

# Development Of Value Of Road Safety Model By Combining Behavioral Theory Of Perspective Economics And Psychology As The Basis Preferences

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## Abstract

Several studies on value of road safety (VRS) has been widely applied in various countries. One approach that is commonly used to calculate the VRS is to measure public willingness to pay (WTP) in order to increase the safety aspect. In this model preferences are based on the behavioral theory of economics perspective that explains that every human behavior based on the preferences and each preference has a utility value further in human behavior will select preferences that have a high utility value. This model has been criticized from several researchers in the field of psychology because many factors affect human behavior and the researchers believe the results of measurements of preferences in this model is still a bias that ultimately affect the validity of the results of the calculation of VRS. For these reason the objective of this research is to develop a model of VRS by combining behavior forecasting from the economics perspective and psychology perspective so that the result is closer to reality.

**Keywords :** Value of Road Safety, Preferences, Behavior Theory

## 1. Introduction

In many countries research on value of road safety (VRS) have been carried out. While a number of different approaches have been proposed for the definition and estimation of VRS, only two would seems to deserve serious consideration, namely the gross output (or human capital) approach and willingness to pay (WTP) approach (M.W. Jones Lee, 1981). Human Capital approach to calculate the VRS is not popular today, then WTP approach to calculate the VRS is widely used by the researchers (Blomquist, 1979; Jones-Lee et al, 1985; Person, 1989; Maier et al, 1989; Luis I Rizzi et al, 2001; Paula Iraguen et al, 2002; Henrik Andersson, 2006; David A. Hensher, et al, 2009; Mikael Svensson et al, 2010; etc)

In connection with the VRS, Policymakers often must make decisions based on non-market valuation estimates obtained from either revealed preference (RP) or stated preference (SP) techniques. Questions may vary widely, such as: How much money should be spent to improve road safety? RP techniques use actual consumer decisions to model consumer preferences and exploit the fact that consumer decisions reveal preferences for goods, in both market and non-market contexts. SP techniques ask people questions that are intended to elicit their preferences for goods, without requiring that the consumer act accordingly.

A common feature of a SP survey is that respondents are asked to indicate their preferences for hypothetical stimuli. In microeconomic theory preference is assumed to determine choice. A choice in the fictitious situation is called as a SP, and an actual behavior or choice a revealed preference (RP). A utility function denotes relations between preference and external factors. For an overview of many different variants of SP methods, see for instance Levin and Louviere (1981) and Lee- Gosselin (1996). Microeconomic theory, on which SP methods, assumes that the utility function is coherent and invariant (Arrow et al., 1996). However, this assumption has been tested and rejected in numerous empirical studies conducted in cognitive and social psychology.

The object of this study is the toll road users in Indonesia. Topics studied are public willingness to pay to improve road safety. The objective of this study was to develop a conceptual framework VRS models, with a preference re-construct that is used to measure the willingness of the toll road users to pay in order to improve road safety. Reconstruction is done with preference theory approach of behavioral psychology perspective, using theory of planned behavior (TPB). The expected outcome of this research is to obtain the value of the preference relations from the perspective of economics and psychology

In this paper we will therefore describe the VRS, the concept value of statistical life, critique this basic assumption of an invariant utility function underlying the SP method. We then outline an alternative framework based on theory of planned behavior (Ajzen, 1998) which may be employed in VRS.

## 2. Value of Road Safety

Indonesia as a developing country facing problems of a fatal accident on the road . on May 11, 2011 agreed all member states of the United Nations to make the program Decade of Action for Road Safety 2011-2020. The target of this action to reduce the number of fatalities from traffic accidents in 2020 by 50 % . Based on the quantity Police Republic of Indonesia data, traffic fatalities in 2010 in Indonesia reached 31,234 souls, made predictions up to 2020 reached 37,493 inhabitants. To achieve the success of the Decade of Action for Road Safety 2010-2011 , the number of fatalities should be able to be pressed into 50 % of the 37 493 people ( or 18 747 inhabitants in 2020) , then in 2020 there were 88,600 expected life saved from premature deaths caused by traffic accidents on the road .Whilst these trends give cause for concern in developing countries, road safety is but one of the many problems demanding it's share of funding and other resources.

