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The Future of Human Mobility

Special Issue : Asian Economic Corridor

PREFACE

Dear Readers,

Once again, Welcome to the second volume (Volume 2), issue number 2, of the JOURNAL OF SOCIETY for TRANPORTATION and TRAFFIC STUDIES, an international peer-reviewed on-line journal. Four issues of the journal are published annually. This issue presents 4 technical papers: two on urban related issues, the first paper presents a method for predicting congestion in Bangkok, the second describes the effect of level of urbanization on provincial government spending on infrastructure and transportation; the other two papers talk about road safety, one presents the value of a fatality in Malaysia and the other discusses how active safety systems of vehicle can increase road safety. The special issue in this volume is about the condition of an Asian economic corridor along route 12 which links Thailand, Lao PDR, Vietnam and Guangxi in China. The paper concludes with recommendations to improve logistics and tourism activities on R12 economic corridor for each country to implement.

I trust you will enjoy reading this issue and find the information and research findings helpful.

Pichai Taneerananon Professor Chair of Editorial Board

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DEVELOPMENT OF REAL-TIME SHORT-TERM TRAFFIC CONGESTION PREDICTION METHOD

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Abstract: In this paper, we investigated the traffic flow characteristics conducting to congestion on Bangkok highways. The congestion likelihood was calculated by applying the Dynamic Time Warping algorithms in time series of traffic flow data for the first time. The effectiveness of new approach algorithms are suffering by meantime to detect and false alarm rate. As a result, it was shown that the standard deviation of speed and speed were found to outperform other indicators in Bangkok highways data. The preliminary result indicates the effectiveness of new approach algorithms that it has better performance than conventional classification with constrain of the limitation of data.

Key Words: Congestion, Precursor, Traffic flow, Dynamic time warping

1. INTRODUCTON

With the massive increase in the number of vehicles in Bangkok, it is causing more heavy traffic congestion in many highways especially during the rush hours as other large-sized According worldwide metropolis. to Nachaivieng T., the public motoring cost during traffic congestion delay is worth more than billions baht causing congestion management has been a major research topic transportation studies. There are numerous researches study how to manage the congestion problem in Thailand however the most of them have focused on analyzing historical data in order to understand the behavior of traffic congestion. In

recent years, the availability of installed sensors and provided infrastructures helping researchers are able to study easier and process real-time traffic data. This paper presents a method for prediction highway congested condition using real-time traffic data from CCTV cameras. In this paper, researchers have focused primarily on recurrent traffic congestion and extended to nonrecurrent traffic congestion in future work. Preliminary results show that the new approach algorithms are effective base on three months offline data, but these have to be confirmed by further field trials.

We have organized the rest of this paper as follows. In Section 2, we review the related

literatures. We review background material, introduce the meaning of precursor and the structure of the proposed model in Section 3. Section 4 suggests the methods to determine congestion precursors in the model using real traffic flow data and evaluates the performance of the model. Finally, we offer some conclusions and recommends future work in Section 5.

2. BACKGROUND MATERIAL

In this section, we first introduce the basic definitions and terminology of traffic congestion analysis and time series analysis in the meaning of Intelligent Transportation System (ITS)

2.1 Issues on Traffic Congestion

In the transportation studies, traffic congestion generally relates to an excess of traffic demand on a portion of roadway at a particular time resulting in slower speed than normal and typically categorized as either recurrent or nonrecurrent

Recurrent congestion is consequence of fluctuations in demand greater than the technical maximum throughput capacity of the roadway. When roadways are operated at or near their maximum capacity, small changes in available capacity due to such factors as differential vehicle speeds, lane changes, and acceleration and deceleration cycles can trigger a sudden switch from flowing to stop-and-go traffic. This type of congestion acts periodically and might be predictable on the transportation system, such as 8.00 a.m. and 17.00 p.m. in weekdays, holidays or weekend festivals. However, even recurrent congestion can display a large degree of randomness, especially in its duration and severity.

Non-recurrent congestion or usually called "incident" is the effect of unexpected or unplanned occurrence and depends on its nature caused by rains, accidents, and other random

events, such as inclement weather and debris. This type of congestion affect parts of the transportation system less than recurrent congestion but they occur randomly and, as such, cannot be easily predicted. The share of nonrecurrent congestion varies from road network to road network and is linked to the presence and effectiveness of incident response strategies, roadwork scheduling and prevailing atmospheric conditions (snow, rain, dust, etc.).



Figure 1. Show the tree of congestion

2.2 Time Series Analysis

In this section, we review the basic of time series analysis beginning with a definition of our data type of interest, time series according to Jiawei Han and Micheline Kamber (Data Mining: Concepts and Techniques, Second Edition)

A time-series database consists of sequences of values or events obtained continuously over repeated measurements of time. The values are typically measured at equal time intervals (e.g., hourly, daily, weekly). Time-series databases are popular in widely applications, such as stock market analysis, engineering and traffic data. A time-series database is also a sequence database. However, a sequence database is any database that consists of sequences of ordered events, with or without concrete notions of time. For example, Web page traversal sequences and customer shopping transaction sequences are sequence data, but they may not be time-series data. Figure 2 show the one-day example time series of traffic data in Khlonglhong highway from 6.00 a.m. (60000) to 18.00 p.m. (180000)



Figure 2. Traffic time series data of Khlonglhong highway

Sliding Windows Instead of sampling the data stream randomly, we can use the sliding window model to analyze stream data. The basic idea is that rather than running computations on all of the data seen so far, or on some sample, we can make decisions based only on recent data. More formally, at every time t, a new data element arrives. This element "expires" at time t +w, where w is the window "size" or length. The sliding window model is useful for stocks or sensor networks, where only recent events may be important. It also reduces memory requirements because only a small window of data is stored

3. LITERATURE REVIEW

Traffic congestion analysis in order to detection and prediction has been wide interest in Intelligent Transportation System (ITS). There are numerous of existing studies and vary of algorithm approach especially artificial intelligent method. Thus, we will divide the review section into following two classes and mainly interest in prediction algorithms.

3.1 Traffic Congestion Detection

The traffic congested detection algorithms have been studied extensively in a decade ago. They provide much importance basics algorithms that may be implementing into prediction method. Many algorithms were developed in the different of principles, complexity and implementation method however most of them could be only operated on trained roadways data which their accuracy and reliability was heavily affected by the quality of data. In this section, we are about to focus on the part of algorithm development and review only the grouped of algorithms that yield the good results of accuracy and flexibility based on theirs principle. These algorithms consist of statistical algorithm, artificial intelligent algorithm and time series algorithm

The statistical algorithm is the oldest approach technique but yield satisfactory result. This algorithm uses the standard statistical theory in order to determine whether observed detector data differ statistically from estimated or predicted traffic characteristics. The standard normal deviate (SND) algorithm (Dudek et al., 1974) and Bayesian algorithm (Levin and Krause, 1978; Tsai and Case, 1979) are two representative types of statistical traffic congested detection algorithms that show impressive with simulation results and preprocessing data. However, the quality of raw data is most importance. With field implementation, it shows catastrophic result due to noises and uncontrolled parameters.

Time series algorithm is the next generation statistical algorithm development that assumes traffic normally follows a predictable pattern over time. They employ time series models to predict normal traffic conditions and detect incidents when detector measurements deviate significantly from model outputs. Several different techniques have been used to predict time-dependent traffic for congestion detection, including the autoregressive integrated moving-average (ARIMA) model (Ahmed and Cook, 1977, 1980, 1982) and high occupancy (HIOCC) algorithm (Collins et al., 1979).

Artificial intelligence algorithm is the newest approach method beginning with the age of computerization all decision making by machine. This algorithm usually refers to a set of procedures that apply inexact or "black box" reasoning and uncertainty in complex decisiondata-analysis making and processes. The artificial intelligence techniques applied in automatic congestion detection system include neural networks (Ritchie and Cheu, 1993; Cheu and Ritchie, 1995; Stephanedes and Liu, 1995; Dia and Rose, 1997; Abdulhai and Ritchie, 1999; Adeli and Samant, 2000), fuzzy logic (Chang and Wang, 1994; Lin and Chang, 1998), and a combination of these two techniques (Hsiao et al., 1994; Ishak and Al-Deek, 1998).

3.2 Traffic Congestion Prediction

Recurrently, researchers have become increasingly interested in traffic congestion prediction. Due to lack of traffic observation infrastructure and technology limitation causing tardy development in the beginning and few of papers were published. This type of study examines a number of traffic flow characteristics potentially congested traffic. that These characteristics are observed prior to congestion occurrence usually called as "congestion precursors". Many modeling approaches were help predict recurrent proposed to and particularly for incident (non-recurrent) traffic congestion. Among all types of incident, accident

prediction is the most interesting to researchers because their economic and human life impacts. Recent studies of precursor are summarized below.

Golob and Recker (2002) determined the flow condition classified into mutually exclusive regimes on an urban freeway that differ in terms of likelihood of crash by types by applying nonlinear canonical correlation with cluster analysis. Although they did not conduct a fullscale validation of their modeling approach, they did find that accurate estimation of crash rates heavily depends on the quality of loop data.

Oh et al. (2003) applied a nonparametric Bayesian classification method by developed probability density functions in order to predict real-time accident likelihood using loop detector data of a freeway section in California. The results indicate that the standard deviation of speed 5 minutes prior to crash occurrence is the best indicator that distinguishes conditions leading to crash occurrence from normal conditions and reducing the variation in speed generally reduces the likelihood of freeway crashes. This study show an innovative approach however there are some limitations First, using only one parameter (standard deviation of speed) to evaluate of traffic characteristics leading to accident but the accident normally occur as a result of complex interaction of many factors. The single parameter cannot sufficiently explain a broad spectrum of pre-crash conditions. Second, the measure of crash likelihood estimated from probability density function overlooked such exposures as volume, distance of travel and so on. To control for these external conditions, the variation of exposures over space and time must be taken into account in the probability density function. Third, the method is still inefficient and produces a significant rate of false alarm.

Lee *et al.* (2003) proposed a probabilistic incident prediction model using 13 months of loop detector data from an urban freeway in

Toronto. However, the model also displays some limitations. First, the determination of precursor factors is subjective. The model makes an assumption that the traffic factors 5 minutes prior to crash occurrence are important although it is uncertain whether 5 minutes are the most desirable observation time period. Second, the model uses a number of categorical variables but the study does not clearly explain how to choose the optimal number of categories and the boundary values of each category. Finally, the study fails to show if the model is robust for any categorization of precursors, and that the model performance is not sensitive to different

boundary values that are determined subjectively. This paper addresses these issues. Madanat et al. developed binary logit models for prediction the likelihood of two freeway incidents include accidents and overheating vehicles. They considered both loop and environment data in their model development. They found that the peak period, temperature, rain, speed variance, and merge section to be significant predictors of overheating incidents. For the crash prediction model, only three were found to be statistically variables significant, which are rain, merge section, and visibility.



Figure 3. Summarize of precursor model from literature review

4. METHODOLOGY

4.1 Data Description

In this study, we selected the 10-kilometer-long stretch of the Khonglhong highway traffic data

from 158 closed circuit television or CCTV cameras installed around Bangkok metropolitan area including 12 active and 146 inactive cameras, may be changeable, at the date of writing this paper. The data was extracted by embedded system that included image-

processing algorithm monitoring vehicles enter and leave the camera. The image-processing algorithm has two reference lines in order to detect the vehicles enter and leave in each camera and record a time of each vehicle when it enter to reference line and leave out the reference line. The speed can be calculate by physical formula which the real distance between enter and leave reference line divided by time that vehicle travel in the reference line. For example, To Bangkok direction, Assume a vehicle moving enter the reference line at 6:00:00 a.m. and leave the reference line at 6:00:04 a.m. with assuming the distance between two reference line is 100 meters yield the average speed of this vehicle is 90 km/h . Traffic flow can be calculate by counting the number of vehicles pass through this section with a given time interval. The algorithm was verified by Kantip Kiratiratanapruk and Supakorn Siddhichai (Kiratiratanapruk *et al*, 2006) with a good accuracy of data output.

The studied section of the Khonglhong highway locate in Pathumthani, Thailand consist of three main lanes and two outer lane per each direction. The camera installed about 30 meter height at PTT petrol station signboard. The data were collected starting from 6.00 am to 18.00 pm over a six-month period from August 8, 2008 to February 10, 2009. Details of highway are shown below in figure 4, point A show the position of installed CCTV and figure 5 show the example image from CCTV.





Figure 4. Section details of Khonglhong highway



Figure 5. Show the example image of CCTV

The congestion database was created by the observers watching CCTV monitor and recorded when congestion was occurred. We defined traffic database into two traffic condition including of *normal traffic condition*, which the condition of free flow state, and *congested traffic*

condition, which the condition of section average speed per direction below two time standard deviation of free flow speed. There are 64 congestions occur during this period. Figure 6 below show the example of two traffic conditions



Figure 6. Details of dataset

4.2 Identification of Candidate Congestion Prediction Models

A precursor is a parameter calculated from time series of traffic data. The value of parameter presenting its variations that can be indicate some patterns leading to in traffic flow congestion behavior. Recent researches in incident prediction model have widely used the concept of precursors in its models for predictions. *Traffic speed* has traditionally been a precursor interesting to many researchers for statistically relating to traffic congestion. This precursor has been statistically most significant. However, it is a very sensitive precursor and short time aggregation before congestion causing some restriction of using speed as a precursor in real-time prediction systems.

Traffic flow, which is a shorter time aggregation of volume, is another precursor that has been used by a couple of researchers to predict recurrent traffic congestion rate. The results of models involving hourly flow have indicated some definitive correlation between hourly flow and accident rate, as in the work of Hiselius an increasing rate of accidents with hourly flow is indicated. Segregating hourly flow rate by vehicle type, Hiselius also observed a constant increase in accident rate with hourly flow in the case of cars, but a decreasing rate with hourly flow in the case of trucks. Another study also affirms that hourly flow provides a better understanding of the interactions like incidents; however, there has not been elaborate work on hourly flow as a precursor and a convenient prediction model for real-time applications.

Time headway has been tried as a casual precursor. Research shows that shorter headways have been the reason for collisions. However, again, there has been no convincingly explanatory model for use of this precursor in real-time incident prediction systems.

Owing to the characteristics of Khonglhong camera that processed data all lanes per each

direction simultaneously, headway data per lane cannot be extracting. Therefore, we prefer to use two available indicators; speed and flow to represent an obvious difference between normal traffic conditions and congested traffic conditions as defined above.

