PROCEEDING OF 11TH ATRANS ANNUAL CONFERENCE:
YOUNG RESEARCHER'S FORUM 2018

TRANSPORTATION FOR A BETTER LIFE:

LESSONS LEARNED FROM GLOBAL EXPERIENCES TO LOCAL BEST PRACTICES

24 August 2018

Bangkok, Thailand

Proceeding of 11th ATRANS Annual Conference:

Young Researcher's Forum 2018

"TRANSPORTATION FOR A BETTER LIFE: LESSONS LEARNED FROM GLOBAL EXPERIENCES TO LOCAL BEST PRACTICES""

24 August 2018

Bangkok, Thailand

Welcome Message from the Chair of ATRANS Annual Conference & Activity Committee

Dear ATRANS Young Researcher's Forum 2018 participants,

It is a pleasure to welcome you to the 11th ATRANS Annual Conference: Young Researcher's Forum 2018. ATRANS has approached 11 years of its establishment and we shall celebrate this significant moment by making our world a better place to live, utilizing technology for smart mobility and making the roads safer for our journey.

In this eleventh year, ATRANS receives magnificent supports from reputedly well-known speakers coming from multidisciplinary area across the continent to share their knowledge, information and valuable experiences with the conference's delegates and the participants on 24 August.

Transportation plays an important role to fuel its economic growth and development. Utilization of technologies for development of transport infrastructure will shape the cities in capable of movement connecting people from one place to another. Management of mobility and road safety are the key to sustainable transportation. Losing lives on roads every hour is unacceptable. Safe system approach for Traffic Safety Measures associated with Technological Responses and Infrastructural Measures as well as Education would effectively help mitigate road traffic accidents. Everything around us is becoming increasingly digitized. We are permanently connected to a vast global network. Policy Responses and International Best Practices are vital exemplifications that we should take into account. These are among other reasons why this year conference's theme is upon "Transportation for a Better Life: Lessons Learned from Global Experiences to local Best Practices."

On behalf of ATRANS, I wish to express my sincere gratitude to the Young Researcher's Forum Committee who worked relentlessly to make the Young Researcher's Forum 2018 possible. I earnest hope that you all, will enjoy listening to the presentations and have good times spending in our ATRANS Annual Conference and the Young Researcher's Forum. Have a pleasant stay in Thailand.

Tuenjai Fukuda, Dr. Eng.

ATRANS Secretary-General, and
Chair of ATRANS Conference & Activity Committee

August 2018

Welcome Message from ATRANS Young Researcher's Forum Advisory Committee 2018

Dear ATRANS Young Researcher's Forum 2018 participants,

On behalf of the Symposium Committee, I would like to welcome delegates to the 11th ATRANS Annual Conference: ATRANS Young Researcher's Forum (AYRF) 2018. This is the greatest annual international event for young researchers in transportation that brings together students, researchers, practitioners, policy makers, and so on.

I encourage you to attend the AYRF session(s) where you will find many interesting papers with different stages of development ranging from the results of graduate studies to the academic journal-level papers. Meanwhile you will find several interesting case studies and applications, not only in the developing cities but also the developed ones. Please take this opportunity to exchange idea and share experiences with the presenters, who are young and energetic researchers.

Last but not the least, this event would never be possible without the great efforts contributed by AYRF committee who are graduate students from various university across Thailand. Sincere appreciation are also due to the reviewers who kindly read the manuscripts and provided useful comments to the authors. Finally, I strongly believe that the 11th ATRANS Annual Conference 2018 will be again as remarkable as the previous ones.
Best Regards

Varameth Vichiensan, Ph.D.

Kasetsart University
Vice-Chair of ATRANS Conference & Activity Committee

August 2018

Welcome Message from ATRANS Young Researcher's Forum Advisory Committee 2018

Dear ATRANS Young Researcher's Forum 2018 participants,

It is my great pleasure to welcome all distinguish guest to the ATRANS Annual Conference 2018, and this year theme is "Transportation for a Better Life: Lessons Learned from Global Experiences to Local Best Practices". A number of honorable guest speakers will deliver speeches in this event.