In order to assist in this decision-making process it is essential that a method be devised to determine the cost of road accidents and the value of preventing them.

## 3. The Concept Value of Statistical Life

The concept 'Value of a Statistical Life' (VoSL), is often used for monetising safety effects, in the context of road safety. In order to value safety effects in monetary terms, including human costs, the concept of the Value of a Statistical Life (VoSL) was developed and is now used in several countries. This 'statistical human life' can be illustrated by the following example. The chance of a fatal crash of, for instance, 10 per 100,000 inhabitants means that statistically, each year 10 out of every 100,000 people will die in a road crash. A decrease from 10 to 5 road deaths per 100,000 means that 5 of every 100,000 'statistical lives' are saved. To determine the monetary value of this decrease in the crash rate, the welfare economic concept 'willingness to pay' is used. This is the maximum amount that people are prepared to pay for a given decrease in crash rate. This concept originates from the economic welfare theory and makes it possible to put a price on a specific risk reduction and hence on the saving of statistical lives. Suppose that people are prepared to pay \$50 for a crash rate reduction from 10 to 5 per 100,000. It then follows that 100,000 people are collectively prepared to pay \$50 x 100,000 = \$5 million. The VoSL is then \$5 million/5 statistical lives saved = \$1 million per statistical life. Note that the VoSL is not about valuing a specific individual life, but about the value of the decrease in crash rate. Most people would 'give anything' not to die. In the concept 'willingness to pay', people make a trade-off between crash rate and money. Every day people make decisions in which, unconsciously or not, they make such a trade-off. Take for example ,choosing food, choosing driving speed, choosing whether to install a smoke detector or not, or choosing whether or not to smoke.

### 3.1 Theoretical model Value of Statistical Life

The expression of the value of a statistical life (VSL) refers to the population mean of the marginal rate of substitution between mortality risk and wealth. The theoretical expression is derived in a state-dependent expected utility framework where the individual is expected to maximize his utility (Jones-Lee, 1974; Rosen, 1988). Let  $p$  denote the baseline mortality risk and  $u_s(w)$ ,  $s \in \{a, d\}$ , the state dependent utility of wealth ( $w$ ) where the states are either alive ( $a$ ) or dead ( $d$ ). The individual is then assumed to maximize the following expression,

$$EU(w, p) = pud(w) + (1 - p)ua(w) \quad (1)$$

We assume that the utility functions are twice differentiable and we adopt the standard assumptions that the utility of wealth is larger if alive than dead, the marginal utility of wealth is also larger if alive than dead and nonnegative, and that individuals are weakly risk averse to financial risks, i.e.

$$ua > ud; u'a > u'd \geq 0; \text{ and } u's \leq 0 \quad (2)$$

The expression for the VSL is obtained by totally differentiating Eq. (1) and keeping utility constant,

$$VSL = \frac{dw}{dp} \Big|_{EU \text{ Constant}} = \frac{u_a(w) - u_d(w)}{p u'_d(w) + (1-p)u'_a(w)} \quad (3)$$

which is the standard expression for the MRS(w, p). It is straightforward to show that under the properties of (2), VSL is positive and increasing with w and p (Jones-Lee, 1974; Pratt & Zeckhauser, 1996; Weinstein, Shepard, & Pliskin, 1980).

Eq. (3) is the VSL for “true” marginal changes in WTP and mortality risk. In this study, as in many studies using the SP approach. That is, in the SP survey used to obtain stated WTP respondents are asked about a finite change in the probability of death. Let  $\Delta w$  and  $\Delta p$  denote finite changes in wealth and risk and Eq. (3) is given by,

$$VSL = \frac{\Delta W}{\Delta P} \quad (4)$$

The expression in Eq. (4) is an approximation of the true marginal WTP and reveals that  $\Delta w$  should be near-proportional to  $\Delta p$ .

