiplying the CV value ($26.32/year) by 1,000,000/8 gives a value of statistical life of $3,290,000. These results are shown in Table 3.

Table 3: Accident Costs Using CV

Risk	Option A	Option B
Value of an avoided fatality	$1,436,000	$3,290,000

It can be seen that while respondents were willing to pay for a reduction in the risk of being killed in an accident, they seemed unable to differentiate between low probabilities of being involved in an accident. This led to a wide range for the value of statistical life by CV, $1,436,000 – $3,290,000 for the two risk reduction percentages considered.

5. Stated Preference

5.1 Questionnaire Design

5.1.1 Choice Context

Given the primary objective of the study was to derive WTP valuations of time, operating costs and accidents for different modes, SP experiments could be designed in either a route choice or mode choice context. The route choice was selected because it could offer a realistic choice to respondents. In Singapore, using a mode choice context could run the risk of losing respondents who do not have a realistic alternative mode available.

The values of time and operating cost were being derived for all modes whereas the values of accident were derived for car drivers and motorcycle riders only. It was felt presenting scenarios in which public transport passengers would be killed would be unacceptable. Separate SP experiments were produced for respondents based on their mode used: car, motorcycle, bus, MRT, or taxi.

When developing SP experiments there was a trade-off between complexity and the number of SP experiments presented. Because the study was demanding in terms of the different parameter values required, it was better to present two simpler experiments than one overly complex experiment. In order to cover the range of parameters of interest two experiments of nine scenarios were presented to each respondent.

5.1.2 Experiment Design

In designing the SP experiments it is necessary to determine how many different values, or levels, each of the variables included in the experiment should have. Generally the larger the number of levels the more accurate a variable may be estimated but this has to be weighed against the larger number of scenarios needed. The way in which the different levels of each of the variables are combined must be carefully determined. It is important to ensure that the variables are combined so that there are low correlations between them, otherwise multi-collinearity results and estimation problems may result. The standard procedure for determining how the different variables are combined is to use the 'orthogonal' designs presented by Kocur et al (1982). An orthogonal design is a design where the correlation between the variables is zero.

For the SP design to derive value of AC for car and motorcycle there were three variables of interest: travel time, ERP (Electronic Road Pricing) charge, and number of accidents. The number of scenarios needed was 27 based on each variable having three levels. This was clearly too many for a single interview, so it was decided to present nine scenarios to respondents and these would be selected randomly by the program.

In order for the designs to be robust it is important that the designs contain a good range of trade-offs and that the implied boundary values cover a good range. A boundary value is the value at which the utility between two modes is exactly the same and can be calculated for each scenario presented. For example, the boundary VOT is a very useful concept in making sure that the designs are capable of covering a range of values of time both higher and lower than the expected base values. The boundary values used in the designs was based on the results from the previous study results, and also from the Pilot Survey.

The levels were selected as realistic as possible to respondents. The levels of journey time were based on their nominated typical journey, which was collected from the main questionnaire.

The journey time of interest was the in-vehicle time, which was the overall door-to-door journey time minus any wait or walk time. The distance bands for car and motorcycle users were:

- short: 15-30 minutes
- medium: 31-45 minutes
- long: more than 45 minutes

The ERP charges were broadly related to the levels people faced at that time. Given imaginary situations were presented it was possible to deviate from existing conditions to a certain degree. However the different levels were combined according to the underlying orthogonal design, which provides a boundary value of time for each scenario.

The number of accidents per year was estimated using the average accident rates from the past five years for arterial and expressway, and an assumed percentage travelling on expressway depending on the distance bands.

In the interview, respondents got two separate SP sets based on their chosen mode. Each set consisted of nine scenarios (nine different screens) where the respondents were asked to choose one of the two alternatives shown based on the information presented. Before the SP trade-off scenarios, the respondents were shown an introductory screen outlining the trade-off.

There were two overall types of SP designs for car drivers and motorcyclists – one looked at time whilst the other looked at accidents. Only the SP design to derive the accident costs is presented here.