The ATRANS Annual Conference also provides a great opportunity for young researchers to participate in the Young Researcher's Forum to present their papers to the public. As an advisor to the Young Researchers Chapter, I am delighted to tell you that the papers this year are very interesting.

In organizing the Young Researcher's Forum, I would like to congratulate our young researcher committee who works very hard to bring us a great event this year.

I hope that we will have a successful conference this year.

Sumet Ongkittikul, Ph.D.

Thailand Development Research Institute (TDRI)
Vice Chair of ATRANS (Symposium) Conference & Activity Committee

August 2018

Welcome Message from President of ATRANS Young Researcher's Forum Committee 2018

Dear ATRANS Young Researcher's Forum 2018 participants,

On behalf of ATRANS Young Researcher's Forum Committee, I would like to express my great pleasure to have the opportunity to participate in the organization of this Annual Conference, it is a great honor for me and also a big opportunity to exchange experiences with other participants.

The theme "Transportation for A Better Life: Lessons Learned from Global Experiences to Local Best Practices" will provide a platform for young researchers to demonstrate their interests. I hope this conference will bring about the exchange of ideas and friendship among the participants through the presentations by our presenters, that will be of great benefit to our current and future society.

As the president of AYRF 2018, I am Hopefully that the organization of this event will be successful, following the theme. I hope that we will fulfill your desire for knowledge.

Finally, on behalf of ATRANS Young Researcher's Forum 2018 organizing committee, I am grateful to all participants for your interest and participation in ATRANS Annual Conference. I wish you would gain a good impression and fruitful experience during the conference.

Suchada Pongsawat

Burapha University (BUU)
President of ATRANS Young Research's Forum Committee 2018

August 2018

List of ATRANS Young Researcher's Forum 2018 Organizing and Scientific Committee

AYRF Organizing and Scientific Committee		
1	Ms. Suchada Pongsawat (President of ATRANS Young Researcher's Forum Committee 2018)	Burapha University
2	Mr. Bethala Aditya (Vice-President of Scientific Committee 2018)	Asian Institute of Technology
3	Mr. Pattarapon Pupetch (Vice-President of Organizing Committee 2018)	Chiang Mai University
4	Ms. Bolla Vidya Sundari (Secretariat of ATRANS Young Researcher's Forum Committee 2018)	Asian Institute of Technology
5	Ms. Kanjana Saengkham (Secretariat of ATRANS Young Researcher's Forum Committee 2018)	Rangsit University
6	Ms. Yatawee Kit-ek (Paper Coordinator of ATRANS Young Researcher's Forum Committee 2018)	Prince of Sonkla University
7	Ms. Supawan Nuallaong (Paper Coordinator of ATRANS Young Researcher's Forum Committee 2018)	Prince of Sonkla University
8	Mr. Kanin Wongyai (Paper Coordinator of ATRANS Young Researcher's Forum Committee 2018)	Burapha University
9	Ms. Wanattra Sawangjai (Paper Coordinator of ATRANS Young Researcher's Forum Committee 2018)	Chiang Mai University
10	Mr. Navapon Pongpool (Graphic Designer of ATRANS Young Researcher's Forum Committee 2018)	Chiang Mai University