When analyzing observed behavior we are studying discrete choices where an individual will use a safety device only if the benefits of using it are larger than the costs. Hence, by rearranging Eq. (4) it can be shown that,

$$\Delta w < VSL \times \Delta p \quad (5)$$

#### 4. Microeconomic Theory and Attitude Theory

Will SP surveys always make possible to quantify core preferences? Some cognitive psychologists have argued that all preferences are “constructed”, thus being in part dependent on particular contexts (Fischhoff, 1991; Montgomery, 1983; Svenson, 1992, 1998). In other words, stable core preferences may not exist prior to a choice. This may be especially true of SP surveys that involve non-existing alternatives which respondents are not familiar with before the survey (Ajzen et al., 1996; Schkade and Payne, 1994; Slovic, 1995). Of course, these arguments do not imply that it is always impossible in SP surveys to capture core preferences. Nevertheless, these arguments imply that it is extremely difficult to identify core preferences based on SP surveys; it would demand very carefully designed surveys to properly quantify core preference.

Even if core preference can be quantified by SP methods, the utility function may fail to forecast willingness to pay accurately if it is not faithfully reflected in actual behavior. An important question to ask is therefore: How much does core preference determine actual behavior in the real world? There are two reasons to suspect that actual choice does not always faithfully reflect core preferences. The first reason is that context is a true determinant of actual behavior and response to SP questions.

The second reason is that in social psychology it has been shown that the attitude toward a behavior, that is, a subjective evaluation of a behavior with some degree of favor or disfavor, is relatively stable and coherent regardless of the context (Eagly and Chaiken, 1993). In this vein, core preference may be regarded as, or at least include, attitude as defined in social psychology. However, it has been empirically shown that attitude is often an inaccurate predictor of behavior (Fishbein and Ajzen, 1975; Sheppard et al., 1988). This is in part because many other factors influence behavior. Social pressure is one such factor (Asch, 1951; Fishbein and Ajzen, 1975; Wood, 2000). Other factors include personal norm, moral obligation, and perceived behavioral control (Ajzen, 1985, 1991). The inability of attitude to predict behavior accurately due to these other factors is another reason to suspect that actual behavior is not solely determined by core preference. For these reasons, it may be the case that even if one is able to validly quantify core preference from SP data, it would only partially improve the prediction of actual behavior.

#### 5. Stated Preference, Behavioral Intention and Behaviour

The single most important insight from attitude theory is that behavioral intention is a better predictor of behavior than any other measures, as was argued using empirical data in, for example, Ajzen (1985, 1991); Fishbein and Ajzen (1975), and Garling et al. (1998). A behavioral intention entails a commitment to act in addition to a desire to act. Whereas a desire may reflect core preferences, commitment is not likely to do this. A subjective commitment, for instance, a commitment to help a person regardless of the cost of helping, often induces a behavior which cannot be explained by microeconomic theory (Sen, 1977).

In the SP methods based on microeconomic theory, a survey serves as an instrument to observe stated preferences. A stated preference obtained from a survey, however, can also be interpreted as a stated behavioral intention. This is probably more likely the case when the survey question solicits a stated intention.

Although behavioral intention is a better predictor of behavior than any other measure, it is nevertheless not perfect. Many other contributing factors have been identified in empirical studies based on attitude theory. A

way of conceptualizing the effects of these factors has been proposed by Garling et al. (1998) who distinguished errors of omission from errors of commission. A respondent may state that he will choose an alternative but then fail to actually do so (an error of commission), or he may not state that he will choose an alternative but actually do so (an error of omission).

## 6. Behavioral Model of Psychological Perspective

In the field of psychology, known to some theories regarding behavior. These theories each have a different rationale from one another. Broadly speaking there are two fundamental concepts of thought and behavior of these theories, the first concept is based on human behavior that is altruistic, that human behavior is more concerned with the interests of others or the common good, and the second is based on the concept utility value or usefulness value.

The concept is based on the altruistic nature of human behavior states that a person's behavior is done because of the judgment / moral obligation of the individual with the interests of others or the common interests and put a side his own interests. The concept of this behavior can only be applied to individuals who already have a high awareness that a certain behavior will have consequences for a common goal. Of course this concept is not relevant to the condition in which an individual's consciousness is still very low. In contrast to the concept of altruistic behavior, which is based on the concept of utility values indicate more rational human behavior in determining his choice. This concept has similarities with the concept of rational economic theory of consumer behavior in which individuals are likely to perform a behavior that will give optimum satisfaction but unlike the theory of consumer behavior based on the preferences of voting behavior, the theory of rational behavior and the psychological perspective of human behavior based on attitude

The model of behavior is based on the attitude has contributed much to the understanding of behavior is behavioral intention model. In this model, intentions are assumed to capture the motivational factors that influence a specific behavior, ie indicators described how hard someone wants to try, how much effort that he mobilized to perform a behavior. In general it can be said that the stronger a person's intention to perform a behavior, the more likely the person is doing.