The purpose of this experiment was to derive a value of WTP per trip by individuals for reducing the number of fatalities and seriously injured accident casualties, as well as a value of time travelling in busy conditions in relation to ERP charges. Since the accident casualty rates were presented as a number per year, the value of risk reduction for a fatality or serious injury was determined by multiplying the WTP with the total annual traffic using the selected route in a year. The approach was based on work carried out in this field by Hojman, Ortuzar & Rizzi (2005).

There were three experiment designs for accident cost:

- Car Accident 1 – represented a choice between two routes, each was described in terms of ERP cost, journey time and the number of fatalities per year
- Car Accident 2 – represented a choice between two routes, each was described in terms of ERP cost, journey time and the number of seriously injured per year. The serious injury presented to respondents was defined as an injury involving hospitalised for a minimum of 7 days or more.
- Motorcycle Accident – represented a choice between two routes, each was described in terms of ERP cost, journey time and the number of fatalities per year

Figure 3 shows an introductory screen for the Car Accident 1 experiment, and Figure 4 shows a scenario in which a respondent would have to make a choice between two routes.

Figure 3: Introductory screen for the Car Accident 1 experiment

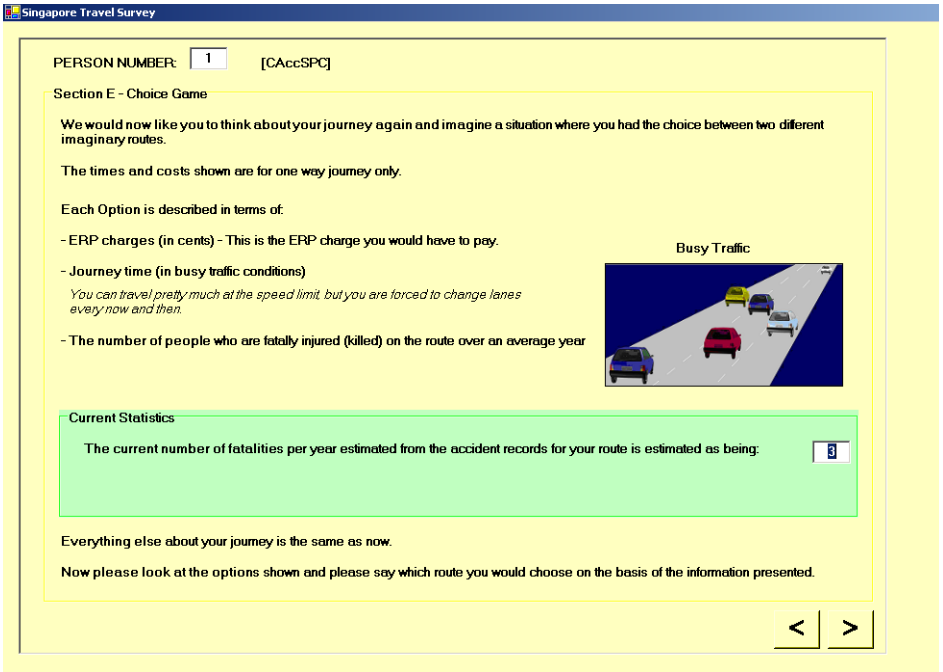
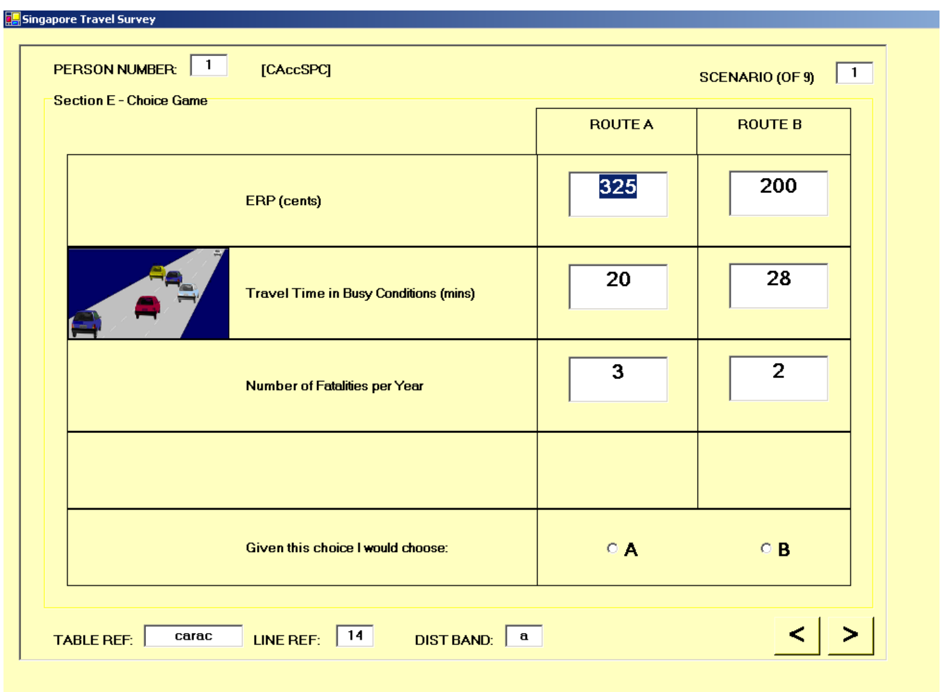