We calculate the best indicator by applying statistical t-test approach based on a statistical idea of the difference between two dataset. Three candidates are selected as an indicator includes flow, mean of speed and standard deviation of speed. The data set is composed of 64-congestion sample and the rest is non-congestion sample. For the different experiments we performed a stratified random split of the data in training and test sets according to a train/test ratio equal to 60:40 or 3/2 resulting of 39-congestion samples for training and 25-congestion sample for evaluate or test an effectiveness of algorithm. To determine the best indicator new database that contained the calculated value of mean speed, standard deviation of speed and minutely flow count was built with supporting robust and automatic calculation. Each congestion candidate of training dataset was calculated compare with non-congestion sample that the most likely external and internal factor such as 15 minute before and after the congestion occur at the time of day, the same time of other day before and after the week. The worse case or lowest calculated t-statistic of all cases was selected. For example, the congestion candidate occur on Friday January 9, 2009 at 17.00 pm and finish at 18.00 pm, this candidate is about to selected to compare with the non-congestion training data set include:

Case a. Friday January 9, 2009 at 16.45 pm (15-minute before) Case b. Friday January 9, 2009 at 18.15 pm (15-minute after) Case c. Thursday January 8, 2009 at 17.00 pm (1-day before at the same time) Case d. Saturday January 10, 2009 at 17.00 pm (1-day after at the same time) Case e. Friday January 2, 2009 at 17.00 pm (1-week before) Case f. Friday January 16, 2009 at 17.00 pm (1-week after)

In addition, we assume the calculated t-test for each case in table 1.

Case	a	b	с	d	e	f
t-test	<u>2.8</u>	<u>2.9</u>	3.5	3.7	6.2	3.8

 Table 1. Assuming t-test for each case

If the result of calculating t-statistic shown that *case a.* is the worst case, Friday January 9, 2009 at 16.45 pm will be select. For training dataset, it was due to lack of congestion dataset that the non-congestion dataset would be selected as twice causing we have 39-congestion samples

and 78 non-congestion samples for training algorithm.

The most statistically significant candidate is about to select as an indicator representing the change of traffic conditions. Table 2 summarizes the t-test results.

Candidatas		Flow	
Candidates	Average	Standard Deviation	Average
1-Min	4.93	<u>3.77</u>	-0.83
2-Min	3.39	2.31	-0.63
3-Min	2.30	2.01	-0.63
5-Min	2.57	1.99	-0.43

Table 2. t-test Analysis for find the best precursor

We found that the most significant was for 1minute average of speed follow by 1-minute standard deviation of speed and flow indicated statistically insignificant. For simplicity, we therefore chose speed and its standard deviation as indicator to distinguish congested traffic conditions leading to an accident and normal traffic conditions.

4.3 Dynamic Time Warping Algorithm

There have been many researches that developing existent data mining algorithms to compute similarity between time series database. Almost of them used Euclidean distance adding

some distort or extend algorithm. However, main disadvantage of Euclidean distance is over sensitivity to small distortion in time axis causing its results are very unintuitive. To overcome this problem, the novel algorithm was proposed in 1996 by Berndt and Clifford. Recently dynamic time warping (DTW) has become widespread and being use extensively in computer science especially in speech recognition. However, it never used to process data in transportation. To understand the algorithm, we first introduce the basic of Dynamic Time warping and follow by its application to congestion matching in traffic time series.



Figure 7. Sample of DTW algorithm (J. Keogh, 2001)

Figure 7 show using DTW, two identical sequences a. will clearly produce a one to one alignment b. However, if we slightly change a local feature, in this case the depth of a valley c, DTW attempts to explain the difference in terms

$$Q = q_1, q_2, ..., q_i,...,q_n$$

 $C = c_1, c_2, ..., c_j,...,c_m$

To align two sequences using DTW we construct an n-by-m matrix where the (i^{th}, j^{th}) element of the matrix contains the distance d(qi,cj) between the two points q_i and c_j (Typically the Euclidean distance is used, so $d(q_i,c_j) = (q_i - c_j)2$). Each matrix element (i,j) corresponds to the alignment

$$W = W_1, W_2, \ldots, W_k, \ldots, W_K$$

The warping path is typically subject to several constraints to prevent singularities (Sakoe, & Chiba 1978). We briefly review them here.

1. Boundary conditions w1 = (1,1) and $w_K = (m,n)$, simply stated, this requires the warping path to start and finish in diagonally opposite corner cells of the matrix.

2. Continuity: Given $w_k = (a,b)$ then $w_{k-1} = (a',b')$ where $a-a' \le 1$ and $b-b' \le 1$. This restricts the allowable steps in the warping path to

$$DTW(Q,C) = min \left\{ \sqrt{\sum_{k=1}^{K} \frac{w_k}{K}} \right\}$$

The K in the denominator is used to compensate for the fact that warping paths may have different lengths. This path can be found very efficiently of the time-axis and produces two singularities (d).

According to Keogh and Pazzani, assume we are given a set of time series X and Y, of length n and m respectively, where:

$$(1)$$
 (2)

between the points q_i and c_j . This is illustrated in Figure 8. A warping path W, is a contiguous (in the sense stated below) set of matrix elements that defines a mapping between Q and C. The kth element of W is defined as $w_k = (i,j)_k$ so we have:

 $\max(\mathbf{m},\mathbf{n}) \le \mathbf{K} < \mathbf{m} + \mathbf{n} - 1 \tag{3}$

adjacent cells (including diagonally adjacent cells).

3. *Monotonicity:* Given wk = (a,b) then wk-1 = (a',b') where a-a' ³ 0 and b-b' ³ 0. This forces the points in W to be monotonically spaced in time.

There are exponentially many warping paths that satisfy the above conditions, however we are interested only in the path which minimizes the warping cost:

using dynamic programming to evaluate the following recurrence which defines the cumulative distance $\gamma(i,j)$ as the distance $\gamma(i,j)$

found in the current cell and the minimum of the cumulative distances of the adjacent elements:

$$\gamma(i,j) = d(q_i,c_j) + \min\{\gamma(i-1,j-1), \gamma(i-1,j), \gamma(i,j-1)\}$$
(5)



Figure 8. An example of warping path.

4.3 Training DTW Algorithm with Traffic Time Series

According section 4.2, with train/test ratio equal to 60:40, we have 39-congestion from 64congestion sample and 78-non-congestion sample for training DTW algorithm in database and 25-congestion sample for evaluate effectiveness of this algorithm. In case of speed, we import congestion database in the term of speed time series to memory and then generate the moving windows to capture speed characteristics while congestion occur. The length of moving windows is 15 minute derive from our objective that require prediction period 15 minute before real congestion occur.



Figure 9. Details of training algorithm

The moving window is collecting all 39congestion occurrences to be precursor representation. The standard deviation is taking the same capture approach.

4.4 Trigger of algorithm

To conserve processor consumption, we generate trigger to run algorithm. Each precursor is calculated the mean and standard deviation when traffic is normal and one time of standard deviation from its mean is considerate to be a trigger of algorithm by statistically reason.





T2 is the invert of T1 that is indicated DTW to stop its algorithm.



Figure 11. Trigger of standard deviation algorithm

From figure 11, it is show the case of standard deviation (SD) precursor. The same approach is used, T1 is one time standard deviation of the SD precursor mean indicated DTW to run and stop by the condition direction of its algorithm ; The algorithm is waiting for trigger to run algorithm or the algorithm is running waiting for stop.

4.5 Evaluate DTW Algorithm

We have 39-congestion sample that representative as precursor. To evaluate DTW, we use the rest of them (25-congestion that not use to training DTW) to find the effectiveness of this algorithm.

In the case of speed precursor, the preliminary result shows that 20 from 25 congestions sample can be classify into congestion correctly that yield its performance at 80% of accuracy.

In the case of standard deviation of speed precursor, the preliminary result shows that 18 from 25 congestions sample can be classify into congestion correctly that yield its performance at 72% of accuracy.

Without tuning any parameter of algorithm, the preliminary experiment shows an impressive result however we need to modify and tuning some parameter in order to improve the performance of algorithm and suitable for traffic time series.

5. CONCLUSIONS

The objective of this study is to develop the precursor algorithm that is able to approach with the available traffic data in Thailand. With processing real-time data to estimate short-term traffic characteristic leading to congestion is one of the most interesting features of this study however the quantity and quality of data is one of the constrain for this research that similar with other researchers to conduct theirs similar research. To overcome this constrain, we applying time series pattern matching with dynamic time warping approach in order to classify congestion traffic from normal traffic automatically. Difference from traditional artificial intelligent algorithm that require the large training data set and/or prior knowledge to satisfy the accuracy of result, the dynamic time warping approach require small training data set but result in high accuracy and it has much ability to classification in very complex time series such as speech recognition which yielding high accuracy.

The result show that Dynamic Time Warping has the potential capability of identifying traffic conditions that lead to congestion however the noise which infect in the raw data both training and classifying method is the main limitation of this algorithm that causing singularity occurrence leading to miss classify and resulting in low accuracy. Moreover, insufficient data led to limited the scope of this study to another precursor. These are being addressed in ongoing studies with more extensive data.

REFERENCES

Anderson, IB, K.M. Bauer, D.W. Harwood and K. Fitzpatrick. Relationship to safety of geometric design consistency measures for rural two-lane highways. In Transportation Research Record 1658,TRB, National Research Council, Washington, D.C., 1999, pp. 43-51

Balke, K.N. (1993). "An evaluation of existing incident detection algorithms." Research Report, FHWA/TX-93/1232-20, **Texas Transportation Institute**, the Texas A&M University System, College Station, TX, November 1993.

Cedar, A., and M. Livneh (1982). "Relationships between Road Accidents and Hourly Traffic Flow— I." Accident Analysis and Prevention, Vol. 14, pp.19-34.

Chang, E.C.P., 1992. A neural network approach to freeway incident detection. In: The 3rd International Conference on Vehicle Navigation and Information Systems (VNIS), pp. 641–647.

Chassiakos, A.P., Stephanedes, Y.J. Smoothing algorithms for incident detection. Transportation Research Record 1394, 9–16, 1993

Cheu, R.L., Srinivasan, D., Teh, E.T., 2003. Support vector machine models for freeway incident detection. In: **Proceedings of Intelligent Transportation Systems**, 1, pp. 238–243.

Gribe, P. (2003). "Accident Prediction Models for Urban Roads." Accident Analysis and Prevention, Vol. 35, pp. 273-285.

Jin, X., Srinivasan, D., Cheu, R.L., 2001. Classification of freeway traffic patterns for incident detection using constructive probabilistic neural networks. **IEEE Transaction on Neural Networks 12** (5), 1173–1187.

Kiratiratanapruk K. and Siddhichai S. Vehicle Detection and Tracking for Traffic Monitoring System. **TENCON 2006**, IEEE, 2006

Kirchsteiger, C. Impact of Accident Precursors on Risk Estimates from Accident Databases. Journal of Loss Prev. Process Ind., Vol. 10, No. 3, 1997, pp. 159-167.

Knuiman, Matthew W., F.M. Council, and D.W. Reinfurt. Association of median width and highway accident rates. **Transportation Research Record 1401**, TRB, National Research Council, Washington, D.C., 1993, pp. 70~82

Kockelman, K. M., and J. Ma (2004). "Freeway Speeds and Speed Variations Preceding Crashes, within and across Lanes." Presented at ITS America 2004, **14th Annual Meeting and Exposition**, San Antonio, Texas.

Krammes, R.A. and S.W. Glascock. Geometric inconsistencies and accident experience on two-lane rural highways. **Transportation Research Record 1356**, TRB, National Research Council, Washington, D.C., 1992, pp. 1-10

Lee, C., B. Hellinga, and F. Saccomanno (2003). "Real-Time Crash Prediction Model for Application to Crash Prevention in Freeway Traffic." **Transportation Research Record**

EVIDENCE OF URBANIZATION ON INFRASTRUCTURE AND TRANSPORTATION PROVINCIAL EXPENDITURES IN THAILAND

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Abstract: The purpose of this paper is to examine the effect of urbanization on infrastructure and transportation in the level of provincial government expenditures by using the data of 76 provinces across Thailand. Previous research has shown that one of tools that can affect on urban growth is the urbanization level. In this paper, the model focuses on the formation of the endogenous function in terms of aggregations of total provincial expenditures between infrastructure and transportation in terms of per capita. The findings reveal the positive impact of urbanization on infrastructure provincial government expenditures as well as transportation expenditures. In this paper, it also examines the relationship between provincial expenditure growth and various exogenous variables that these can be considered as sources of expenditure growth on infrastructure and transportation.

Key Words: infrastructure, transportation, urbanization, provincial expenditures

1. INTRODUCTON

Over the last decades in the South East Asia (SEA) countries, the countries have dramatically grown in economy sizes. Thailand is one country in this region, which emerges from the substantial growth in an economy size and obviously throughout the whole country. As the pattern of developing countries, migration from rural to urban sectors has been occurring over observations, country time. By the is experiencing concentration of the urban population, as the economy grows. Urban population is linked to the term of "urbanization", which, in this paper, is stood for the concentration of population in urban areas. By the United Nations (UN), Thailand in 2005 has approximately 20,820 thousand habitants or 32.5% of the entire country population. Compared to other neighbor countries, urban population in the SEA region is shown on figure 1.

An economy would be simply considered into rural and urban components. Urbanization is mainly caused by rural-urban migration on which migrants have moved from rural to urban sectors and their resettlement incentives are generally categorized into two dimensions: wages and basic infrastructure such as housing, education, facilities or roads. Also urbanization itself is one of the measurements that not only examines the impact on the economy, society and also characterizes environment, but the agglomeration of productions and consumptions, which generates the growth of investment on infrastructure and transportation sectors. Theoretically, agglomeration of productions and consumptions are the by-product of each other, SO called the urbanization effect of "agglomeration economies", which means that centralized labor forces in urban areas caused by rural-urban migration have an input of productions and industrial clusters leading to technological and educational productivities. Thus infrastructure and transportation sectors are

inevitably stimulated and needed by an enormous urban demand, and they also are shaped by a huge consumer market.



Source: Author, Data from World Urbanization Prospects: The 2003 Revision by the United Nations (UN)

Figure 1. Urban population in South East Asia by Countries

Furthermore, urbanization economies of scale, such as urban servicing diversifications, play a crucial role to form the growth of infrastructure, transportation and the size of urban areas. Simultaneously, an increase of agricultural goods can be anticipated by an entire economy both rural and urban areas. Yet rural areas are still supply sources of those necessary commodities for urban areas. Under circumstances, higher prices of agricultural goods and technological replacement such as cheaper mechanical equipments or transportation enhancement will pay off a compensation of labor migration. This mechanism would go back and forth until reaching an equilibrium point between rural and urban areas in terms of equal expected wages and the similar decent standard of living.

In Thailand, the trend of the rate of urbanization varies across 76 provincial jurisdictions, hereafter called "province", and there is an increase in urban population over time. Along with the growing of urbanization, an uneven urbanization distribution affects the provincial expenditures directly and indirectly. The public

infrastructure investment. especially transportation sectors, can be observed from everywhere. In addition, the development of urban areas will stimulate the transportation investment to serve sufficiently the concentration of economic activities as well as the spillover to rural areas. Moreover, the relationship between infrastructure and transportation provincial expenditures and urbanization can be seen by an increase of an amount of urban population. The development of urban systems should be taken the into account on concentration of transportation expenditures. In other words, the urbanization effect on the infrastructure and transportation provincial government expenditures should be balanced as a challenging task of governments.