### 6.1 Model of Planned Behaviour

Models of planned behavior postulates three determinants and intention to behave conceptually independent . The first is the attitude towards the behavior (A) , which is an assessment of a behavior whether pleasant or unpleasant . The second factor is the subjective norms (SN), namely the influence of social pressure that expects or wants someone to perform or not perform a behavior . While the third factor is perceived behavioral control (PBC) , ie the perception of a difficult or easy it is to perform the behavior. Perceived behavioral control in the model is derived from self-efficacy theory proposed by Bandura in 1977 , which is derived from social cognitive theory. In general it can be said that the more fun a behavior, the more positive influence on the behavior of others, and the greater ease in one's beliefs will behave, then the greater the person's intention to perform a particular behavior .

According to the model of planned behavior, perceived behavioral control together with behavioral intention can be used directly to predict the behavior. According to Ajzen (1991), there are at least two reasons that can be used to explain this hypothesis. The first is if the intention is not to change behavior or constant, then it is likely the individual will perform a particular behavior will be greater if the individual feels capable or able to do so. The second reason , assuming there is a direct relationship between perceived behavioral control and behavior is due to perceived behavioral control can be used as a substitute for actual measurement control. Measurement of perceived behavioral control can replace actual measurements of control is highly dependent on the accuracy and perception. When individuals have relatively little information about the specific behavior, perceived behavioral control measures may only add a bit of accuracy of prediction of behavior . However , the extent to which perceived behavioral control is realistic, then it can be used to predict the probability of an individual to behave .

The model and the theory of planned behavior is illustrated in Figure 1 where the relationship between the determinants of the intention to behave can be seen .

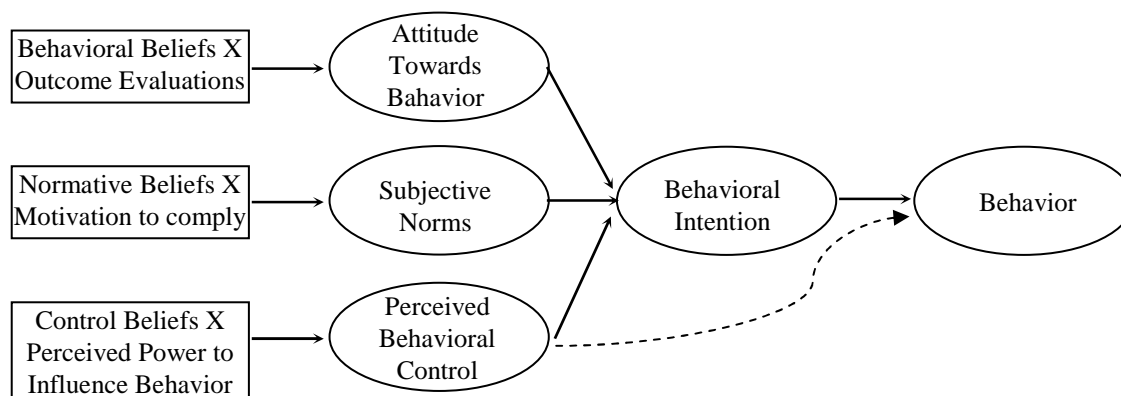


Fig.1 : Model of Planned Behavior

Interpretation of Value A, SN and PBC are seeing the effect of value A, SN and PBC towards behavioral intention safer on the toll road. The greater the positive value means greater influence on intention otherwise if the value is getting smaller and negative influence on intention means getting smaller

The theoretical constructs shown in the above diagram are hypothetical or latent variables. They cannot be directly observed but must instead be inferred from observable responses. This is as true of actual behavior as it is of the other constructs.