AYRF Organizing and Scientific Committee		
11	Mr. Arif Siriwat (Graphic Designer of ATRANS Young Researcher's Forum Committee 2018)	Prince of Sonkla University
12	Mr. Nattawat Panyasai (Graphic Designer of ATRANS Young Researcher's Forum Committee 2018)	Khon Kaen University
13	Mr. Pasit Wonghabut (Registrar of ATRANS Young Researcher's Forum Committee 2018)	Khon Kaen University
14	Ms. Nuttha Chumnanya (Registrar of ATRANS Young Researcher's Forum Committee 2018)	Khon Kaen University
15	Ms. Supphakan Sridan (Registrar of ATRANS Young Researcher's Forum Committee 2018)	King Mongkut's University of Thechnology Thonburi
16	Mr. Thanapat Poolsawat (Registrar of ATRANS Young Researcher's Forum Committee 2018)	Burapha University
17	Mr. Nopphon Settisakgo (Registrar of ATRANS Young Researcher's Forum Committee 2018)	Burapha University
18	Mr. Pola Rahul (Paper Coordinator of ATRANS Young Researcher's Forum Committee 2018)	Asian Institute of Technology

List of Mentors of AYRF 2018 Committee

AYRF 2017 Mentors		
19	Mr. Songkiet Duangsadee (Mentor of ATRANS Young Researcher's Forum Committee 2018)	Khon Kaen University
20	Mr. Naruphol Niyom (Mentor of ATRANS Young Researcher's Forum Committee 2018)	Prince of Songkla University
21	Mr. Jetsada Kumphong (Mentor of ATRANS Young Researcher's Forum Committee 2018)	Khon Kaen University

List of AYRF 2018 Committee Advisory Committee

International Advisory Committee		
1	Dr. Tuenjai Fukuda	Nihon University, Japan
Local Advisory committee		
2	Asst.Prof.Dr. Varameth Vichiensan	Kasetsart University
3	Asst.Prof.Dr. Sittha Jaensirisak	Ubonratchathani University
4	Asst.Prof.Dr.Paramet Luathep	Prince of Songkla University
5	Dr. Sumet Ongkittikul	Thailand Development Research Institute

List of ATRANS Young Researcher's Forum 2018 Paper Reviewers

NO.	Name	Organization
1	Prof. Dr. Atsushi Fukuda	Nihon University, Japan
2	Prof. Dr. Hironori Suzuki	Chiba University of Technology, Japan
3	Prof. Dr. Alexis Morales Fillone	De La Salle University, Philippines
4	Assoc. Prof. Dr. Chumnong Sorapipatana	King Mongkut's University of Technology Thonburi
5	Assoc. Prof. Dr. Sorawit Narupiti	Chulalongkorn University
6	Assoc. Prof. Dr. Thaned Sathiennam	Khon Kaen University
7	Asst. Prof. Dr. Sittha Jaensirisak	Ubonratchathani University
8	Asst. Prof. Dr. Varameth Vichiensan	Kasetsart University
9	Assoc. Prof. Dr. Viroat Srisurapanon	King Mongkut's University of Technology Thonburi
10	Asst. Prof. Dr. Paramet Luathep	Prince of Songkla University
11	Asst. Prof. Dr. Saroch Boonsiripant	Kasetsart University
12	Asst. Prof. Dr. Preda Pichayapan	Chiang Mai University
13	Dr. Suwat Wanisubut	National Economic and Social Development Board (NESDB)
14	Dr. Rungsun Udomsri	Chiang Mai University
15	Dr. Tuenjai Fukuda	Nihon University, Japan
16	Dr. Thirayoot Limanond	Thai Oil Group
17	Dr. Nuwong Chollacoop	National Metal and Materials Technology (MTEC)
18	Dr. Sumet Ongkittikul	Thailand Development Research Institute (TDRI)
19	Dr. Pattarathep Sillapacharn	Department of Highways, Thailand
20	Dr. Passakon Prathombutr	National Electronics and Computer Technology (NECTEC)

Program of 11th ATRANS Annual Conference on Transportation for a Better Life: Lessons Learned from Global Experiences to Local Best Practices
24 August 2018, 09:00 – 18:00 at Grand Ball Room, 4th Floor, Radisson Blu Plaza Hotel, Sukhumvit Road, Bangkok, Thailand