Figure 4: A typical scenario for the Car Accident 1 experiment



During the design process, one option which presented fatality and serious injury together as levels was considered. However this option might introduce the package effect (Hojman et al, 2005) which may underestimate the fatality cost. Moreover the addition of one option would come at a cost of reducing the sample size of the others or increasing the number of scenarios for respondents to cover the additional level presented. The latter would overload the respondents. After considering all the effects, this option was dropped.

In the survey all 1,350 car drivers were offered a SP set to obtain VOT, and 500 of them were split equally between the two types: Car Accident 1 and 2. The remaining 850 car drivers were offered other SP sets. All 150 motorcyclists were offered the fatality accident set.

5.2 Analysis and Results

In order to produce consistent stated preference models, all data relating to the same modes namely: car, motorcycle, bus, MRT and taxi, were pooled into separate sets for data analysis. The non traders which accounted for 24% of respondents were excluded from the analysis.

It is an assumption under the multinomial logit model that the observations extracted from stated preference experiments are independent of one another. In reality, individuals make a series of choices within a stated preference environment; it is doubtful that these choices are always independent of each other. If there is correlation between individuals' choices, this will have the effect of reducing the size of the standard errors associated with each estimated parameter. In turn, the associated t-ratios will be upward biased implying a greater degree of statistical significance for each model parameter. It had been thought that the influence of these so called "panel effects" was limited to affecting the standard errors. However, emerging research suggests that correlation between an individual's choices may also lead to biases in the parameter estimates themselves. Consequently the models reported here were corrected for this using an error component logit specification, which allowed for correlation between an individual's responses to be captured by separating the error term into two components.

The first component, η captures the correlation across alternatives and choices as it is included in the specification of all utility functions. It is assumed that η follows a normal distribution with zero mean and a variance of σ^2. The second component ε has the same interpretation as under multinomial logit estimation i.e. independent of other errors with each error following a Gumbel distribution. All other parameter estimates remain fixed for all individuals and hence can be interpreted in the same manner as under multinomial logit. The error component model specification follows the following form:

$$U_{n,i,car} = \beta_{carIVT} IVT + \beta_{carerp} ERP + \beta_{caracc} ACC + \eta + \varepsilon_{n,i,car}$$

Where

U = Utility

β = Parameters to be estimated

IVT = In vehicle time (TIMEAB – Time in busy conditions)

ERP = Electronic Road Pricing Charge

ACC = Accidents (either fatal or serious injury)

The estimated model for car users is shown in Table 4 and the estimated model for motorcycle users is shown in Table 5. For both models all the parameters are significant and of the expected sign. The goodness of fit as measured by rho squared are 0.105, 0.187 respectively which is good. Those variables relevant to the Accident Cost SP were shaded.