The behavior of interest is defined in terms of its **T**arget, **A**ction, **C**ontext, and **T**ime (TACT) elements Defining the TACT elements is somewhat arbitrary

The belief strengths and outcome evaluations for the different accessible beliefs provide substantive information about the attitudinal considerations that guide people’s decisions to engage or not to engage in the behavior under consideration. Belief strength and outcome evaluation can also serve, however, to compute a belief composite that is assumed to determine the attitude toward the behavior (AB) in accordance with an expectancy – value model, as shown symbolically in the following equation:

$$AB \propto \sum bie_i \quad (6)$$

Belief strength (b) is multiplied by outcome evaluation (e), and the resulting products are summed over all accessible behavioral outcomes.

Measures of normative belief strength and motivation to comply with respect to each accessible referent offer a “snap shot” of perceived normative pressures in a given population. An overall normative belief composite is obtained by applying the expectancy – value formula to these measures, as shown in the following equation:

$$SN \propto \sum nimi \quad (7)$$

Normative belief strength (n) is multiplied by motivation to comply (m), and the resulting products are summed over all accessible normative belief outcomes.

Examination of the average strength and power of the different control beliefs provides a picture of the factors that are viewed as facilitating or impeding performance of the behavior. Using an expectancy – value formulation, as shown in the following formula, it is possible to compute a control belief composite.

$$PBC \propto \sum cipi \quad (8)$$

Control belief strength (c) is multiplied by Control belief power (p)), and the resulting products are summed over all accessible control belief outcomes.

## 7. Data

### 7.1 Population and Sample

The population of this study are toll road users in Jakarta. The sampling technique is done by simple random sampling method . The basic principle is that every member of the population has an equal chance to be drawn as members of the sample ( Gulo , 2002) .

Good data are population , but not possible because of time, effort and cost , so that the data sample is taken to

present the characteristics of the population .

The minimum sample size for the application of structural equation models is still debated by experts ( Kusnendi , 2008) . According Hoelter (1983 ) , the minimum sample size for structural equation models is 200 samples. Ding , Velicer and Harlow (1995, in Hair, Anderson , Tatham & Black , 1998) recommends a minimum sample size of 100 to 150 samples. Anderson and Gebing (1988, in Holbert & Stephenson , 2002) recommends a minimum sample size of 150 samples. Ferdinand (2002) based on literature review concluded a minimum sample size of 100 to 200 samples for the maximum likelihood estimation technique.

According to Hair et. al (2006) a minimum sample size associated with complex case of the model are analyzed. The complexity is shown by the number of constructs and indicators contained in the model . The more complex the model , the greater the minimum sample size required .

## 7.2 Data Collection Method

Collecting data in this study conducted by distributing WTP and TPB questionnaires to respondents simultaneously.

Before performing data collection preliminary survey was made. Preliminary survey was conducted to obtain information about the respondents' understanding of the question on the questionnaire. Preliminary investigation is important to know the constraints that may arise in sampling conducted prior to the main survey. Preliminary survey conducted as a pilot in getting the data by asking some respondents to complete a questionnaire and provide comments and input on the questionnaire distributed.

To design the survey form conducted focus group discussion. The purpose of the focus group discussions to obtain feedback on the WTP and TPB survey form are made to fill in the survey form tendentious and can not be understood by the respondents. The entire input from participants is used to repair the survey form.

## 8. Discussion

Preliminary investigation has been carried out on the 30 respondents toll road users in Jakarta with a method of distributing questionnaires. Of the 30 respondents, 5 questionnaire answers identified can not be analyzed and 25 questionnaire answers can be analyzed.

### 8.1 WTP Result

The total value of WTP is 19,300,000 IDR, therefore the average value of WTP is 772,000 IDR. The greatest value of WTP is 2,500,000 IDR and the lowest value of WTP is 100,000 IDR relating to the midpoint value of WTP is 1,300,000 IDR. Of the 25 respondents, 5 respondents (20%) who have WTP values above the mean and 20 respondents (80%) had a WTP values below the middle value. This condition is a portrait of society that willingness to pay for the improvement of traffic safety on the highway is still low.