Day 1, 24Aug2018	Main Conference Day		
08:00 09:00	09:00 – 09:05	09:05 – 09:15	09:15 – 09:40
Registration	Opening Session at Grand Ball Room, 4th Floor Hosted by Dr. Tuenjai Fukuda, ATRANS Secretary – General and Dr.NuwongChollacoop, Vice-Chair of Research Committee		
	Welcome Remarks **Mr. Chamroon TANGPAISALKIT** ATRANS Chairperson	Introductory Remarks **General Pol. Satoshi KAMADA** Executive Director of International Association of Traffic and Safety Sciences (IATSS) and Former Senior Commissioner of National Police Agency, Japan	Opening Remarks **His Excellency, Mr. Arkhom TERMPITTAYAPAISITH** **Minister of Transport, Thailand**
09:40 – 10:00	Coffee break and See exhibition and poster sessions		
10:00 – 12:00	Morning Session – Panel Discussion		

Plenary Session	Moderator	Invited Speaker 1	Invited Speaker 2	Invited Speaker 3	Invited Speaker 4	Invited Speaker 5
Session 1: *Lessons Learned from Global Experiences to Local Best Practices on Road Traffic Safety* **Room**: Grand Ball Room *(Each speaker has 15 minutes for presentation)*	Dr. Witaya CHADBUNCHACHAI Director of WHO Collaborating Center for Injury Prevention and Safety romotion, Thailand	(10:00-10:15) Road Traffic Safety: Lessons Learned from UK to Local Best Practices By **Mr. Barry SHEERMAN** Chairman of Global Network for Road Safety Legislators and Member of Parliament, United Kingdom	(10:15-10:30) Road Traffic Safety: Lessons Learned from Australia to Local Best Practices By **Mr. Robert KLEIN** Traffic Accident Commission International Consultant, Australia	(10:30-10:45) Road Traffic Safety: Lessons Learned from Vietnam By **Dr. Khuat Viet HUNG** Executive Vice Chairman of National Traffic Safety Committee, Vietnam	(10:45-11:00) Accident and Road Safety Managements on National Highway in Thailand By **Mr. Sujin MUNGNIMITR** Director of Highway Safety Bureau, Department of Highways (DOH), Thailand	(11:00-11:15) Road Safety Improvementon the Rural Road Network By **Dr. Chakree BAMRUNGWONG** **Director of Road Safety Audit Bureau, Department of Rural Roads (DRR) Thailand**
45minutes for panel discussion		(11:15-12:00)Panel Discussion				
12:00 – 13:10	Luncheon provided at 27 Bites on 2nd Floor					
13:10 - 15:10	1st Afternoon Session – Parallel Sessions					

Session	Moderator	Speaker	Speaker	Speaker	Speaker
Session*: 2A Smart City: Connecting Peoples* Room: Grand Ballroom A, 4th Floor *(Each speaker has 20 minutes for presentation)*	Asst.Prof.Dr. SitthaJAENSIRISAK Ubonratchathani University, Thailand	(13:10-13:30) Singapore's Smart Mobility Initiatives: Towards a Smart Global City By **Mr. Loh Chow KUANG** President of Singapore Urban Transport International Academy (SingUT)	(13:30-13:50) Policy and Development of Smart City in Japan By Prof.Dr. Atsushi FUKUDA ATRANS Honorable Advisor, Nihon University, Japan	(13:50-14:10) Smart City and Smart Mobility as a Future City By Prof.Dr. Agachai SUMALEE Director of Smart City Research Center, King Mongkut's Institute of Technology Ladkrabang, Hong Kong Polytechnic University	(14:10-14:30) Smart City: Connecting People By **Dr. MonsakSOCHAROENTUM** Senior Expert, Smart City Promotion Dept., Digital Economy Promotion Agency
40 minutes for discussion, Q&A		(14:30-15:10) Discussion, Questions and Answer			
15:10 – 15:30	**Coffee break and See exhibition and poster sessions**				