This paper therefore focuses on the effect of urbanization on provincial government expenditures on infrastructure and transportation. Notwithstanding, infrastructure expenditures are able to categorize into human capital infrastructure and physical infrastructure. In this study, infrastructure just composes of the

accumulations of education, health, social work, electricity, gas, water supply, and construction whilst transportation attempts to just explicate on physical infrastructure the basis of for transportation, storage, and communication. The following questions are aimed to answer under its environments: How is the behavior between infrastructure and transportation provincial government expenditures and urbanization?. Are there any effects of these interactions?. How large are these effects?

In exploring the relationship, this paper provides the relative evidence from the cross sections of 76 provinces throughout Thailand by using the pooled data. The endogenous growth model including infrastructure analysis and transportation provincial expenditures as а dependent variable, and urbanization and several variables as independent variables are applied to attain the desired objectives of this empirical test based on pooled data above. This paper is organized in total five sections. Section 2 displays the related literature review including the theoretical and empirical parts. The econometric model including variables is carried out and demonstrated in Section 3. The empirical results of the model will be demonstrated in Section 4. The last section, Section 5, contains the conclusion and recommendations of the study. Appendices present the descriptive statistics and sources of data.

2. LITERATURE REVIEW

Several literatures available on the interaction effect are written and concentrated on the infrastructure expenditures and urban economic development. Urbanization is another contribution that can affect the accumulation of expenditures on infrastructure as one of exogenous variables in which transportation is lumped into. Some chronically related studies are conducted including empirical and theoretical articles to examine the effect of urbanization on infrastructure expenditures and urban growth. Linn (1982) states that the concerns with urbanization costs can be characterized into fiscal, financial, efficiency and equity concerns. The demand for public services and the investment decisions are to result commonly in higher average per capita service levels for most public services compared with smaller levels. Per capita public expenditures in urban areas tend to be higher than those in rural areas. Also they tend to be higher in large than those in small urban areas.

Dao (1995) analyzes the effect of urbanization on the model of per capita spending for government infrastructure across countries. The estimations are categorizes into 4 groups: all countries, top 30 democracies, less developing countries (LDCs) and sub-sample of small LDCs. The composition data of government services such as housing, defense, education, and social security and welfare are tested to find the relationship with urbanization and population density. The investigation shows that there is no statistically significant relationship between urbanization and public spending on defense. Also population density has a positive impact on per capita expenditures on housing, social security and welfare and education in developed economies. On the other hand, urbanization explains variations in per capita expenditures on social security and welfare among less democratic countries while both urbanization and population densities are relatively high in democratic countries.

Jones and O"Neil (1995) construct a theoretical model to examine the impact of migration of a number of urban and rural sectors involving with government spending policies. The activities of the government spending involve with provisions of urban infrastructure to manufacturers. Fiscal efficiency is considered to provide the public services for urban sectors. By the comparative static, the results show that the effect of changing the government investment on infrastructure is unambiguous for а number of urban employments.

Randolph et.al. (1996) examine the several factors that can influence on the public expenditures on infrastructure in terms of transportation and communication. The empirical framework utilizes the four-sector general equilibrium model and characterizes into 4 exogenous variable groups including characteristics of the economy, other variables reflecting the structure of the economy, the level and mix of external funding, and government objectives by using pooled data from 27 low income countries. Urbanization is considered as one variable of characteristics of the economy by using a number of population living in urban areas. The results show that the level of urbanization is a negative and significant determinant to per capita infrastructure spending both consolidated and central infrastructure expenditures. Moreover, the findings demonstrate that the urbanization elasticity is -1.1. They also find that higher population density is negative and significant to per capita infrastructure spending both consolidated and central infrastructure expenditures.

Jin and Zou (2002) empirically investigate the mechanism of fiscal decentralization on the aggregate government sizes, both national and sub national level in developed and developing countries. One of control variables that is used to determine a decentralized government size is a number of population living in urban areas, i.e. the expenditures of a government depends upon a change of urban population. The estimated coefficient of urban population is positive and significant on the government size. This means that the impact of an increase in urban population would raise expenditure spending to develop a sub-national jurisdiction. Furthermore, Bertinelli and Black (2004) examine the relationship between urbanization and growth. The dynamic model investigate the effect of inefficiency of the technological progress covering human capital infrastructure might reflect an uneven distribution of urban population. A size of city should be optimal to maintain the output and prevent the loss of externalities such as congestion. The findings show that a misused government policy would lead to a potentially slow rate of the aggregate level of growth whereas the economy is trapped in a development economic gap.

Issah et.al. (2005) extend the rural-urban migration "Harris-Tadaro" (H-T) model into the effect of urban infrastructure and amenity for urban immigrants. The comparative static is applied to find to the impact of exogenous variable at equilibrium. The theoretical results illustrate that an increase in urban infrastructure has a positive impact on the manufacturing employment sector of urban employment, but employment in the informal sector of urban employment has an ambiguous effect. The improvement of urban infrastructure and amenity would or would not attract an immigrant from rural sector. The implication implies that the infrastructure level and government expenditures infrastructure for gain benefits with unemployment, yet the urban population is questionable. The empirical results show that infrastructure provisions such as electricity promote the strong effect of rural-urban migration. There is a necessity for a government to distribute sufficient infrastructure in urban and rural areas to control the level of urbanization.

3. METHODOLOGY

3.1 Econometric Method

The analysis of the study will use the single regression model modified and based on Dao (1994)¹ The model will be based on panel data for provincial expenditures on infrastructure and transportation as dependent variable. Urbanization and other important variables are independent variables. The cross-sectional data from 76 provinces throughout Thailand and the time series from year 2000 to year 2002 are obtained from several royal Thai government

¹ See Dao, M. Q. (1994).

agencies as follows: the National Economic and Social Development Board (NESDB), the Revenue Department of Thailand (RDT), and the National Statistics Office (NSO).

The use of pooled data means that the error term in this model may not only represent the error variation across the observations (a crosssectional unit: α_i) that reflect an individual (provincial) specific effect, but also include the variation across the time and cross-sectional units (an unsystematic error: ϵ_{it}). The model will be regressed using the pooled ordinary least square (OLS), fixed effects (FE), and random effects (RE or Generalized Least Squares (GLS) approach)²

The main consideration in comparing between FE and RE is whether α_i and the independent variables are correlated³ FThe Hausman test is applied to test the null hypothesis that the coefficients estimated by RE are as consistent as the ones estimated by FE. If this holds, then RE estimators will be consistent, but more efficient than FE estimators. Note that endogeneity problems caused by a correlation between *it* ϵ and the independent variables would be led into the model and fixed by further econometric issues.⁴

3.2 Model Specification and Data

Adapting the per capita expenditures on government services model of Dao $(1994)^5$, the variables that are imposed in the model are the which parameters. influence kev on infrastructure expenditures. Thus per capita expenditures on government services (E/P) is a function of per capita incomes (Y^{pc}) , the price per unit of public goods (P^g), urbanization (U), population density (D), and the total population (P). The value of E is the costs of provincial government expenditures on infrastructure. Repeatedly, the accumulations of education, health, social work, electricity, gas, water supply, and construction are on infrastructure expenditures. The model of per capita expenditures can be expressed as follows:

² See Johnston, J. and DiNardo, J. (1997), Econometric Methods, pp.397-399.

³ See Wooldridge, J.M. (2002), Econometric Analysis of Cross Section and Panel Data, pp.289-291.

⁴ For a further study, econometric issues will consider correcting the violation of strict exogeneity through the utilization of instrumental variables (IV) procedures and the presence of heteroskedasticity through the generalized method of moments (GMM). This means that the standard IV coefficient estimators are consistent, yet the usual variance estimators yield standard errors that are invalid for statistical inference. The widely employed approach used to cope with both issues; endogeneity and heteroskedasticity of unknown form can be handled by GMM-IV.

⁵ See footnote¹

$$\log(E/P)_{il} = b_0 + b_1 \log Y_{il}^{pc} + (1+b_2) \log P_{il}^g + b_3 \log U_{il} + b_4 \log D_{il} + (1+b_2)(a+c-1)\beta_5 \log P_{il} + \alpha_i + \varepsilon_{il}$$
(1)

Where i (province) = 1, 2,..., 76 and t (year) = 1, 2, 3 (or year 2000, 2001, 2002) *a* is publicness coefficient ranging between 0 when the goods are pure public goods and 1 when the goods are private goods.

- *c* is a coefficient when the positive value represents diseconomies of scale while the negative value shows economies of scale in provisions of public goods.
- b_2 (in absolute value) is the price elasticity of the demand for public goods.

As mentioned earlier, this paper only emphasizes on physical infrastructure expenditures proxied by transportation sectors (T_g) including transportation, storage, and communication. The standard model of per capita expenditures is extended into the equation (2) as follows:

$$\log(T_g / P)_{it} = b_0' + b_1' \log Y_{it}^{pc} + (1 + b_2') \log P_{it}^g + b_3' \log U_{it} + b_4' \log D_{it} + (1 + b_2')(a + c - 1)\beta_5' \log P_{it} + \alpha_i + \varepsilon_{it}$$
(2)

Where i (province) = 1, 2, ..., 76 and t (year) = 1, 2, 3 (or year 2000, 2001, 2002)

The provincial government expenditures on infrastructure and transportation are measured by the provincial expenditures adjusted, and based on the calculations of consumer price index (CPI) base year 1988. Per capita incomes will utilize the data obtained from the Provincial Gross Products (GPP) and adjusted on the calculation consumer price index base year 1988. Due to unavailability of data, the price per unit of public goods will be proxied by the average share of the individual income tax (IIT), which is paid by an individual in a province in each particular year. Population density is proxied by the proportion of total provincial population to total provincial areas.

Urbanization is measured by the index proposed by Arriaga $(1970)^6$. The index is calculated by the percentage of the proportion population living in urban areas to the total population. Compared to the case of Thailand⁷, since a single

province composes of several districts and then each district will consider a municipal area as an urban area, the data from NSO are available in terms of total population who reside in the municipal areas in a province. Expect for the Bangkok province, the metropolitan administration system does not segregate the municipal areas, i.e. all of Bangkok areas will be accounted as one municipal area. Thus urbanization for Bangkok will be considered as the proportion equal to one hundred percent.

3.3 Hypothesis

The questions asked in this paper are to investigate whether the effect of urbanization behaves and how the effect of urbanization on infrastructure and transportation provincial expenditures is. To examine the effect of urbanization on these expenditures for the statistical test, for Model 1, this paper uses the hypothesis for the urbanization level on infrastructure provincial expenditures shown as follows; $H_0:b_3 = 0$ and $H_1: b_3 \neq 0$. For Model 2, it is also expected to have the effect on urbanization by considering an independent

⁶ see Arriaga, E. E. (1970).

⁷ Most provinces fall into a low-urbanization-level type (< 35%) leading that the dummy-variable regression on different levels of urbanization (high, medium and low) is not meant to perform.

variable as transportation provincial expenditures unproductive. Therefore, the hypotheses are H₀: $b'_{3}=0$, H₁: $b'_{3}\neq 0$.

The sign of an estimated coefficient can be translated into the synchronized direction, e.g. the positive sign of urbanization indicates that the higher 1% of the urbanization level, the infrastructure transportation higher or expenditures. In other words, a 1% change of the urbanization level would affect the infrastructure transportation provincial and expenditures equivalent to the value of percentage of an estimated coefficient. In case of a negative sign, it indicates that the urbanization level lower the infrastructure and transportation provincial expenditures. Adding to this explanation, the magnitudes of the coefficient also reflect to how large of effects to the level of urbanization on these provincial expenditures.

4. RESULTS

4.1 Infrastructure Provincial Expenditure Model

The regression estimations and the estimated coefficients of explanatory variables results based on Model 1 for infrastructure expenditures on provincial governments are presented in Table 1.

As mentioned in Section 3.3, the estimated coefficient in this paper will be shown in the elasticity value. In Model 1, the elasticity of the urbanization level in OLS is positive and statistically significant at the 5% level. The estimated coefficient is 0.1092. The Hausman

test shows that the random effects estimators are consistent and efficient under this condition where the p-value is not statistically significant at the 10% level. Thus the coefficient of urbanization is positive, with magnitudes of less than one. The estimated coefficient is 0.1345 and statistically significant at the 5% level, which means that any province, on the average, one percent increase in the urbanization level, i.e. a number of urban population will increase average per capita of total expenditures on government infrastructure by less than the amount of urbanization, which is about 0.1345 percent, holding other variables constant. The findings reveal that the urbanization level is an important determinant of variations in infrastructure provincial expenditures.

Regarding to Randolph et.al. (1996), they find elasticities that their of the estimated urbanization rate are -1.10 and -1.15 for the infrastructure central and consolidated expenditures, respectively. This means that higher urbanization is associated with lower per capita infrastructure provincial expenditures. In contrast to this paper, the results reveal that the higher urbanization level will reinforce higher infrastructure expenditures in a province. However, Dao (1994) also finds that the estimated coefficient is positive on the urbanization level and shows that the effect of higher urbanization will associate with higher per capita infrastructure expenditures in aggregated terms of social security and welfare that the elasticities are equal to 0.540 and 0.686 for the samples entire and all LDCs sample, respectively.

Dependent variables	s Per Capita Expenditures on Provincial Infrastruc			
Independent variables	OLS Fixed Effects (FE)		Random Effects (RE or GLS)	
Constant	0.6921*** (0.1904)	2.6382** (1.326)	0.6975* (0.2708)	
Per Capita Provincial Incomes (Ypc)	0.4221*** (0.0491)	0.4045*** (0.0950)	0.4288*** (0.0620)	
Price of Public Goods (Pg)	0.1546*** (0.0435)	0.0264 (0.0899)	0.1310** (0.0523)	
Urbanization (U)	0.1092** (0.0510)	0.1034 (0.0819)	0.1345** (0.0574)	
Population Density (D)	-0.0426** (0.0205)	(dropped)	-0.0379 (0.0340)	
Population (P)	-0.0171 (0.0219)	-0.3418 (0.2182)	-0.0259 (0.0369)	
$\frac{R^2}{R^2}$	0.8742	0.6653	0.8739	
Adjusted R ² Hausman Test (p-value)		-	- 0.3254	
. *** Significant at 1%	** Sig	nificant at 5%	* Significant at 10%	

Table 1. Estimation results

Numbers in parenthesis are standard errors

In addition, per capita provincial incomes and price of public goods are positive and significant both OLS and RE. In OLS, the elasticity of per capita provincial incomes is 0.4221 and significant at the 1% level while its RE estimator is 0.4288 at the same significance. Considering the price of public goods, its elasticity is 0.1546 and 0.1310 for OLS and RE at the 1% level of significance, respectively. In case of RE, the coefficient of the price of public goods indicates that the price elasticity of the demand for public goods (b_2) is -0.8690 (or 0.1310 - 1.000). Then the value of b_2 is congruent with the nature of provisions of public goods that is negative and has a low price elasticity of demand for public goods indicating that infrastructure goods are necessary for habitants. And the population density coefficients are negative for both OLS and RE, but significant at the 5% level only in OLS. Higher population density is negatively associated with higher provincial expenditures on infrastructure, but the theoretical view for its inclusion is weak.