Table 4: Car User Model

Variables	Parameter	Std Err	T ratio
ERP	-0.0056	0.00022	-25.54
TIMEAB	-0.0903	0.00434	-20.8
TIMECD	-0.101	0.00717	-14.09
TIMEEF	-0.146	0.00907	-16.12
PARK	-0.0049	0.00027	-18.07
PETROL	-0.0031	0.00070	-4.43
SEARCH	-0.166	0.0374	-4.43
WALK	-0.0921	0.0161	-5.73
SERIOUS	-0.197	0.0127	-15.52
FATAL	-0.258	0.0266	-9.71
Number of observations	15856		
Number of individuals	1036		
Null log-likelihood	-10990.5		
Final log-likelihood	-9841.66		
Rho-square	0.105		

Table 5: Motorcycle User Model

Variables	Parameter	Std Err	T ratio
ERP	-0.0144	0.00167	-8.59
TIMEAB	-0.0732	0.0179	-4.1
TIMECD	-0.124	0.0279	-4.45
TIMEEF	-0.16	0.0400	-4.01
FATAL	-0.599	0.0562	-10.66
Number of observations	1278		
Number of individuals	89		
Null log-likelihood	-885.84		
Final log-likelihood	-720.44		
Rho-square	0.187		

The values for avoided fatal and serious injury casualties were derived by dividing the relevant accident parameter in Table 4 and Table 5 by the ERP cost parameters, and shown in **Table 6**. The standard errors for the value of avoided fatality and serious injury were estimated using the Delta/Taylor Expansion method.

Table 6: Value of avoiding a fatal/serious injury casualty per trip

Cost (cents)	Car		Motorcycle	
	Value	Std Err	Value	Std Err
Value of an avoided fatality (per trip)	46	4.77	42	4.95
Value of an avoided serious injury (per trip)	35	2.33		

Estimates of the Value of Statistical Life (VSL) and the value of avoided serious injury were obtained by multiplying the WTP values per trip in Table 6 by the average annual traffic volume on the road network as estimated by the 2008 LTA Strategic Transport Model (STM). The average weekday traffic for all links in the networks, weighted by link lengths, obtained from the model was 13,582 vehicles per weekday. This equates to an average annual traffic volume of 4,074,661 vehicles (using the STM weekday to annual expansion factor of 300). The vehicle or the driver population rather than the vehicle occupant population was used in the expansion process to be consistent with the SP design in which only drivers were interviewed. The resulting VSL and value of avoided serious injury estimates are shown in Table 7.

In principle, separate VSL and value of avoided serious injury estimates could be derived by weighting each SP survey respondent with the weighted average annual traffic volume along the route of their nominated trip. Overall, VSL and the value of avoided serious injury estimates could then be determined within the SP models. However, it is impractical to calculate separate weighted average annual traffic volumes for all respondents' trips and conduct SP estimation on a weighted sample. Therefore the method that has been adopted is considered to provide a practical and reasonable approximation.

Table 7: Value of avoiding a fatality / serious injury

Cost	Car	Motorcycle
Value of statistical life (avoided fatality)	$1,874,000	$1,711,000
Value of avoided serious injury	$1,426,000	

The value of statistical life estimates derived from the SP survey data were $1,874,000 and $1,711,000 for car and motorcycle users respectively, which are within the range obtained with the CV approach. The value of avoided serious injury was $1,426,000.

It is considered more appropriate to adopt the value of statistical life derived from car user responses as a single "equity" value for all fatalities rather than using the separate (lower) value that was obtained from motorcycle users. The car user value is likely to be more robust because it is based on SP data from 500 respondents, whereas there were only 133 motorcycle user respondents.