AYRF 2018Program of Paper Presentation, Parallel Sessions: 2B, 2C, and 2D

Parallel Session	Program of ATRANS Young Researcher's Forum (AYRF) Paper Presentation Sessions		
Duration 13:10 – 15:10	<Session 2>: Parallel Session of ATRANS Young Researcher's Forum Paper Presentation (Each presenter has 12-minute for presentation and 2-minute for questions and answers)		
	<Session 2B>Topics: 1 – 9(English Session) Room: Grand Ballroom B, 4th Floor Chaired by Dr.RungsunUdomsri, ATRANS Board Member *Paper Evaluator: Dr.PattarathepSillapacharn, DOH*	<Session 2C>Topics: 1 – 9(English Session) Room: China Table, 3rd Floor Chaired by *Asst.Prof.Dr.ParametLuathep, Prince of Songkla U.* *Paper Evaluator: Col. Pol. Dr. WaiphotKulachai, Burapha University*	<Session 2D>Topics: 1 – 9(TH Session) Room: The Gallery, 3rd Floor Chaired by *Prof. Dr. Alexis M.Fillone* *De La Salle University, Philippines* *Paper Evaluator: Assoc. Prof.Dr. ThanedSatiennam, KKU*
13:10 – 13:24	AYRF18-002 Impact of dependency parameter of each discrete-continuous choice on model estimation results using Frank copula-based discrete-continuous model By Monorom RITH, Prof. Jose Bienvenido Manuel B. BIONA, and Prof. Dr. Alexis M. FILLONE	AYRF18-016 A Survey on Motorcycle Drivers' Phone Use While Driving in Vietnam By Ha Huy Nguyen Nam	AYRF18-001 Bridge Safety Under Extreme Hydrological Conditions By Chi Thi Kim Thai
13:24 – 13:38	AYRF18-005 Estimating Effects of Fuel Price Hikes on the Transport Sector By Krister Ian Daniel Roquel, Alexis Fillone, and Kris Danielle YU	AYRF18-019 Practical Approach for Improving Safety of School Transport in Thailand By ThanachartPaliyawate	AYRF18-003 Automated Car and Public Acceptance in Developing Countries: Case Study in Viet Nam By Hoang Phuc Hai and Prof. Zhao Sheng Chuan
13:38 - 13:52	AYRF18-010 Good practices on freight transport management: Lessons-learned and applicability for Vietnam By Dr. Nguyen ThiBinh	AYRF18-020 Policy Impacts to Traffic Safety: Experience of Seoul (Korea) and Hanoi (Vietnam) By Dr. An Minh Ngoc	AYRF18-014 Advantages and disadvantages of transport infrastructure connectivity at seaport – a case study of Haiphong (Viet Nam) By Nguyen ThiNhu
13:52 – 14:06	AYRF18-013A study on the trips generated in Southville 7 integrated into the planning of a shuttle service system By Angelo Josh E. Custodio, Jacob D. Layug, Reil Dominic Z. Catolos, Jonathan M. Uy, and Dr. Maria Cecilia R. Paringit	AYRF18-029 A Study on the Effect of Motorcycle Traffic Safety Workshop for High School and University Students in Phnom Penh, Cambodia By ToshikiKoyanagi, Nagahiro Yoshida, and Yuto Kitamura	AYRF18-018 Perspectives of the use of GPS in travel survey: Research on Identification of missing trips in a GPS pilot survey in Hanoi By Dr. Thanh Tu NGUYEN
14:06 – 14:14	8 minutes Break and continue the 2nd half session		

Continued AYRF 2018 Paper Presentation Sessions

Continue AYRF 2018Program of Paper Presentation, Parallel Sessions: 2B, 2C, and 2D