4.2 Transportation Provincial Expenditure Model

The estimations based on Model 2 (transportation provincial expenditures) are shown on table 2.

Dependent variables	es Per Capita Expenditures on Provincial Infras				
Independent variables	OLS	Fixed Effects (FE)	Random Effects (RE or GLS)		
Constant	-1.5684*** (0.3143)	-4.2741** (2.0159)	-2.0155*** (0.4464)		
Per Capita Provincial Incomes	0.1579*	0.5930***	0.3172***		
(Ypc)	(0.0810)	(0.1444)	(0.1002)		
Price of Public Goods	0.3703*** 0.3585***		0.3432***		
(Pg)	(0.0717) (0.1366)		(0.0843)		
Urbanization	0.3761***	-0.0003	0.1505*		
(U)	(0.0841)	(0.1246)	(0.0918)		
Population Density	-0.0158	(drawn a d)	0.0038		
(D)	(0.1904)	(dropped)	(0.0570)		
Population	0.0711*	0.4009	0.1141*		
(P)	(0.0362)	(0.3317)	(0.0620)		
R^2	0.8114	0.7543	0.8001		
Adjusted R ²	0.8071	-	-		
Hausman Test (p-value)	-	0	.0150		

 Table 2. Estimation results

*** Significant at 1% ** Significant at 5% Numbers in parenthesis are standard errors * Significant at 10%

In OLS, the urbanization level shows the elasticity value is positive and significant at the 1% level. The estimated coefficient is 0.3761. Although the p-value is not statistically significant at the 1% level, the Hausman test displays that the random effects estimators are consistent and efficient under this condition. The estimated coefficient of the urbanization level is positive and statistically significant at 10% level with a magnitude of 0.1515. This indicates that one percent increase of the urbanization level will raise per capita transportation expenditures in a province by amount of 0.1515 percent, holding other variables constant. As one expected, a total number of population in urban areas will affect on provincial expenditures on transportation infrastructure such as roads or logistics.

The estimated coefficient of per capita provincial incomes is positive and statistically significant for both OLS and RE at the 10% level with a magnitude of 0.1579 and 0.3172, respectively. All coefficients of price of public goods are

positive and statistically significant at the 1% level. From the RE estimation, the price elasticity of demand for public goods is 0.3432 -1.000 = -0.6568. The price elasticity of demand for public goods is less than 1 in absolute value, i.e. the public goods can be considered as "necessities". None of the population density statistically coefficients is significant. Meanwhile, the effect of population on RE is positively associated with per capita expenditures on provincial transportation at 0.1411 at the 10% level. Higher population would require more for transportation provisions.

For implications, the province of Phitsanulok is used for a representative because it is employed as a pilot province for the Thailand 2010 population and housing census according to its variety of population structures, its province size (medium) and its urbanization level (at 19.58% whereas national average regarded as a lowurbanization-level country at 23.59% during 2000-2002). Besides, standard transportation model studies are conducted in Phitsanulok.

With this study data, Phitsanulok, s urbanization growth in 2001 is approximately 2.5% with growth of per capita expenditures on provincial transportation about 7%. In 2002, its urbanization growth is just 0.8%; however, growth of per capita transportation provincial expenditures reflects the minus sign at a magnitude of 0.4%. A single reason to work on this urbanization effect is that a government is likely to consider spending on transportation investments for a province with continuously high growth of urban population, e.g. the basis of 5-year growth rate. Another obvious example of high transportation investments always reflects in high urbanization provinces, e.g. Bangkok and vicinity. Note that the effect of the urbanization level for Bangkok is still needed to further explore in a different aspect for the terminology "urban primacy" (a country"s city whose urban population is extremely high concentration).

5. CONCLUSION

From previous research, the urbanization level might have both positive and negative directions to infrastructure expenditures meaning that the urbanization level would generate increase the government investment on infrastructure, while a certain amount of urban population would induce impact the negative on infrastructure expenditures. This paper examines the effect of urbanization on expenditures for infrastructure and transportation in the provincial level throughout Thailand. The following results are concluded as below:

The level of urbanization plays a crucial role in the provincial government spending on infrastructure and transportation. The anticipated effect is positive, which means that a higher number of urban population would lead a provincial government involving investing more in constructions on basic infrastructure and transportation such as basic utilities or highways. The elasticity of the urbanization level is positive and statistically significant around 0.1345 for infrastructure provincial expenditures and 0.1505 for transportation provincial expenditures. Thus its value reflects a degree of urbanization should be taken into account on the balanced size of infrastructure and transportation expenditures for either a centralized or decentralized policy planner.

Since the interaction between rural and urban areas is an indispensable link, this implication will stimulate government expenditures via infrastructure and transportation. For example, roads are very necessary to be sufficiently provided and efficiently served along with urbanization growth. To be precise, urban areas where servicing and manufacturing sectors are localized render a company or an industry to absorb excessive rural labor and drive essential economic sectors such as financial services or non-agricultural manufacturers. Government expenditures are able to focus and deliver quality improvement toward better transporting cost reduction, especially in urban areas. Accordance with transportation concerns, the investment to improve on either road conditions or network always spills over and goes hand-in-hand from urban to rural areas, where most agricultural goods are produced, transferred, and served for growth of urban population. Although population density do not display the significant sign in models on which it responds with the urbanization level, a possible explanation is the fact that several provinces have large agglomerations of people in one city whereas they still have huge unused and vacant lands so easy that it drives their population density low.

One might expect along with the theoretical frameworks that the urbanization level should have a strongly positive impact on either infrastructure or transportation provincial expenditures. What this paper has learnt from findings that the responsibility of urbanization is associated with positive and statistic significance on the effect on infrastructure and transportation provincial expenditures. Moreover, this paper finds that the price elasticity of demand for public goods is low and has a negative value, which supports the general characteristics of public goods as necessities. Per capita provincial incomes and the price of public goods display a significant impact on infrastructure and transportation spending of provincial governments.

Several recommendations of this paper should be addressed for future work as follows:

- A larger size of pooled data can enhance the study results on the impact on

infrastructure and transportation provincial expenditures.

- The classification of expenditure categories may lead to mixed results and differ from the theoretical point of view.
- A more structural, advanced model, such as the quadratic form of urbanization or decentralization, may be incorporated into a model specification.
- Econometric issues may be concerned and constructed to examine in more details.

REFERENCES

a) Books and Books chapters

Johnston, J. and DiNardo, J. (1997) Econometric Methods, 4th edition, McGraw Hill.

Wooldridge, J.M. (2001) Econometric Analysis of Cross Section and Panel Data, 1st edition, The MIT Press.

b) Journal papers

Arriaga, E. E. (1970) A New Approach to the Measurements of Urbanization, Economic Development and Cultural Change, Vol. 18, No. 2, 206-218.

Bertinelli, L. and Black, D. (2004) Urbanization and Growth, **Journal of Urban Economics**, Vol. 56, No. 1, 80-96.

Dao, M. Q. (1994) Determinants of the Size of Government, Journal for Studies in Economics and Econometrics, Vol. 18, No. 2, 1-14.

Dao, M. Q. (1995) Determinants of Government Expenditures: New Evidence from Disaggregative Data, **Oxford Bulletin of Economics and Statistics, Vol. 57, No. 1,** 67-76.

Issah, I., Khan T. Y and Sasaki, K. (2005) How Do Migrants React to Infrastructure Difference between Urban and Rural Areas?: Development and Application of an Extended Harris-Todaro Model, **Review of Urban and Regional Development Studies, Vol. 17, No. 1,** 68-88.

Jin, J. and Zou, H. (2002) How does fiscal decentralization affect aggregate, national, and subnational government size? Journal of Urban Economics, Vol. 52, No. 2, 270-293.

Jones, D. W. and O"Neil, R. V. (1995) Development Policies, Urban Unemployment and Deforestation: The Role of Infrastructure and Tax Policy in a Two-Sector Model, Journal of Regional Science, Vol. 35, No. 1, 135-153.

Linn, J. F. (1982) The Costs of Urbanization in Developing Countries Economic Development and Culture Change, Vol. 30, No. 3, 625-648.

c) Other documents

Econometric Software (2006) STATA. StataCorp, Texas.

Randolph, S., Bogetic, Z. and Hefley, D. (1996) Determinants of Public Expenditure on Infrastructure: Transportation and Communication, **Policy Research Working Paper 1661, October, World Bank**.

APPENDIX

Table 1: Descriptive StatisticsPer Capita Expenditures on Provincial Infrastructure

 $\log(E/P)_{ii} = b_{0} + b_{1} \log Y_{ii}^{pc} + (1 + b_{2}) \log P_{ii}^{g} + b_{3} \log U_{ii} + b_{4} \log D_{ii} + (1 + b_{2})(a + c - 1)\beta_{5} \log P_{ii} + \alpha_{i} + \varepsilon_{ii}$

Summary (log form):

Variable	Obs	Mean	Std. Dev.	Min	Max
id	228			1	76
year	228			2000	2002
Infrastructure Exp.	228	1.961502	.2307347	1.556018	2.797293
Per capita Incomes	228	2.856563	0.3303881	2.323558	3.89137
Price of Public Goods	228	0.7041005	0.453436	0.0186828	2.153424
Urbanization	228	1.321389	.2005125	.8023759	2
Pop. Density	228	2.11042	.3634288	1.233297	3.624579
Population	228	5.8135	.2809864	5.220108	6.819149

Table 2: Descriptive StatisticsPer Capita Expenditures on Provincial Transportation

$$\log(T_g / P)_{tt} = b_0' + b_1' \log Y_{tt}^{pc} + (1 + b_2') \log P_{tt}^g + b_3' \log U_{tt} + b_4' \log D_{tt} + (1 + b_2')(a + c - 1)\beta_5' \log P_{tt} + \alpha_i + \varepsilon_{it}$$

Summary (log form):

Variable	Obs	Mean	Std. Dev.	Min	Max
id	228			1	76
year	228			2000	2002
Transportation Exp.	228	.0024583	.3110783	4468526	1.206949
Per capita Incomes	228	2.856563	0.3303881	2.323558	3.89137
Price of Public Goods	228	0.7041005	0.453436	0.0186828	2.153424
Urbanization	228	1.321389	.2005125	.8023759	2

Summary (log form):

Variable	Obs	Mean	Std. Dev.	Min	Max
Pop. Density	228	2.11042	.3634288	1.233297	3.624579
Population	228	5.8135	.2809864	5.220108	6.819149

Where i (province) = 1, 2, ..., 76 and t (year) = 1, 2, 3 (or year 2000, 2001, 2002)

a is publicness coefficient ranging between 0 when the goods are pure public goods and 1 when the goods are private goods.

c is a coefficient when the positive value represents diseconomies of scale while the negative value shows economies of scale in provisions of public goods.

 b_2 (in absolute value) is the price elasticity of the demand for public goods.

Variable	Variable Description	Data Source
Dependent Variable		
Per Capita Infrastructure Provincial Expenditures	The accumulations of education, health, social work, electricity, gas, water supply, and construction divided by mid- year population.	National HEconomic and Social Development Board (NESDB) - Gross Provincial Product 2003 Edition including expenditure and population (Accessed in October 2009)
Per Capita Transportation Provincial Expenditures	The basis of physical infrastructure for transportation, storage, and communication divided by mid-year population.	National HEconomic and Social Development Board (NESDB) - Gross Provincial Product 2003 Edition including expenditure and population (Accessed in October 2009)
Independent Variabl	le	
Per Capita Provincial Incomes	Gross Provincial Product (GPP) divided by mid-year population. Data are in constant 1988 Prices in U.S. dollars.	National HEconomic and Social Development Board (NESDB) - Gross Provincial Product 2003 Edition including expenditure and population (Accessed in October 2009)
Price of Public Goods	The price per unit of public goods is proxied by the average share of the individual income tax (IIT), which is paid by an individual in a province in each particular year.	Revenue Department of Thailand (RDT) and National Economic and Social Development Board(NESDB) - Gross Provincial Product 2003 Edition including population (Accessed in October 2009)

Table 3: Variable Description

-					
Variable	Variable Description	Data Source			
Independent V	Variable				
Urbanization	A province rated on a scale of 0 to 1. This index means that urban population as a percentage of total population is the proportion of a province"s total national population that resides in urban areas (Municipalities).	National Statistics Office (NSO) and National Economic and Social Development Board (NESDB) - Gross Provincial Product 2003 Edition including population (Accessed in October 2009)			
Variable	Variable Description	Data Source			
Population Density	The calculations of population divided by the areas of each province.	National Statistics Office (NSO) and National Economic and Social Development Board(NESDB) - Gross Provincial Product 2003 Edition including population (Accessed in October 2009)			
Independent Variable					
Population	The amount of mid-year population for each province.	National Statistics Office (NSO) (Accessed in October 2009)			

Table 3: Variable Description (Cont.)

MALAYSIAN VALUE OF STATISTICAL LIFE FOR FATAL INJURY IN ROAD ACCIDENT: A CONJOINT ANALYSIS APPROACH

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Abstract: Road accident is currently one of the major causes of death in Malaysia. The effort to ensure better road safety requires large allocation of resources which further signifies the importance of economic valuation in every possible area inflicted by road accident. This task is achievable by associating cost to the potential consequence of fatal risk due to road accident using the willingness to pay approach. Several earlier studies in Malaysia have been conducted using Lost Output, Human Capital and Contingent Valuation Method (CV). This report described and analyzed our latest nationwide valuation study using Conjoint Analysis (CA) undertaken in 2008. In comparing between both Stated Preference approaches our findings suggest minimal difference in the final estimation of the Value of Statistical Life (VOSL). The VOSL estimates for fatal injury in CV study range from RM 1.2 million to RM 1.4 million whilst CA gives a range of RM 1.15 million to RM 1.45 million.

Key Words: Value of Statistical Life, Fatal Injury Costing, Willingness to Pay, Conjoint Analysis, Stated Preference

1. INTRODUCTON

The problem caused by road traffic accidents had been continuously voiced out by global community since decades ago. The death tolls figuring up to annually 1.2 million due to road accidents from around the world (WHO, 2004) proved the scale of the problem and hence called upon immediate attention and action for solutions. Apart from death, the rest of 20 to 50 million people were left with injuries and inabilities as the result of road accident every year. At current rate, the escalation of fatalities and injuries will expectedly raise road accident as the world's major disease at 9th place up to 3rd place in the year 2020 (Murray and Lopez 1996).

Road accident has been reportedly claiming more lives and victims in developing region such as in Asian countries. A study in 2005 by ADB ASEAN found that approximately 75 000 people were killed as 4.7 million victims were left with injuries due to road accident. In 5 years ahead, it was projected that another 385 000 live lost and 24 million injured people will suffer from the accident. Weighing this to the population of about 580 million people in ASEAN countries, the victims of road accident in the region are enormously in large proportion. On the other hand, WHO (2004) reports that almost 60% of accidents occurring worldwide fatal are contributed from Asian countries even though the region accumulates only 16% of all vehicles in the world. In addition, while developed nations are enjoying 10% reduction in their accident death toll, Asian region is suffering from 40% increase in fatal accidents from 1987 to 1995 alone.