### 8.2 TPB Result

The measurement of TPB result is the value of all the variables forming the intention that the value of Attitude Toward Behaviour (A), Subjective Norm (SN) and Perceived Behavioural Control (PBC) In a combination of them, all three of these factors result in behavior intention. In general, if the attitude and subjective norm refers to the positive direction and the control exerted by the stronger it will more than likely someone will do the behavior. The average value of TPB is + 10 and the range Value of TPB is  $-21 \leq TPB \leq 21$

### 8.3 The relationship between WTP and TPB Assessment Results:

Based on the analysis of WTP, the average value of public willingness to pay for improvement in toll road safety aspect is 772,000 IDR or the range of values TPB, are at moderate interpretation of negative values (-13.51);

Based on the analysis of TPB, the average value of the community's intention to improve toll road aspect in the interpretation of positive values are moderate (+ 10) or in the range of WTP values, being the value of 1,871,429 IDR

Based on the analysis of WTP and TPB can be attributed that the range of potential increase in public WTP to the



increase in toll road safety aspect is in the interval value 772,000 IDR up to 1,871,429 IDR or the increase in WTP values could reach 142% of 772,000 IDR

If :

Range Value of TPB ~ Range Value of WTP  
 then:

- 21 to +21 ~ 100,000 IDR to 2,500,000 IDR

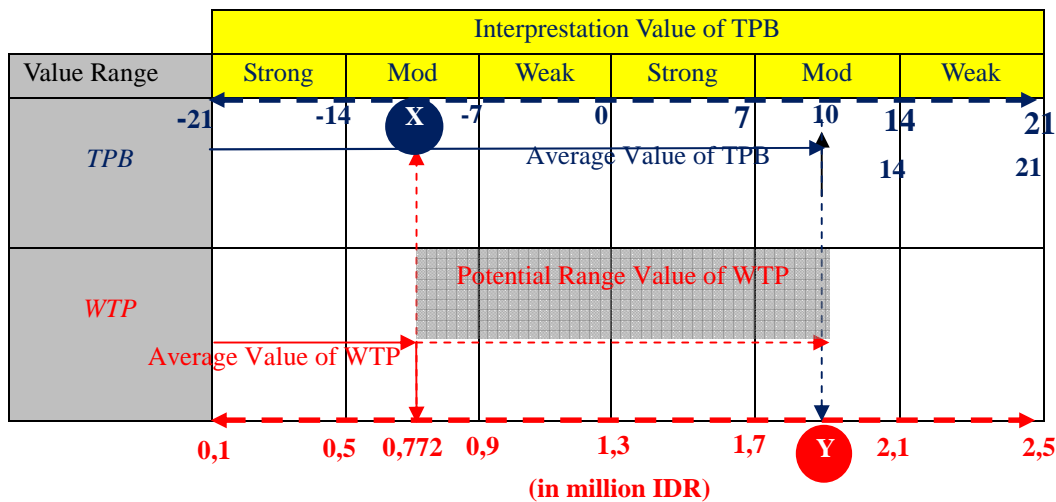


Fig.2 : The relationship between WTP and TPB Assessment Results

Furthermore :

Average Value of WTP ~ Value of TPB X

0,772 ~ Value of TPB X

$$\begin{aligned} \text{Value of TPB X} &= 0 - \{(0,772 : 1,2) \times 21\} \\ &= - 13,51 \end{aligned}$$

Average Value of TPB ~ Value of WTP Y

10 ~ Value of WTP Y

$$\begin{aligned} \text{Value of WTP Y} &= 1,3 + \{(10 : 21) \times 1,2\} \\ &= 1,871,429 \text{ IDR} \end{aligned}$$

## 9. Conclusion

Value of Road Safety Model that is based on the willingness to pay approach is based on the theory of behavioral economics perspective explains that human behavior is based on the selection of preferences.

Theories of behavioral psychology perspective criticized willingness to pay approach is based on the theory of behavioral economics perspective , and explains that human behavior is based on the intention that shape the behavior instead of the selection preferences .

The differences between these two theories lead to bias in the model Value of Road Safety , and this bias creates the opportunity for researchers to develop a model of Value of Road Safety , by combining these two theories .

Preliminary investigation has been carried out on the 30 respondents toll road users in Jakarta with a method of distributing questionnaires. Of the 30 respondents, 5 questionnaire answers identified can not be analyzed and 25 questionnaire answers can be analyzed. From the Preliminary investigation that found evidence of a relationship between WTP values with the value of the TPB ( WTP values of respondents still may be increased up to 142 % from. 772,000 IDR) .

Furthermore, to prove more detail the relationship between WTP values and TPB will require further research

with larger samples and more in-depth analysis .

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