Parallel Session	Program of ATRANS Young Researcher's Forum (AYRF) Paper Presentation Sessions		
Duration 14:14– 15:10	<Session 2B>Topics: 1 – 9(English Session) Room: Grand Ballroom B, 4th Floor Chaired by *Dr.PattarathepSillapacharn, DOH* *Paper Evaluator:* Dr.RungsunUdomsri, ATRANS Board Member	<Session 2C>Topics: 1 – 9(English Session) Room: China Table, 3rd Floor Chaired by *Col. Pol. Dr. WaiphotKulachai, Burapha University* *Paper Evaluator: Asst.Prof.Dr.ParametLuathep, Prince of Songkla U.*	<Session 2D>Topics: 1 – 9(TH Session) Room: The Gallery, 3rd Floor Chaired by Assoc. Prof.Dr. ThanedSatiennam, KKU *Paper Evaluator:* Prof. Dr. Alexis M.Fillone *De La Salle University, Philippines*
14:14– 14:28	AYRF18-017 A GPS-based Application for On-road Emergency Needs of Drivers By Maria Cristine Mariano Tan, Kathleen Ann Reyes Dacullo, Max Aldea del Rosario, Lance Kua Koa, Prof. Dr. Alexis Morales Fillone, and Dr. Maria Cecilia Rubio Paringit	AYRF18-015TH Study risk behavior of motorcyclists on Mittraphap Road in KhonKaen, Thailand By NattawatRasri, ChananonChonyuth, NuttawutSriponpek, JetsadaKumphong, and Assoc.Prof.Dr. ThanedSatiennam	AYRF18-022 Study on Traffic Management in Order to Reduce Congestion [Surrounding Areas of Primary Schools in Center of Hanoi By Vu Van Huy, Ngo Trung Phuong, Nguyen The Ngoc Anh, and Assoc.Prof.Dr. Dinh Van Hiep
14:28 – 14:42	AYRF18-024 Estimation of Disaster Damage Costs by Urban Flood and Impacts of Adaptation Policies -The Case Study of KhonKaen, Thailand- By Noriyasu TSUMITA, Hiroki KIKUCHI, and Prof. Dr. Atsushi FUKUDA	AYRF18-028TH Effects of Motorcycle Lane Width on Traffic Efficiency By JatuwitSuwannarong	AYRF18-023 Strategy for Multimodal Transport Development: Case Study of Hanoi-Lao Cai Corridor By Dr. Le Thu Huyen and Dr. Pham Hong Nga
14:42 – 14:56	AYRF18-026 Analysis of Park and Ride Usage in Bangkok Metropolitan Region -Case of Adjacent Area along Purple Line- By HirotoNuma, Hironori Ozawa, Dr. MalaithamSathita, Prof. Dr. Atsushi Fukuda, and Asst.Prof.Dr. VaramethVichiensan	AYRF18-031TH Effects Of Health Literacy Program With Shot Film Multimedia On VCD For Creating Health Literacy Skill In The Prevention Of Traffic Accidents From Motorcycles in 60-69 Years Old of The Elderly In KasetSombun District, Chaiyaphum Province By NutthaChumnanya	AYRF18-025Reliability of Breadth First Search finding missing link of Bluetooth data collection: Case study Bangkok, Thailand By Dr. RattanapornKasemsri, Piyapong SUWANNO, Prof. Dr. Atsushi FUKUDA, Assoc. Prof. Tetsuhiro ISHIZAKA, Assoc. Prof. Sorawit NARUPITI
14:56 – 15:10	AYRF18-032Assessment on-Street Parking Demand Depend on Land Use in Downtown, Case Study; Kahramanmaras City, Turkey By Ahmet Basid DOGRU, Ahmet YILDIRIM, and Sayana SER		
15:10 – 15:30	Coffee break and See exhibition and poster sessions		

Continued Program of 11th ATRANS Annual Conference

Continued Program of 11th ATRANS Annual Conference on Transportation for a Better Life: Lessons Learned from Global Experiences to Local Best Practices