1.1 The Cost of Road Accidents

Understanding the statistics of fatalities. casualties and damaged vehicles alone is definitely insufficient to portray the real long term consequences of road accidents including trauma, pain, grief and sufferings of the injured, families and love ones of those killed or injured. At household level, death or serious injury impact of income earner is almost instantly felt as the result of the job losses, cost of medical property damage. treatment and The incapacitated victims will definitely need extra help and care from other people to sustain their remaining life. Consequently, others too would be unintentionally dragged into the dilemma that cause continuous and long may term consequence of losing productive hours, income and deficiency to manpower and labor sources.

The recognition of different areas inflicted by the problem has signified another important measure of road accident impact at individual, society and national level. Socioeconomic impact of road accident had long been considered by developed countries in their effort to formulate better road safety. European countries like United Kingdom, Australia, and Sweden has been continuously revising and updating their cost valuation of road accident death and injuries. Two main benefits from costing road accidents have been noted, firstly, the total annual accident cost at national level can justify the government in providing appropriate resource allocation to road safety sectors. Secondly, it acts as a tool in the process of economic appraisal and cost benefit analysis with regards to road safety funding and investment. (Transport Road Laboratory, 2005 and Global Road Safety Partnership, 2005),

Appropriate funding and investment are required to initiate any action plans and intervention programs. As road safety is part of the road transport allocation for Malaysia's development, the competition to acquire financing and resources allocation is inevitable. Hence, justifying the losses and the possible future savings from road accident reductions could be the proper mechanism to weight the worthiness of granting road safety funds and investments.

In Malaysia, there have been several studies that attempt to estimates the cost of road accidents. The first known valuation exercise using a simplified loss of output costing was undertaken by ESCAP in 1983. Later in 1994, Maradiah made a second attempt using the human capital approach that combine loss of output cost, medical treatment cost, vehicle repair cost, administrative cost. insurance and It is note that Maradiah interesting to had incorporated a certain percentage to reflect the value of pain, grief and suffering. Ex-ante costing using the willingness to pay method was pioneered by Norghani and Mohd Faudzi (2003) in Malaysia. Initially, the first VOSL study using contingent valuation method was restricted to

only young motorcyclists. A subsequent study to estimates the VOSL of motorcyclist fatal and non-fatal injuries was conducted in Seremban municipality (Mohd Faudzi 2004). The breakthrough on VOSL was made in 2006 when a nationwide valuation exercise was conducted on all road users. Table 1 shows the series of valuation studies and their estimated values

conducted in Malaysia. However, it is important to note that all these stated preference studies were limited only to the contingent valuation approach. To ascertain the robustness of the estimates, it is pertinent that the use of other valuation approaches must contribute as referent value to the future cost- benefit analysis (CBA) projects.

Studies	Methods	Year	Area	Fatal	Serious	Minor
		Reported/ Published	Coverage	Accident (RM)	Injury (RM)	Injury (RM)
ESCAP (Klockner)	Lost Output	1985	No Information	145,000	14,500	1,450
Maradiah	Human Capital	1994	No Information	193,095	14,292	1,087
Norphani et.al.	WTP (CV) on Young Motorcyclists	2001	West Malaysia	1.2 million	-	-
Mohd Faudzi et.al.	WTP (CV) on Motorcyclists	2004	Seremban Municipality	1.1 million	-	-
Norghani and Mohd Faudzi	WTP (CV) on Road Users	2003	West Malaysia	1.2 million	-	-
Abu Sufian	Stated Preference (CA) and Revealed Preference	2006	State of Kedah	920,555 1.26 million	-	-
Mohd Faudzi and Norghani	WTP(SG)	2003	Seremban Municipality	-	84,000	-

Table 1. Available studies	on valuation of road	accident related co	st in Malaysia
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Although the nationwide study embraces both fatal and non-fatal injuries due to road accidents, this paper focused only on the fatality component. This paper is organized as follows. Section 2 will explain about the methodological part of the study with the detail on the design of questionnaire and execution of the survey. The result and analysis will be presented in section 3 followed by discussion and conclusion in section 4. Pilot study using CV method will only be discussed as result and comparison in section 4.

2. METHODOLOGY

This paper reviews the result of VOSL on road accident injury using Conjoint Analysis Approach. The next part of this section will briefly discuss about the concepts and approaches utilized in the study followed by the sampling and questionnaire design for CA study.

2.1 Value of Statistical Life

This approach focuses on risk-money tradeoffs for very small change in risks of death, injuries and other mishaps (Viscusi, 2005). As Persson et al (2001) stated in his report, theVOSL in road safety context is estimated by examining the relationship between an individual's WTP for a marginal reduction of the risk of being killed in a road traffic accident and that risk reduction.

The main argument that puts VOSL in favor as opposed to other available methods is its ability to value any non market goods including safety and health Tervonen (1999). The VOSL in a road traffic context is estimated by examining the relationship between an individual's WTP for a marginal reduction of the risk of being killed in a road traffic accident and reduction or the change of that fatality risk. Empirically, the formula for calculating VOSL can be described as below:

$$VOSL = \frac{WTP}{\Delta p}$$
(1)

WTP : willingness to pay (RM) Δp : risk change

2.2 Conjoint Analysis Approach

Conjoint analysis (CA) was originally developed for market research to observe how people select on certain brand or product. Compared to CV, it simplifies the valuation of price and good i.e. risk (Telser & Zweifel, 2000). The selections are presented with relevant attributes of the goods and follows closely to real life situation. The selection exercise also allows for explicit tradeoffs between the different level of attribute. Another bonus feature from CA is that the nature of CA design caters for situations with well defined constant and variables (Rizzi & Orthuzar, 2001).

2.3 Samples

This study used post-stratification sampling technique where the distributions of sample were stratified according to types of vehicles and demographic profiles. The Malaysian Road Transport Department database of registered vehicles in Malaysia was used to determine the population framework. The study was considered a comprehensive and detail project with more than 4000 respondents covering all the 13 states of Malaysia including Federal Territory Kuala Lumpur. Face to face interview was conducted to ensure respondents were able to understand and choose their WTP appropriately.

It should be useful to also note that at the time the study was conducted, Malaysia was experiencing the hike up in its fuel price as well as downturn in her economic development. The occurrence may in some ways affect the study but its implication has yet to be investigated.

2.4 Questionnaire

The questionnaire used in this study acts as a medium to elicit out people's WTP. The questions prompting on WTP is designed and formatted in such a way that the result can be analyzed and interpreted using CA method. Choice experiment technique is employed in the study. Thus, all the attributes are arranged to orthogonal combination achieve between attributes and level of attributes. For every injury category there are two attributes with three levels each. The two attributes are the cost to install for a safety device to the vehicle and the risk reduction after installing the device. Fullfactorial design gives 9 profiles selections which are broken down to 3 profiles per questionnaire for each injury category. These produce 3 different sets of questionnaire with 3 profiles in each.

The presentation of the choices of selection make used of Stated Preference (SP) approach by asking people to imagine a hypothetical safety device with certain features that may help reduce their accident risk or injury risk. Other than the cost and risk, other variables are assumed constant. Following the CA design and SP choices, the design therefore separates the questions into four sections as follows:

SECTION A: Introduction

This section explains the aim of this study to respondent and introduces the concept of risk regarding road safety. The questions aim to acknowledge respondent and their family experiences relating to road accident and to assess individual perceptional risk of their own safety regardless of their kin risk.

SECTION B: Selection of safety devices and travel scenarios

The primary cause of conducting this study relies on respondent selection of cost trade off in conjunction to their risk reduction. The first part of this section is designed to simulate such user behavior by optioning series of cost and risk reduction alternatives to respondents. To familiarize respondents with the available alternatives, an imaginary situation is presented whereby respondents are offered to install a speed controlling device to their vehicles. The characteristics of the device are assumed equal with exception for the monthly installation cost and the efficiency of the device to reduce the base risks. The random pairings of cost and risk reduction are treated as the selection of attribute and alternatives. Three sets of profiles are hence presented in each set of questionnaires.

SECTION C & D: Personal details, Transport ownership and usage information

Demographical background of respondent is monitored through section C. This comprises of age, gender, race, religion, marital status, income and other relevant factors that may influence or describe respondent preference in valuing their life. Section D brings about a quick glance of respondent details to licenses, vehicle usage, driving experiences, accident and injury involvements and purpose of using and owning transport.

Currently the base values to estimate accident losses are based on the findings of previous researches (Mani et el 2005). Table 2 below shows the breakdown of the values according to injury casualties.

Injury Casualties	Base value for Losses
Death	RM 1.2 Million
Severe Injury	RM 120 000
Slight Injury	RM12 000

Table 2. The base value to estimates the accident loss

Source: Road Safety Department (http://www.jkjr.gov.my/statistik.html)

It is important to note that the estimation for severe and slight injury losses were based on ESCAP initial recommendation i.e. all severe injuries are estimated to be 10% of fatalities and 10% of serious injuries determine the losses for slight injuries. Figure 1 below indicates the estimated the annual monetary loss from death and injury due to road accident in Malaysia. Presently, only the VOSL estimations were vigorously studied, it is assumed that the excepted base value has yet to consider the other components of the comprehensive accident costs namely the lost output, medical costs, damage costs and the administrative costs of police and insurance.



Figure 1. Losses from accident according to injuries from year 2001 to 2007 (RM)

3. RESULT

A total of 3285 respondents were involved in the CA study amounting to 9855 (3285 x 3) samples. This is the result of treating each profile for every injury as individual samples. Since there are 3 choice profiles for each injury category, thus three samples are administered from a respondent. Out of 9855 samples, 855 samples are excluded inclusive of 717 samples (239 respondents) which failed to properly value their own fatal risk. The rest 138 samples are among 46 respondents who illogically stated their monthly expenses exceeding their monthly incomes. After the cleaning process, a total of exactly 9000 samples were examined in this survey. There were 4578 samples for cars and the remaining 4422 samples for motorcycle.

Brief examination on selected demographical profile of the samples gives the insight of the age, race, gender and income distribution. For car, most of the respondent aged between 30 to 40 years with 44% while 49% of the same age group goes for motorcycle. Male respondent dominates gender distribution with 55% for car and 69% for motorcyclist. Distribution of race follow the stratified sampling design with 52% and 73% of the respondent for car and motorcycle respectively are from Malay ethnic. Interestingly, Chinese occupy 38% among car sample but only 16% for motorcycle. Income level for most respondents accumulates around RM 1000 to RM 1500 per month.

Inspection on accident history reveals that on average 90% of the respondent have seen accident and more than half of them were involved in road accident. Assessment on family shows that half of the respondents have at least one of their family members injured in road accident. There are only 8% to 11% of them whom their family member become the victim/s in fatal accident. Most respondent for car considers their fatal risk as 1 to 5 per 100000 populations while for motorcyclist, they perceive their risk as 1 to 10 deaths per 100000 populations.

3.1 Conjoint Analysis

Since the choices of WTP are in discrete choice presentation, logistic regression analysis was used to run for the VOSL estimate. Logistic regression is more favorable in this study since it includes the interactions in the possibility of respondents selecting and not selecting either alternative. Moreover the binary nature of the choice selection exercise does not allow for the assumption of linear interaction between WTP and risk in regression analysis. Linear regression analysis was utilized to determine the variables influencing the value of VOSL estimates. All the analysis exercises are accomplished using Social Package for Statistical Science (SPSS) software package. Data are separated into car and motorcycle categories. Thus, there are 2 different models constructed which are car fatal injury -CFI and motorcycle fatal injury - MFI.

Table 3 below shows the VOSL for fatal injuries according to all states in Malaysia. As seen from the table the values for CFI ranges from 1.3 million to 1.71 million with the highest estimated in Selangor state and Federal Territory Kuala Lumpur. Evidently a lower VOSL is recorded for MFI where the range is between 1 to 1.3 million.

The highest estimate is also in Selangor state followed by Pahang state. For both CFI and MFI models, having the highest estimate in Selangor are in accordance to the fact that the state is the most developed, densely populated and urbanized area compared to other states.

CFI – Cat Fatal Injury	
STATE	FATAL INJURY
JOHOR	1.46
MELAKA	1,43
NEGERI9	1.42
SELANGOR	1.70
W.P K L	1.71
PERAK	1.42
KEDAH	1.41
PULAU PINANG	1.40
PERLIS	1.30
KELANTAN	1.40
TERENGGANU	1.43
PAHANG	1.42
SARAWAK	1.39
SABAH	1.43

Table 3. The value of statistical life for fatal injury

MIF – Motorcycle Fatal In	jury
STATE	FATAL INJURY
JOHOR	1.03
MELAKA	1.15
NEGERI9	1.11
SELANGOR	1.32
W.P K L	1.20
PERAK	1.11
KEDAH	1.12
PULAU PINANG	1.20
PERLIS	1.10
KELANTAN	1.10
TERENGGANU	1.04
PAHANG	1.30
SARAWAK	1.22
SABAH	1.13

4.2 Factors influencing the selection of WTP

Close inspection on the variables influencing the value of VOSL for both car and motorcycle reveals some familiar trend with previous studies on VOSL. This is shown in Appendix A Table 5. These variables are first tested by means of linear regression analysis for the possibility of multicollinearity. Further analysis suggests that variables passing the multicollinearity test and significantly correlate with the value are income, race, gender, family accident history, vehicle ownership and employer for CFI model while factors contributing to MFI model estimate are income, family history of death and injury in accident, witness accident, employer and vehicle ownership.

Income is the contributing factor for both estimation of car and motorcycle. In both cases,

respondents with higher income are more prone to choose higher WTP and thus have higher VOSL compared to other lower income class. Another variable that were found to be significantly outstanding is vehicle ownership. For both models, respondents with vehicles in possession have higher VOSL as opposed to respondents not owning any vehicle.

Respondents who own and drive cars and have experience casualties among family member due to road accident are less willing to pay to reduce their fatal risk while respondents with no accident death among family member quote higher VOSL. Motorcyclists with family being injured too have lower WTP compared to the other with no family injuries. The reason behind this occurrence could be psychological and thus needs further investigation to be verified. External factor could be the reason behind this occurrence since during the time the survey was conducted, Malaysia is experiencing the hike up in the fuel price as well as the economic downturn.

Respondents who had witnessed accident event also allocated more WTP compared to their opposite. This could be due to their sense of awareness on safety on the road after the glance at the accident scene. Variable on respondent involvement in accident however is not found to be significant influence in the study. On the other hand, differences in employment sector affect the VOSL in different ways. In CFI model, respondents working in government sectors values their lives higher compared to worker in private sectors. This occurrence is possibly contributed by the more stable state of income earning among government servant compared to private sector. However, the reverse pattern was observed in MFI with higher VOSL among private company workers seconded by selfemployed respondent while government servants provided the lowest value.