6. Comparison with other studies

6.2 Comparison with international serious injury costs

Whilst a number of studies had been undertaken worldwide to establish WTP values for fatal casualties, those that had calculated values for non-fatal injuries were more limited. This was primarily due to problems designing questionnaires to elicit reliable estimates for WTP values for such injuries, especially as the category of ‘serious injury’ covered a wide range of injury from conditions almost ‘worse than death’ to conditions from which recovery was quick and certain.

The European Conference of Ministers of Transport (ECMT) in 2000 contained two papers on studies undertaken in the UK and Sweden, which used detailed survey methods – involving numerous contingent valuation questions and comprehensive analysis – to obtain estimates of WTP values of non-fatal injuries. The resulting values are shown in Table 8. Estimates are presented as ratios of serious and slight injury casualty costs to fatal casualty costs to facilitate comparison between countries.

Table 8: Non-fatal casualty costs as a proportion of fatality costs

Accident type	UK (1998)	Sweden (1999)
Serious, as % fatal	11.2%	13.3%
Slight, as % fatal	0.9%	1.8%

Source: ECMT (2000)

The ECMT reviewed these results and proposed ratios of 13% and 1% for serious and slight injuries respectively. The UNITE project (2003) reviewed these ratios and accepted them as the best available. They were subsequently adopted within the European Commission sponsored HEATCO project (2005).

Table 9 shows a comparison of the values for fatal, serious and slight casualties as derived from the SP survey (WTP value) and the avoidable cost approach (lost output value) used in this study with the values obtained from the European studies.

Table 9: Fatal, serious and slight casualty costs derived for Singapore, and comparison with Sweden and UK values

	Cost in Singapore $			Ratio	
Type of casualty	**Fatal**	**Serious**	**Slight**	**Serious/Fatal**	**Slight/Fatal**
Singapore					
WTP	1,874,000	1,426,000	N/A	76.1%	N/A
Avoidable cost/Lost output*	1,114,260	88,370	8,600	7.9%	0.8%
UK	2,411,762	271,009	20,897	11.2%	0.9%
Sweden	3,112,140	414,000	57,103	13.3%	1.8%
ECMT and EC recommended				13%	1%

Notes: *Lost income values factored up by employer overheads (21%) and average indirect taxation (10%)
All values have been converted to Singapore dollars (SGD) and adjusted for purchasing power parity and CPI.

The ratio of Singapore WTP serious casualty costs to fatal costs from the SP survey results (76%) was clearly much higher than the ratios obtained in the two European studies results, and also much higher than the ratio of approximately 8% obtained with the corresponding lost output costs.

Reasons for the high WTP serious injury value might include:

- Difficulties in framing questions to respondents during the survey.
- Respondents’ perceptions of the extent of a serious injury might differ from the Police definitions. The definition for a serious injury used in the avoidable cost approach covered an extremely large range of injuries and only a small percentage resulted in long term hospitalisation and permanent disability. If however, the majority of survey respondents perceived a serious injury to be at the more ‘serious’ end of the range, then

this could partly explain the large disparity between the avoidable cost approach and WTP results.

- Survey respondents might have included anticipated medical costs and damage to property costs in their willingness to pay considerations.

As discussed above, the two European studies used advanced techniques and multiple questions to obtain reliable estimates, whereas in the Singapore study there was limited opportunity to clarify this aspect.

The ratios from the lost output approach (7.9% and 0.8% for serious and minor injury respectively) are lower than the ratios derived in the studies in the UK and Sweden. This is probably explained by the fact that the lost output approach does not adequately capture the value due to pain, grief and suffering associated with serious injuries.

The ratios for serious injury to fatality and slight injury to fatality of 13% and 1% respectively have therefore been adopted for calculation of WTP values of avoided serious and slight injury in Singapore in preference to using the value of avoided serious injury accident derived from the SP survey. The resulting values are shown in Table 10.

Table 10: Adopted WTP casualty costs for Singapore

	Cost in Singapore $ 2008			Ratio	
	Fatal	**Serious**	**Slight**	**Serious/Fatal**	**Slight/Fatal**
WTP value	1,874,000	243,600	18,740	13.0%	1%

The WTP value of an avoided fatality is approximately 1.68 times the corresponding lost output estimate in the avoidable costs approach.