Other variables are exclusive to either CFI or MFI group of respondent. For CFI, male respondents are quoted at higher VOSL than female while Chinese ethnic are at the top of the ranking with VOSL at RM 1,916,712. This is followed consequently by Malay, Bumiputera and Indian ethnic. A closer look at the VOSL according to each influencing factors discussed above can be referred in Appendix A. Analysis of linear regression to get the influence factors gives the significant values for each factors as in table 4 below:

VADIADI E COFFEICIENT	CFI	MFI
VARIABLE COEFFICIENT	B(Sig.)	B(Sig.)
Income	0.074(0.000)	0.060(0.000)
Vehicle Ownership	-0.130(0.000)	-0.091(0.018)
Employer	0.033(0.004)	-0.034(0.005)
Race	0.028(0.004)	-
Perception Risk	-0.005(0.006)	-
Gender	-0.041(0.009)	-
Family-Died	-0.058(0.047)	0.056(0.039)
Seen Accident	-	-0.117(0.000)
Family-Injured	-	-0.055(0.001)

Table 4	The	coefficient	and sid	mificant	voluo	for	factor	variables	in each	model
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4.3 Comparison of Results between CV and CA

The comparison of the estimate of VOSL from this study with the result of pilot study shows that the values are in acceptable range to each other. Pilot study adopting the contingent valuation method gives the estimates of RM 1,392,555 for car and RM 1,259,616 for motorcycle fatal injury. The limitation from pilot study is that the area covered for the survey are only in Klang Valley with about 300 respondents and therefore is not sufficient to represent the whole Malaysian population. The estimated values are also comparable to previous study on motorcycle fatal injury by Faudzi (2003) which proposed the VOSL of RM 1.2 million. This study had also adopted the method of CV in the survey and analysis.

4. CONCLUSION

The effort to battle the increasing event of traffic accident, death and injuries calls for immediate remedies to tackle the problem. In conjunction to this, the government needs to account for proper funding and investment to road safety sector. Foreign studies such as UK, Australia and Sweden have long recognized the important of such practice. Thus, the valuation of accident related cost is more than useful to serve as a tool in decision making and policy implementation to road safety. The method of Value of Statistical Life used in this study has succeeded the aim to conduct the road accident related valuation from human perspective by utilizing the WTP approach. After comparing to the estimated values with former valuation, it is noticeable that the people are more willing to put higher value with regards to their safety on the road. It is therefore suggested that the value of statistical life for each fatal injury involving car and motorcycle road accident in Malaysia are RM 1,450,000 and RM 1,150,000 respectively.

REFERENCES

Economic Evaluation Notes: Valuation of Accident Reduction (2005). **Transport Economics, Policy and Poverty Thematic Group**, The World Bank: Transport Notes No. TRN-16

Mani, K.K.C., Yusoff, M.F.M., Umar, R., Melhuish, C., Ross, A. and Goodge, M. (2005) The Cost of Road Accident In Malaysia. Accident Costing Report AC 5: Malaysia, Asian Development Bank-Association of Southeast Asian Nations

Melhuish, C. M. (2005). **Technical Assistance for Socioeconomic Impact of Road Crashes** (Financed by the Poverty Reduction Cooperation Fund). Energy, Transport, and Water Division, Regional and Sustainable Development Department, Asian Development Bank

Melhuish, C., Ross, A., Goodge, M. and Sigua, R. (2003). Accident Costing Report: The Cost of Road Traffic Accident in the Philippines. ADB-ASEAN Regional Road Safety Program

Mustafa, M. N. (2005). Overview of Current Road Safety Situation in Malaysia. Highway Planning Unit, Road Safety Section, Ministry of Work Malaysia

Nor, N.G.M., Yusoff, M.F.M., Bakar, A.S.A., Jalil, A.Z.A., Zainol, A., Ali, J. and Sahlan, R. (2001). Placing Dollar Value (On Life) for a Better Quality of Life: A Contingent Valuation Study of Malaysian Motorists.

Peden, M., Scurfield, R., Sleet, D., Mohan, D., Hyder, A., Jarawan, E. and Mathers, C., (2004). **The World Report on Road Traffic Injury Prevention. World Health Organization**: http://www.who.int/world-health-day/2004/infomaterials/world_report/en/ Rizzi, L.I., Ortuzar, J de Dios., (2001) Stated Preference in The Valuation of Interurban Road Safety, Department of Transport Engineering, Pontificia Universidad Catolica de Chile, Chile.

Road Safety in Asia Pacific (2006). United Nations Economics and Social Council Statistical Report of Road Accident, **Road Traffic Branch, Royal Malaysia Police Bukit Aman (2008)**. Website of Royal Malaysia Police Bukit at http://www.rmp.gov.my/

Telser, H. and Zweifel, P. (2000). Measuring Willingness-to-Pay for Risk Reduction: An Application of Conjoint Analysis. Working Paper No. 0003, University of Zurich

Tervonen, J. (1999). Accident Costing Using Value Transfer: New Unit Cost for Personal Injuries in Finland. VTT Publications, Technical Research Centre of Finland

Viscusi, W. K. and Aldy, J. E.,(2003). **The Value of a Statistical Life**: A Critical Review of Market Estimates Throughout The World. NBER Working Paper Series No. 9487

Viscusi, W. K.(2005). **The Value of Life. John M. Olin Centre of Law**, Economics and Business, Harvard Law School: Discussion paper No. 517

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APPENDIX

Table 3: VOSL for Fatal Injury According to Contributing Variables (RM)

CFI – Car Fatal	Injury	MFI – Motor Fatal Injury			
VARIABLE	VOSL (RM)	VARIABLE	VOSL (RM)		
INCOME	1,339,610	INCOME	1,138,183		
1000 and below	1,385,953	500 and below	1,164,150		
1001-1500	1,444,278	501-1000	1,215,626		
1501-2000	1,401,773	1001-1500	1,219,415		
2001-3000	1,777,157	1501-2000	1,388,402		
3000-4000	3,178,373	2001-3000	2,603,761		
4000 and above		3000 and above			
	1,493,126				
VEHICLE OWNERSHIP	1,498,560	ACCIDENT HISTORY	1,193,697		
No		Seen accident:	1,234,894		
Yes		No			
	1,413,888	Yes			
RACE	1,916,712		1,242,049		
Malay	1,269,518	Family injured:	1,225,861		
Chinese	1,391,300	No			
Indian		Yes			
Bumiputera			1,235,785		
	1,529,377	Family died:	1,215,723		
GENDER	1,467,419	No			
Male		Yes			
Female			1,179,425		
	1,496,269	VEHICLE OWNERSHIP			
EMPLOYER	1,472,818	No	1,239,318		
Government		Yes			
Private					
		EMPLOYER	1,276,437		
ACCIDENT HISTORY	1,517,645	Private	1,206,501		
Family died:	1,480,087	Government	1,248,448		
No		Self-job			
Yes					

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Abstract: Vehicle safety has been a primary consideration in automotive development for decades, with a strong focus on passive safety technologies – like seatbelts and airbags – that offer the benefit of mitigating the consequences of a crash. In recent years, active safety systems such as the Antilock Braking System ABS and the Electronic Stability Program ESP® have taken centre stage. The importance of these systems will continue to grow into the future as the focus moves further from crash protection to crash prevention. Active safety technologies have been internationally proven to contribute significantly to the reduction of road fatalities and injuries.

Key Words: Accident avoidance, traffic safety, active safety systems, driver assistance, predictive emergency braking systems

1. ACTIVE SAFETY SYSTEMS PREVENT CRASHES: FROM ABS TO ESP[®]

Passive safety systems such as e.g. airbags, seat belts, and seat belt tensioners offer effective injury protection for vehicle occupants after a crash has happened. Active safety systems add a new dimension to driving safety: They assist drivers in critical driving situations in an effort to prevent accidents.

1.1 The Antilock Braking System ABS

All active safety systems are based on the pioneering ABS technology, which was first introduced into the market in 1978. In critical driving conditions – emergency braking or braking on a wet or a slippery surface – the vehicle wheels may lock during braking, thereby reducing the adhesion between the tires and the road surface. This may result in the tire not being able to transfer any lateral traction forces. The

vehicle becomes uncontrollable, as it no longer reacts to the steering input of the driver. In a vehicle equipped with ABS, wheel-speed sensors detect the speed of rotation of the wheels and relay this information to the ABS control unit. It calculates the degree of slip between the wheels and the road surface and detects whether any of the wheels are about to lock. If this is the case, the ABS intervenes to stabilize or decrease brake pressure. In doing so, it prevents the wheels from locking and the vehicle remains steerable during braking, thus allowing the driver to avoid possible obstacles.

A hydraulic modulator is the central component of the ABS system (see figure 1). It includes valves that control brake pressure at each individual wheel, a return pump, and an electronic control unit. In addition, each of the four wheels is fitted with a speed sensor. They measure the speed of each wheel and transmit this information to the control unit. If a wheel is about to lock under heavy braking, the hydraulic unit reduces the braking pressure on that individual wheel. Once the wheel turns freely again, brake pressure is again increased. This increase and release of pressure continues until

the driver reduces the force applied to the brake pedal, or until the tendency to lock has been overcome – if there is more grip on the road surface, for instance.



Figure 1. Components of bosch ABS

Scenarios where ABS may be essential to traffic safety include following real-life situations:

Emergency braking

An emergency braking is often the only way to avoid an accident. Typical situations include standing traffic hidden behind a curve, an obstacle appearing suddenly or the car in front braking abruptly. The oncoming traffic impedes evasive action. The driver has to perform full emergency braking. When braking hard, the wheels of a vehicle may lock, reducing the adhesion between tires and the road surface and the braking distance is longer. A car with ABS is brought safely to halt within a shorter braking distance which might prevent a collision (see figure 2).



Figure 2. Emergency braking with and without ABS

Emergency braking and steering

If an obstacle appears without warning, emergency braking may not suffice to prevent a collision: The driver must brake and take evasive action. Because the wheels have locked, a car without ABS no longer responds to the driver's steering intention and crashes into the obstacle. A car with ABS remains steerable even during emergency braking, and the driver can safely avoid the obstacle (see figure 3).



Figure 3. Emergency braking and steering with and without ABS

Emergency braking on varying road surfaces

Road surfaces which are partly wet, dirty, icy or covered with wet leaves are especially dangerous. When braking on such uneven road surfaces, the braking powers vary considerably, particularly on the front wheels. This can cause the vehicle to spin out of control. In this situation, a car without ABS becomes unstable and the driver loses control. The Antilock Braking System can compensate by applying different braking pressure to individual wheels. The vehicle remains under control.

1.2 The Traction Control System TCS

Critical driving situations can occur not only when braking, but also whenever there is a need to transfer strong longitudinal forces to the contact area between the tire and the ground: When starting off and accelerating, particularly

on slippery roads, on hills, and when cornering. Whereas ABS prevents wheel lock during full brake by reducing the braking pressure, Traction Control ensures that the wheels do not spin when driving off or accelerating. Based on the ABS technology, the Traction Control System (TCS) was launched in 1986. By adding an engine management interface to the ABS, TCS reduces the drive torque at each driven wheel and, if necessary, brakes individual wheels in order to regulate the slip of the driven wheels as quickly as possible to the optimum level. TCS therefore provides a logical extension of ABS. Traction Control improves the traction of the vehicle and increases vehicle safety by avoiding unstable driving situations within the limits of physics.

1.3 The Electronic Stability Program ESP®

Everyday traffic situations provide manifold reasons for sudden evasive action. This sort of

manoeuvres increases the danger of loss of vehicle control and could very easily put the car in the path of oncoming traffic. ESP® assists the driver in such critical moments.

The Electronic Stability Program ESP® comprises the functions of the Antilock Braking System and the Traction Control System, but can do more. It detects if a vehicle is about to skid and intervenes to counteract such a lateral movement, thus considerably improving driving safety.

ABS and TCS provide effective support in the case of speed alterations longitudinally to vehicle movement. ABS assists vehicle braking and TCS

vehicle acceleration. The Electronic Stability Program additionally supports the driver in movement transverse to the direction of travel by improving the vehicle's lateral dynamics. Thus, it ensures stable driving behaviouristic in all directions.

ESP® is always active. Based on data received by a steering angle sensor, ESP® recognizes the desired direction of travel. Wheel speed sensors measure the rotational velocity of all wheels. At the same time, yaw sensors measure vehicle rotation around its vertical axis, as well as lateral acceleration (see figure 4). From this data, the control unit calculates the actual movement of the vehicle, comparing it 25 times per second with the driver's steering input.



Figure 4. Components of bosch ESP[®]

If the vehicle moves in a different direction – either understeering or oversteering – ESP® detects the critical situation and reacts immediately. To do so, it uses the brakes as a tool for "steering" the vehicle back on track. Specific braking intervention is applied to individual wheels, such as the inner rear wheel to counter understeer (see figure 5), or the outer front wheel during oversteer (see figure 6).

These selective braking interventions generate the desired counteracting force, so that the car reacts as the driver intends.



Figure 5. Understeering with and without ESP[®]

For optimum implementation of stability objectives, $ESP^{\mbox{\ensuremath{\mathbb{B}}}}$ not only initiates braking

intervention, but can also intervene on the engine side to accelerate the driven wheels.



Figure 6. Oversteering with and without ESP®

ESP[®] thus substantially reduces the complexity of the steering process and lessens the demands placed on the driver.

1.4 ESP[®] Effectiveness and Net Benefit Studies

Loss of vehicle control, or skidding, has been demonstrated to be the dominant risk factor in a pre-crash situation. An international comparison of the occurrence of skidding in the pre-crash phase proved that at least 20 percent of all accidents resulting in injury are related to skidding of the vehicle in the pre-crash phase, and in the case of fatal accidents this figure rises to 40 percent.

Numerous international studies undertaken by leading automobile manufacturers and safety authorities to assess the effectiveness of ESP[®] since its launch back in 1995 came to the conclusion that ESP[®] significantly reduces the number of road fatalities and injuries and makes an important contribution towards road safety (see table 1).

Accident research has shown that ESP[®] reduces the probability of being involved in a serious or

fatal single-vehicle accident – in which no other road users are involved – by roughly 40 percent.

 Table 1. ESP[®] effectiveness and net benefit studies by regions / countries



Sources: Farmer 2004 / 2006, NHTSA 2006, Unselt et al. 2004, Zobel 2004, Tingvall et al. 2005, Baum et al. 2007, Aga et al. 2003, Ohono et al. 2005, Baum et al. 2009, Scully et al. 2007

Cost-benefit impact assessments conducted in the US, EU, Australia and Japan have proven that ESP[®] is the most important life-saving vehicle technology after the seat belt : If every car were fitted with ESP[®], approximately 10,000 fatalities per year could be prevented in the US, 4,000 in the EU and 350 in Japan.

2. MARKET PENETRATION OF ACTIVE SAFETY SYSTEMS

Governments worldwide have been increasingly defining clear road safety targets in terms of fatality and injury reduction and active safety systems such as ABS and ESP® have a major contributing role to play. Indicative of this development is the fact that regulative steps have been taken in a number of countries mandating ESP[®] as standard vehicle equipment in the near future.

2.1 Legislation

In 2007, the US Government approved the Federal Motor Vehicle Safety Standard No. 126 making ESP® mandatory in all new US light vehicles up to 4.5 tons, sold in the US market commencing 1st September, 2011 (National Highway Traffic Safety Administration, 2007).

In the European Union, the Regulation No 661/2009 of the European Parliament and of the Council of 13th July, 2009 makes ESP[®] mandatory (European Union, 2009). According to the regulation, from November 2011 all new passenger cars and commercial vehicle models registered in the European Union will have to be equipped with ESP®. From November 2014 this will then apply to all new vehicles including old models. The impact assessment that accompanied the Commission's proposal

concluded that relying on market forces alone was unlikely to result in full fleet penetration, thus justifying the regulation.

In June 2009, the Australian Federal Government announced that ESP[®] would become mandatory on all new models of passenger vehicles from November 2011 and all models from November 2013 (Vehicle Standard, 2009). The regulation is part of the National Road Safety Action Plan for 2009 and 2010 and ESP® is seen as playing an important role in an effort to reduce the number of fatalities in the country. In addition to that, the Action Plan identifies the government as an important actor in making the necessary steps to consumers purchase **ESP**[®] encourage to equipped cars.

Canada has followed the steps of the US by proposing a regulation which requires the installation of ESP[®] as standard equipment on all new vehicles up to 4.5 tons made for sale in

Canada from September 2011 (Department of Transport, 2009). In addition, Canada has chosen to support a rapid take-up of ESP[®] through educational and promotional campaigns. Such a campaign was launched in October 2008 by the Canadian Automobile Association (CAA) with support from the FIA Foundation. As part of the campaign, Transport Canada has asked manufacturers to distribute ESP[®] promotional material through advertising, car dealers and promotional events.

2.2 Installation Rates

The number of vehicles equipped with ABS, TCS and ESP® has steadily increased. The latest installation rate data shows that in 2008 worldwide about every third new passenger car and light commercial vehicle below 6 tons was equipped with ESP[®] whereas ABS is fitted in three out of four (see table 2).

 Table 2. Installation rates ABS, TCS and ESP® by region in 2008 (%)



Source: Bosch

Manufacturers first began equipping vehicles with ESP[®] in the mid 1990s in Europe. Whereas ESP[®] first appeared as an option in more expensive, luxury vehicles, within a few years manufacturers introduced it as standard equipment across their entire vehicle range. Since then the take rates of ESP[®] have increased steadily worldwide, particularly in developed countries.

In developing countries such as China, India, Brazil or Thailand, with a fast growing number of roads and first-time car owners, the installation rates are still at a low level, but the demand for active safety systems is rising.

3. THE FUTURE OF ACTIVE SAFETY SYSTEMS

The active safety systems ABS, TCS and ESP® help the driver to maintain vehicle stability in critical traffic situations. With the additional support of surround sensors such as video or

radar, the car is able to "see" its surroundings, interpret the situation and recognise dangerous situations. This information is used to warn and support the driver and even automatically intervene in emergency situations.

3.1 Predictive Emergency Braking Systems

Predictive Emergency Braking Systems have been developed in order to enable a faster reaction in critical situations. These systems are based on a networking of a radar sensor with the active safety system ESP® to support the driver by means of an intelligent predictive warning concept and effective brake assistance in case of emergency. Rear-end collisions can then be avoided or the consequences of a collision can be mitigated. These technologies decisively compensate for the human shock second and automatically initiate safety measures (see figure 7). Thus, they help the driver to ultimately avoid collisions and serious accidents.



Figure 7. Predictive emergency braking

Predictive Collision Warning

If the distance to the preceding vehicle becomes critically short, Predictive Collision Warning identifies the risk of collision and prepares the brake system for potential emergency braking. Thus, the driver has full braking power available valuable hundredths of seconds earlier. Additionally, the driver is warned at an early stage by means of an audible and/or a visual signal, followed by a haptic alert making him aware of the acute threat and enabling him to react earlier to potentially avoid a rear-end collision. The timing of the warning is calculated on the basis of the stopping distance and the driver's reaction time, thereby also taking into driver account whether the has reacted accordingly at this stage, e.g. by braking or steering.

Emergency Braking Assist

Emergency Braking Assist extends the functions included in Predictive Collision Warning with intelligent braking support. The information from the radar sensor is used to continuously calculate the brake pressure necessary for avoiding a rearend collision. If the driver brakes in time after the collision warning but fails to apply sufficient brake force, Emergency Braking Assist automatically increases the braking pressure so that the driver is able to bring the vehicle to halt before a collision. Therefore, the function provides effective braking support for the driver and assists in avoiding potential impact with a preceding obstacle or vehicle.

Automatic Emergency Braking

Automatic Emergency Braking extends Predictive Collision Warning and Emergency Braking Assist by automatic partial and full braking. Valuable time can pass before a driver reacts to a critical situation. Time that is actively used by the Automotive Emergency Braking function: Following the collision warning, the system automatically initiates partial braking to decelerate the vehicle and to provide additional time for the driver to react accordingly. As soon as the driver actuates the brake, Emergency supports Braking Assist the effective deceleration. If the driver does not react and the rear-end collision is unavoidable, automatic full braking is triggered to brake the vehicle to the maximum extent in order to reduce impact speed and minimize the consequences of the accident (see figure 8). This places highest demands on precision in object recognition and accident risk evaluation. For this purpose, the radar sensor is supplemented with video technology.



Figure 8. Automatic emergency braking

3.2 Lane Keeping Support

The Lane Departure Warning and Lane Keeping systems monitor Support the upcoming roadmarkings and the position of the vehicle within the road lane by means of an on-board camera. Whereas the Lane Departure Warning function alerts the driver in case the vehicle is accidentally leaving the lane, Lane Keeping Support goes beyond a simple warning by providing the driver with active steering support to keep the lane. By doing so, both systems give the driver time to correct the vehicle's trajectory before an accident occurs. The systems recognize whether a change of lane is intended based on specific input – such as indication and strength of steering movement – in order to suppress system intervention when not desired by the driver. Additional to that, Lane Keeping Support can help keep the vehicle safely in lane. However, the driver can override this function at any time.

3.3 System Networking as the Key to Safer Vehicles

provides Networking the opportunity to intelligently utilize existing components and systems. Modular safety systems like Bosch CAPS - Combined Active Passive Safety networks the information from individual systems previously acting independently from each other: CAPS interlinks active safety systems such as ESP®, passive safety systems such as the airbag control unit, Predictive Emergency Braking Systems and vehicle communication such as the navigation system. This networking makes multiple uses of sensor signals possible and is the basis for new functions which further increase the safety of vehicle occupants as well as of other road users (see figure 9).



Figure 9. System networking

In future, the primary task will continue to be the analysis and networking of a wide range of sensor data in order to develop new specific solutions for road safety. These novel functions will not only help to avoid or mitigate potential collisions at the front of the vehicle, but will also do the same for side and rear collisions, thus offering additional advantages when various types of accidents occur. Surround sensors will be the central components for data registration in this respect (see figure 10). From the data provided by these sensors, the systems will calculate the time and position of a collision as well as the relative speed of the vehicles or objects involved.

With the aid of this information, the safety systems can be triggered at the crucial moment in time and in accordance with the requirements of each specific scenario. Exactly there – at the micro-level of the individual situation – is where human life and health can be saved on world's roads.



Figure 10. Surround sensing

4. CONCLUSION

This article offers an overview of active vehicle safety systems and their contribution to reducing traffic accidents and fatalities. The Antilock Braking System ABS which laid the foundation for all active safety systems following its market introduction by Bosch in 1978, is nowadays a standard feature of a modern passenger vehicle, thus allowing drivers all over the world to brake without the risk of wheel slip.

The Electronic Stability Program ESP^{\circledast} – an evolution of ABS – assists drivers in avoiding vehicle skidding and provides increased support in critical skidding situations. Since 1995, the ESP® installation rates have been increasing, especially in developed countries, supported through worldwide public initiatives and

legislative measures calling for mandating ESP[®] on all passenger cars.

ESP[®] provides the vehicle with the ability to brake automatically. Therefore, when combined with surround sensors such as radar or camera systems, ESP[®] enables the functioning of advanced active safety systems such as Predictive Emergency Braking or Lane Keeping Support. Whereas the availability of such advanced technologies is currently confined mainly to luxury segment vehicles, a wider proliferation can be expected.

Road safety and accident-free mobility thus become more and more interrelated with active vehicle safety technologies that are capable of successfully supporting the driver in situations in which making a mistake is human.

REFERENCES

Aga M., Okada A. (2003) Analysis of Vehicle Stability Control (VSC) Effectiveness from Accident Data. **JSAE Automotive Engineering Exposition, Paper No. 541**, Nagoya, 2003.

Baum H., Grawenhoff S., Geissler T. (2007) Cost-Benefit Analysis of the Electronic Stability Program (ESP). **Zeitschrift für Verkehrswissenschaft, 78**. Jahrgang 2007, Heft 3:119 – 223 Verkehrsverlag Fischer, Düsseldorf .

Baum H., Kidokoro Y., Geissler T., Fujiwara T., Westerkamp U. (2009) Cost-benefit analysis of the Electronic Stability Control, **GRIPS Discussion Paper 09-07**. GRIPS National Graduate Institute for Policy Studies, 2009.

Department of Transport (2009) **Regulations Amending the Motor Vehicle Safety Regulations** (Electronic Stability Control Systems). Canada Gazette – Part I, Vol. 143, No. 11: 674 – 682, Ottawa, 2009.

European Union (2009) Regulation (EC) No. 661/2009 of the European Parliament and Council of 13 July 2009. **Official Journal of the European Union**, L 200/1 – L 200/24, 2009.

Farmer C. M. (2006) Effects of Electronic Stability Control (ESC) – An Update – May 2006 – Press Release and Report. **IIHS Insurance Institute for Highway Safety**. Retrieved October 2009, from www.aiam.org

Farmer C. M. (2004) Effect of Electronic Stability Control on Automobile Crash Risk. **Traffic Injury Prevention**, 5:317-325, Taylor & Francis, Arlington, VA, 2004.

NHTSA (2006) Proposed FMVSS No. 126: Electronic Stability Control Systems. US Department of Transportation, National Highway Traffic Safety Administration – Preliminary Regulatory Impact Analysis. Retrieved October 2009, from www.nhtsa.gov

National Highway Traffic Safety Administration (2007) **Federal Motor Vehicle Safety Standards; Electronic Stability Control Systems; Controls and Displays.** Department of Transportation. 49 CFR Parts 571 and 585 [Docket No. NHTSA–200727662] RIN: 2127AJ77.

Ohono, Shimura (2005) Results from the Survey on Effectiveness of Electronic Stability Control (ESC). National Agency for Automotive Safety and Victims' Aids. Retrieved October 2009, from www.nasva.go.jp

Scully J., Newstead S. (2007) **Preliminary Evaluation of Electronic Stability Control Effectiveness in Australasia.** Monash University – Accident Research Centre. Retrieved October 2009, from www.monash.edu.au/muarc/reports

Tingvall C., Krafft M., Kullgren A., Lie A. (2005) The Effectiveness of Electronic Stability Program (ESP) in Reducing Real Life Accidents. eSafety Communication Platform Plenary – Progress Report, Paper No. 05 – 135, London, 2006.

Unselt T., Breuer J., Eckstein L., Frank P. (2004) Avoidance of "Loss of Control Accidents" through the Benefit of ESP. FISITA, **Conference paper No. F2004 V295**, Barcelona, 2004.

Vehicle Standard (2009) Australian Design Rule 31/02 Brake System for Passenger Cars (2009). Federal Register of Legislative Instruments F2009L02533, Canberra, 2009. Zobel R. (2004) VW Research – Germany. ESP Workshop, Ehra-Lessien, 2004.

EXISTING CONDITIONS AND FUTURE OPPORTUNITIES ON ROUTE 12 ECONOMIC CORRIDOR

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Abstract: This paper presents the survey of the Route 12 Economic Corridor (R12), the shortest international land route connecting Thailand, Lao PDR, Vietnam and Guangxi, China. After the opening of the 3rd Thai-Lao Friendship Bridge in November 2011, the R12 corridor will be completed and would be significantly used for logistics and tourism activities. This study includes the survey of existing route condition, as well as, route development plans from Thailand, Lao, and Vietnam. It was found that although the existing route could be used for logistics and tourist activities, many improvements of logistics and tourist facilities along the route would be needed to extend the opportunities of this economic corridor.

Key Words: Economic Corridor, Cross Border Transport, Trade Facilitation, International Route, Land Transport

1. INTRODUCTION

According to the map in Figure 1, Route 12 or R12 is a two-lane highway. It begins at Thakhek (**A** in Figure. 1), Muang Kammouane, Lao PDR, passing through Na Phao (Lao PDR) and Cha Lo (Vietnam) border checkpoint, and ends at Khe Ve intersection (**B** in Figure. 1) in Quang Binh province in Vietnam.

Although the route is relatively short and no urban areas are located along the way, the connections of Route 12 with main highways in Thailand (Highways No. 1, 2, and 22), Vietnam (Highway 5, 1A, 8 and Ngo Gia Tu Road), and China (Nanyou Expressway) would bring a long highway corridor, connecting several large cities

from Bangkok (Thailand), Thakhek (Lao PDR), Vinh and Hanoi (Vietnam), and Nanning (Guangxi, China). This is considered to be the shortest (1,769 km) transportation route from Nanning to Bangkok. We will now call this longer route network "the R12 Economic Corridor". There have been some logistics and tourism activities along this corridor; however, it is expected that this corridor will be popularly used once the construction of the 3rd Thai-Lao Friendship Bridge (crossing Mekong River) at Nakhon Phanom-Thakhek is completed in Dec 2011, along with the full implementation of Greater Mekong Subregion Cross-Border Transport Agreement (GMS CBTA) and ASEAN Agreement.



Figure 1. Route 12 from Thailand to Vietnam (Modified from Google map 2010)

Due to the potential of this corridor, we conducted a survey trip on the whole corridor. The trip started from Nakhom Panom (Thai border), crossing Mekong River to Lao PDR at Thakhek (since the bridge was under construction), and renting a van from Thakhek to Hanoi. It was followed by a bus trip from Hanoi to Nanning. The trip was conducted in October 2010. It included the depth interviews of more than 50 people, both government agents, drivers, custom officers, tour guides, and businessmen in several countries along the route to investigate existing trade facilitation, to understand the obstacles of using this corridor for logistics and tourism purposes, and to recommend a policy in corridor improvement.

This paper will be organized as follows. First, the existing condition (in 2010) of this route will be described. International agreements as well as current development plans are presented next.

Later, the summary of obstacles of using the route for logistics and tourism purposes are presented. It will be followed by the opportunities for trade and tourism on the route if the obstacles have been improved in the last section.

2. EXISTING CONDITIONS

To describe the conditions of R12 economic corridor, the corridor is separated into three sections as shown in Figure 2. Section 1 is between Nakhon Panom (Thailand) and at Na Phao border checkpoint. Section 2 is between Cha Lo border checkpoint to Hanoi. The last section is between Hanoi to Nanning. Note that the section between Bangkok to Nakhon Panom is omitted from this study since it is mostly a standard 4- to 6-lane paved highway links.