6.2 Overall comparison with international values

Table 11 compares the Singapore casualty cost values with corresponding values from a number of other countries, including the UK and Sweden as discussed above. It should be noted that the methodologies used to derive values in Table 11 are not known in all cases (values known to have been derived from WTP studies are marked with an asterisk).

The recommended WTP based values for Singapore were comparable to EU values and those of many European countries. The values were considered to provide a sound basis for Singapore switching from the avoided cost approach to the WTP approach for the estimation of accident cost values.

Table 11: Comparison with international values

Country	Casualty cost in Singapore $			Ratio	
	Fatal	Serious	Slight	Serious/Fatal	Slight/Fatal
Singapore					
WTP based values	**1,874,000**	**243,600**	**18,740**	**13.0%**	**1%**
Lost output values	1,114,260	88,370	8,600	7.9%	0.8%
*US	4,631,754	231,588	59,129	5.0%	1.3%
*UK	2,411,762	271,009	20,897	11.2%	0.9%
*Sweden	3,112,140	414,000	57,103	13.3%	1.8%
*EU	1,757,608	228,489	17,576	13.0%	1.0%
Australia	1,636,889	360,116	13,095	22.0%	0.8%
*New Zealand	2,380,294	248,109	13,181	10.4%	0.6%
Finland	2,132,186	1,206,208	164,483	56.6%	7.7%
Austria	3,501,656	406,192	28,013	11.6%	0.8%
Greece	2,642,824	311,886	59,094	11.8%	2.2%
Germany	1,617,538	111,554	5,578	6.9%	0.3%
Italy	1,248,298	284,938	5,427	22.8%	0.4%
Denmark	1,502,467	157,319	42,577	10.5%	2.8%
Portugal	548,367	34,273	1,714	6.3%	0.3%
Ireland	2,152,703	242,020	19,107	11.2%	0.9%
France	1,505,508	220,635	32,446	14.7%	2.2%
Netherlands	3,129,383	325,977	10,431	10.4%	0.3%
Switzerland	1,549,086	219,210	14,614	14.2%	0.9%
Norway	3,579,370	1,053,551	108,056	29.4%	3.0%
Japan	353,544	116,683	14,212	33.0%	4.0%

Source: UNITE (2003), Maibach, M et al (2008)
Note: All values have been converted to SGD and adjusted for purchasing power parity and CPI.
* known to be calculated from WTP studies.

7. Conclusion

This paper has presented a methodology to derive the willingness-to-pay (WTP) values of accident cost based on two survey approaches, contingent valuation (CV) and the stated preference (SP) survey. The CV approach revealed that while respondents were willing to pay for a reduction in the risk of being killed in an accident, they seemed unable to differentiate between low probabilities of being involved in an accident. This led to a wide range for the value of statistical life by CV, $1,436,000 – $3,290,000 for the two risk reduction percentages considered.

The estimates of accident cost from the more sophisticated SP survey were found to be within the range of the CV values, and were adopted as they were consistent with the value of time and other values derived from the same SP experiment.

The ratio of the WTP serious casualty costs to fatal costs from the SP survey was much higher than the ratio obtained with the corresponding lost output costs, and also higher than the ratios obtained in the two European studies results. Subsequently, the ratios for serious injury to fatality and slight injury to fatality of 13% and 1% respectively from the ECMT (2000) were adopted for calculation of WTP values of avoided serious and slight injury in Singapore.

The WTP values of accident cost were compared against the avoidable cost (i.e. lost output) based estimates. The WTP value of an avoided fatality was approximately 1.68 times the corresponding lost output estimate in the avoidable costs approach.

The resulting WTP based values were comparable with values obtained in international studies and considered appropriate for adopting by LTA. The average cost per reported injury accident by road type and area were estimated using the WTP accident costs. They included an allowance for costs associated with unreported accidents, and were recommended as the most appropriate measure for use in economic evaluations.

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