Figure 2. Three sections of R12 economic corridor

Section 1: Nakhon Panom (Thailand), Crossing Mekong River, Thakhek, Na Phao border checkpoint (Lao PDR)

Since the 3rd Thai-Lao Friendship Bridge was in construction, the crossing of Mekong River from Nakhon Panom (Thailand) to Thakhek (Lao PDR) must be through river-crossing ferry (for

tourists) or motor raft (for trucks), see Figure 3. The location of the under-construction bridge is approximately 10 kms from these piers. It was expected that after the bridge is opened, all trucks will use the bridge; however, some tourists might use either an existing ferry or a new bridge.



Nakhon Panom Customs Passenger River Ferry

Motor River Raft Thakhek Customs

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Figure 3. Border crossing from Nakhon Panom in Thailand to Thakhek in Lao PDR
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Figure 4 shows the road condition between Thakhek to Na Phao (140 km). The road is a two-lane paved highway with narrow shoulders on both sides. Generally, the pavement condition is good but driving on this section must be very careful since cattle and rocks might be found on the traveled way. Most are plain with great views of mountain complex; nevertheless, the last 20km to Na Phao is an uphill area with sharp curves. Through the route, there were no logistics and tourist facilities such as rest area, standard gas station, standard hotel, distribution centers, restaurants and stores. Most drivers on the route are local with full knowledge of route. Normally, vehicles can simply cross the border from Na Phao to Cha Lo due to short distance. However, the road condition between two borders was in lack of maintenance, it is full of potholes with sharp curve. We found that the Vietnam customs and immigration area in Cha Lo is large with a wide yard for goods distribution. In contrast, the similar facilities were not found on Na Phao side. The travel time from Thakhek to Na Phao was 2 hours.



Figure 4. Road conditions from Thakhek to Na Phao border checkpoint in Lao PDR

Section 2: Cha Lo border checkpoint to Hanoi (Vietnam)

The distance from Cha Lo to Hanoi in Vietnam is 503 kms. It can be separated into three subsections; i.e., 1) from Cha Lo to Khe Ve intersection (end of Route 12); 2) from Khe Ve to Vinh (Route AH15); and 3) from Vinh to Hanoi (Route 1A). The total travel time from Cha Lo to

Hanoi could be 8-12 hours depending on traffic. The Route 12 from Cha Lo to Khe Ve (in Figure 5) is a two-lane highway with good pavement condition. However, since it is in a downhill area. There were plenty of rockslides and some cattle on the highway. No facilities (e.g., gas station, vehicle maintenance shops, restaurants, hotels, etc) for tourists or truck drivers were found on the way.



Figure 5. Road conditions from Cha Lo border to Khe Ve intersection in Vietnam

Asian Highway No.15 between Khe Ve to Vinh (in Figure 6) is mostly a two-lane highway with good pavement condition. It is widening to fourlane divided highway in the urban area. This portion is still in a downhill area with lots of cattle on the road. A local gas station and hospital were found on this 115-km distance.



Figure 6. Road Conditions from Khe Ve intersection to Vinh in Vietnam

Highway 1A from Vinh to Hanoi in Vietnam is a standard 2-lane (rural)/ 4-lane (urban) highway with smooth pavement. However, driving on this

route requires special skills since there are lots of bicycles and motorcycles. The speed limit in the urban area is only 25-45 km/hr, while 50-80

km/hr in the rural area. Driving on this highway is slow due to heavy traffic jam, pedestrians and cattle on the road. The exception is the last 57km to Hanoi, which is a long 4-lane divided expressway with 80-100 km/hr speed limit. Generally, this part has many facilities (gas station, hotels, restaurants, etc) provided for tourists and truck drivers. However, four toll collections were on this portion.



Figure 7. Road conditions from Vinh to Hanoi in Vietnam

Section 3: Hanoi to Huu Ngai checkpoint (Vietnam) and Youyi Guan checkpoint to Nanning (Guangxi, China)

Highway 1A from Hanoi to Huu Ngai checkpoint (180 km, 3 hrs) in Vietnam mostly is a standard two-lane highway. The terrain is mostly flat with few mountainous zones near Lang Son. The traffic is light. Most of them are trucks, private cars, motorcycles, and tour buses. Facilities for tourists and truck drivers were found along the way. Huu Ngai checkpoint area has distribution center and many buildings for customs and immigration. The road in China from Youyi Guan to Nanning (200 km, 3 hrs) is Nanyou Expressway. The expressway is in a very good condition. Rest areas, gas stations, and shops are found every 50 km. In addition, the emergency call box was found along the way. The roadways from Hanoi to Nanning are shown in Figure. 8 below.



Figure 8. Road Conditions from Hanoi, Vietnam to Nanning, Guangxi, China

3. GMS AGREEMENTS AND CURRENT DEVELOPMENT PLAN

The ADB supported Greater Mekong Subregion Economic Cooperation program, abbreviated as GMS, started in 1992 by the six nations, i.e., Thailand, Myanmar, Lao PDR, Cambodia, Vietnam, and Southern China. The GMS has four objectives: 1) support the trade, investment, agriculture, and service sector among the region; 2) increase jobs and elevate the GMS residents' quality of life; 3) Promote and Collaborate technology and education among member nations, as well as, sharing natural resources effectively; and 4) increase the capability and enhance the economic opportunity of GMS countries in world market.

The collaborations within GMS have nine areas including transportation and tourism. 3 of 11 GMS development projects are related to economic corridors. These corridors are East-West Economic Corridor (R9), North-South Economic Corridor (R3A/R3B/R5), and Southern Economic Corridor (R1/R10). In these projects, ADB funds the development of roadways to facilitate trade and tourism activities. Note that R12 is not a part of these projects since it is a short-cut route lying in the northeastern direction between Thailand and Hanoi.

The GMS members have agreements to facilitate the movement of people and goods within the region for regional growth. The agreement began transportation with building infrastructure connecting the region. In addition, they agreed to reduce cross border transport obstacles by simplifying and harmonizing legislation, requirements regulations, procedures, and relating to the cross-border transport, and promoting multimodal transport. GMS Cross-Border Transport Agreement (CBTA) includes details of practice such as custom procedures, road traffic regulation, driving permits, etc.

Due to GMS CBTA, each country has improved the R12 corridor as follows. Thai government has collaborated with Lao government to build the 3rd Thai-Lao Friendship Bridge between Nakhon Panom and Thakhek. This bridge was studied since 2001 as a part of Asian Highway No. 15 connecting Udon Thani, Nakhon Panom, and Vinh. The location of the bridge is between Hom Village (8km north of central Nakhon Panom) and Vern Tai Village (13 km north of Thakhek). The bridge construction project includes the development of border gates and roadway connection, as well as, the traffic changeover area (due to opposite driving direction between Thailand and Lao). The bridge connects Highway 212 in Thailand and Highway 13 in Lao as shown in Figure 9. The total project cost is about 58 millions USD.



Figure 9. Location of the 3rd Thai-Lao friendship bridge in Nakhon Panom, Thailand Besides the bridge, the Nakhon Panom customs has a plan to build a single-window and single-

stop inspection (SSI) to facilitate cross border trade and logistics in the future. Also, a new bypass (from Highway 22 to bridge location) is being planned to reduce traffic congestion within the Muang Nakhon Panom. In addition, a government budget is being requested for building a new logistics center, a show-trade building, and information center in the area near the bridge. However, these are not expected to be completed within 3 years after bridge opening.

Lao PDR's central and Kammouane governments have requested some budget from ADB and Thailand to develop the east area of the bridge, as well as, widen the Highway 13 between the bridge to Thakhek from two to four lanes. They plan to widen the whole Route 12 from Thakhek to Na Phao. However, these plans are still in negotiation with funder and have no conclusion as of now.

Vietnam has a plan to widen a roadway from Cha Lo to Highway 1A. However, since the road is on the mountain, it is difficult and costly to expand. Flooding and mudslide also damage the road during the rainy season. Additionally, Vietnam has collaborated with Lao government to build a joint-venture company for expanding the Vung Ang deep-water Port in Ha Tien. This port could be directly connected with R12 for logistics activities in Vietnam, Lao, and northeast Thailand. Regarding the Highway 1A, the most important highway in Vietnam, the government has a plan to widen the road and/or building a parallel expressway to reduce traffic congestion and expedite traffic flows.

From the survey, there are many development plans to improve the R12 economic corridor. However, it has been noted that these plans are still in paper and any construction beyond the bridge is unlikely to be finished before 2015 or later. Therefore, R12 users might encounter several obstacles when they use it in the forthcoming years.

4. MAIN OBSTACLES ON R12 ECONOMIC CORRIDOR

Although the existing R12 Corridor can handle some logistics and tourism activities, there are still obstacles that needed to be improved to enhance these activities:

For logistics activity, a logistics center is needed at Nakhon Panom and Thakhek (Thailand-Lao border). At Thakhek, the customs building is needed to be upgraded to handle more logistics activities. In addition, from Thakhek to Na Phao, trade facilities (gas station. vehicle no maintenance station, rest area, and call box) were found on the way. The driving on this area is difficult due to cattle walking alongside of road. At Na Phao border, the custom procedure is pretty slow and the road condition is poor due to mountains. From Cha Lo to Khe Ve, driving on the way is dangerous due to cattle and pedestrians along the road. In addition, all signs are in Vietnamese, which is difficult for foreign drivers.

For tourism activity, more accommodations are needed at Nakhon Panom area. In addition, immigration procedures at Thakhek, Na Phao, and Cha Lo would be improved to expedite the process. No standard medical centers, restaurants, shops, tourist information center were found between Thakhek and Vinh.

5. FUTURE OPPORTUNITIES ON R12 ECONOMIC CORRIDOR

If all obstacles are improved in the future, R12 could yield some opportunities as follows:

Logistics Activities

After the opening of the new Mekong Bridge, the logistics activities between Thailand's

Northeastern region and Thakhek would be significantly improved. However, since no tax incentives has currently been offered on R12, comparing with R9 (East-West Economic Corridor). Therefore, the increase in logistics activity on the route might not be as high as expected.

For logistics activities between Thailand and northern Vietnam, R12 has better road condition than R8, and shorter than R9. It would likely be a replacement of R8 for trucks. The total time for land transport on R12 is only 1-2 days, comparing with 6-7 days for sea transport. Therefore, it would be suitable for perishable goods to transport on this route. Nevertheless, due to the imbalance of trade activities between Thailand and Vietnam, the transportation cost by road would still be double or triple of sea transport. Another logistics activity on this route is the shipment of goods between Northeastern Thailand/ Kammouane, Lao PDR and Vung Ang Port for sea transport in Vietnam. However, the Vung Ang Port is in the development state and there is no international ship using the port as of now.

For logistics activities between Thailand and Nanning, Guangxi, R12 could be used for fast shipment of perishable goods. However, the amount of trade is likely to be insignificant due to a very long driving distance (3-4 days) and crossing three borders. So far, all fruits exported Thailand to Nanning, from Guangxi are transported by sea from Laemchabang port in Thailand, embarked at Hong Kong or Guangzhou port, and shipped by truck or train to Guangxi. Although it takes a few more days, the sea transport is much less expensive than land transport.

Tourism activities

It is expected that after the opening of the Bridge, more tourists and Thakhek residents would come to Nakhon Panom more frequently since they can easily cross the river without a risky and time-consuming ferry. It would encourage trade activities between Nakhon Panom and Thakhek. Now, Thakhek residents are in difficult to travel, buy a product, and visit a medical center in Nakhon Panom. Also, Nakhon Panom and Thai tourists would more likely to visit Thakhek for cultural and sightseeing purposes.

In spite of lack of historical attractions, R12 offers a pure, beautiful scenario for tourists who are interested in nature. It is full of undisturbed mountains, canals, and forest. Camping and hiking activities might be developed on the route.

The R12 would be one of major tourist spots for cultural experiences. Since R12 is a short international route, tour operators could offer a cultural package tour of three countries (Thailand-Lao-Vietnam) in a day. This would suit for adventurous tourists who like a multicultural experience with reasonable price. This kind of package is now offered on R9, but it might be shifted to R12 due to more beautiful scenario and shorter distance to Hanoi.

Note that R12 is not currently yet a comfortable route for tourists since it lacks several important facilities. It has no gas stations, vehicle maintenance shops, tourist information centers, hospitals, restaurants, and hotels in several areas. A tour on the route might be pleasant and successful if the tour leader has sufficient experiences. The traveler and/or driver on the route could encounter possible life-threaten emergencies especially if the vehicle is run out of gas/broke down, a tour member is sick, etc.

6. RECOMMENDATIONS TO IMPROVE R12 ECONOMIC CORRIDOR

The recommendations to improve logistics and tourism activities on R12 economic corridor are divided into three parts: Thailand, Lao PDR, and

Vietnam as follows:

Thailand

The main problem in Thailand is mostly about infrastructure for logistics activity, such as, warehouse, rest area, and traffic congestion at the border gate. These problems would be solved by the collaboration between the government agents and private business. First, before the completion of bridge construction, the Ministry of Transport (Department of Highways), Ministry of Commerce (Department of Foreign Trade), Ministry of Finance (Department of Customs), Ministry of Tourism and Sports, and Province Governor would come together to develop a management plan for the Bridge area and build a new customs building to serve higher traffic volumes. Secondly, the private companies in Nakhon Panom would help the government agents to build supportive infrastructures for logistics and tourism activities on the corridor such as gas station, warehouse, rest area, etc.

Lao PDR

Major problems in Lao PDR are both customs and road infrastructure due to lack of development fund. It is important that Thailand and foreign countries would need to support the building of crucial infrastructure such as new

customs buildings and a connection roadway between the bridge and Thakhek. In addition, would Thai government support the collaboration of Thai-Lao business partners to invest in basic infrastructures such as gas station, hotels, restaurants, etc. Local business agents (Chambers of Commerce in Nakhon Panom and Kammouane) would be incorporated to develop tourism business between two cities. Lastly, a complaint center would be built as a mediator agent to help international truck drivers and tourists on the corridor if any problem occurs.

Vietnam

The major problem in Vietnam is about driving condition along the route. Vietnam government would need to show traffic signs and direction in English languages for facilitate signs international drivers. In addition, it is proposed that Vietnam would need to build some basic facilities for drivers and travelers such as gas stations, medical centers, vehicle maintenance shops, tourist shops/info center near the border town. A complaint center is also required to solve problems that might occur along the way. Lastly, since driving in Vietnam is very difficult of foreign drivers, it is proposed that logistics and tourism activities within Vietnam would be done by Vietnamese only.

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REFERENCES

Department of Highways, Ministry of Transport (2010) The Third Thai-Lao Friendship Bridge Construction Project, **DOH Project Report**, October 2010.

Department of Land Transport, Ministry of Transport (2008) Greater Mekong Subregion Cross-Border Transport Agreement, also available online at http://www.ltpcenter.com

Transportation Research Institute, Chulalongkorn University (2010) Project Study to Increase the Capability of Thailand's International Trucker Business, **Final Report**, Submitted to the Department of Land Transport, Ministry of Transport, December 2010.