15:30 - 17:30	2nd Afternoon Session – Parallel Sessions					
	Moderator	Invited Speaker 1	Invited Speaker 2	Invited Speaker 3	Invited Speaker 4	
Session*: 3A* *Friendly Transportation-related issues* **Room:**Grand Ballroom A, 4th Floor (*Each speaker has 20 minutes for presentation)*	Prof. Dr. Atsushi FUKUDA Nihon University, Japan	(15:30 – 15:50) Friendly Public transportation in Asia and Central America By **Prof. Dr. Fumihiko NAKAMURA** Vice President, Yokohama National University, Japan	(15:50 – 16:10) Utilization of ITS for Management of Public Transportation By Assoc.Prof.Dr. Sorawit NARUPITI Chulalongkorn University	(16:10 – 16:30) Walkability and Accessibility to enhance Public Transportation Usage By **Capt.Dr. Tongkarn KAEWCHALERMTONG** Chulachomklao Royal Military Academy	(16:30-16:50) Energy Efficiency and Multi-Purpose-Mobility for friendly transport of Senior People By **Mr. Junichi YASU,** JICA Expert, Accurate Systems Inc., and **Dr. YoshinoriKONDO,** National Institute of Environmental Studies (NIES), Japan	
40 minutes for Q&A		(16:50-17:30) Discussion, Questions and Answers				
Session3B: *Road Safety and Education* **Room**: Grand Ballroom B, 4th Floor *(Each speaker has 15 minutes for presentation)*	(15:30 - 15:45) Report of IATSS Cambodia Project Moderated and Presented by **Prof. Dr. Yuto KITAMURA** University of Tokyo, Japan	(15:45 – 16:00) Road Safety Education and Behavior in Vietnam By Dr. Khuat Viet HUNG Executive Vice Chairman of National Traffic Safety Committee, Vietnam	(16:00 – 16:15) Factors Impact to Behavior of E-Bikers By Dr. Pham Thi Kim NGOC Head of Science Management and Law Dept., Hanoi University of Science and Technology, Vietnam	**(16:15 – 16:30)** Influencing Change in Unsafe Driving by Road Safety Education By Asst. Prof. Dr. Sittha JAENSIRISAK Ubonratchanathi University	(16:30 – 16:45) The effectiveness of "Mirroring Method"IATSS Road Safety Research Project in Japan By **Prof.Dr. Kazuhisa OGAWA** Tohoku University, Japan	(16:45 – 17:00) Motorcycle Safety - Technical & Institutional Approaches - By Mr. Keigo YOSHIDA HONDA Research and Development, Japan
30 minutes for Q&A		(17:00-17:30) Discussion, Questions and Answers				
Session 3C: ***Logistics*** Room: The Gallery, 3rd Floor (Each speaker has 20 minutes for presentation)	Dr. Sumet ONGKITTIKUL Research Director, Transportation & Logistics Policy, Thailand Development Research Institute (TDRI)	(15:30 – 15:50) Logistics Management in Thailand By **Dr. Jirapan LIANGROKAPART** Director, Logistics an Engineering Management Program, Mahidol University	(15:50 – 16:10) Cross BorderTransportation forEECfrom Practitioner Perspective By **Dr. Surat JANTHONGPAN** Cross Border Transportation Thailand Product Head, KWE-Kintetsu World Express (Thailand) Co.,Ltd.	(16:10 – 16:30) Green Freight and Logistics: Global Experiences to Local Best Practices, GIZ Perspective By **Mr. Friedel SEHLLEIER** Project Deputy Director Transport and Climate Change (TCC), GIZ Office Thailand	(16:30 – 16:50) Logistics, SCG Perspective By Mr. Chalat WONGSANGUAN Managing Director of SCG Skills Development Co., Ltd.	
40 minutes for Q&A		(16:50-17:30) Discussion, Questions and Answers				

Remarks: (1) Exhibition and Poster Sessions together with morning and afternoon Coffee Breaks are provided during 09:40 – 10:00 and 15:10 – 15:30.

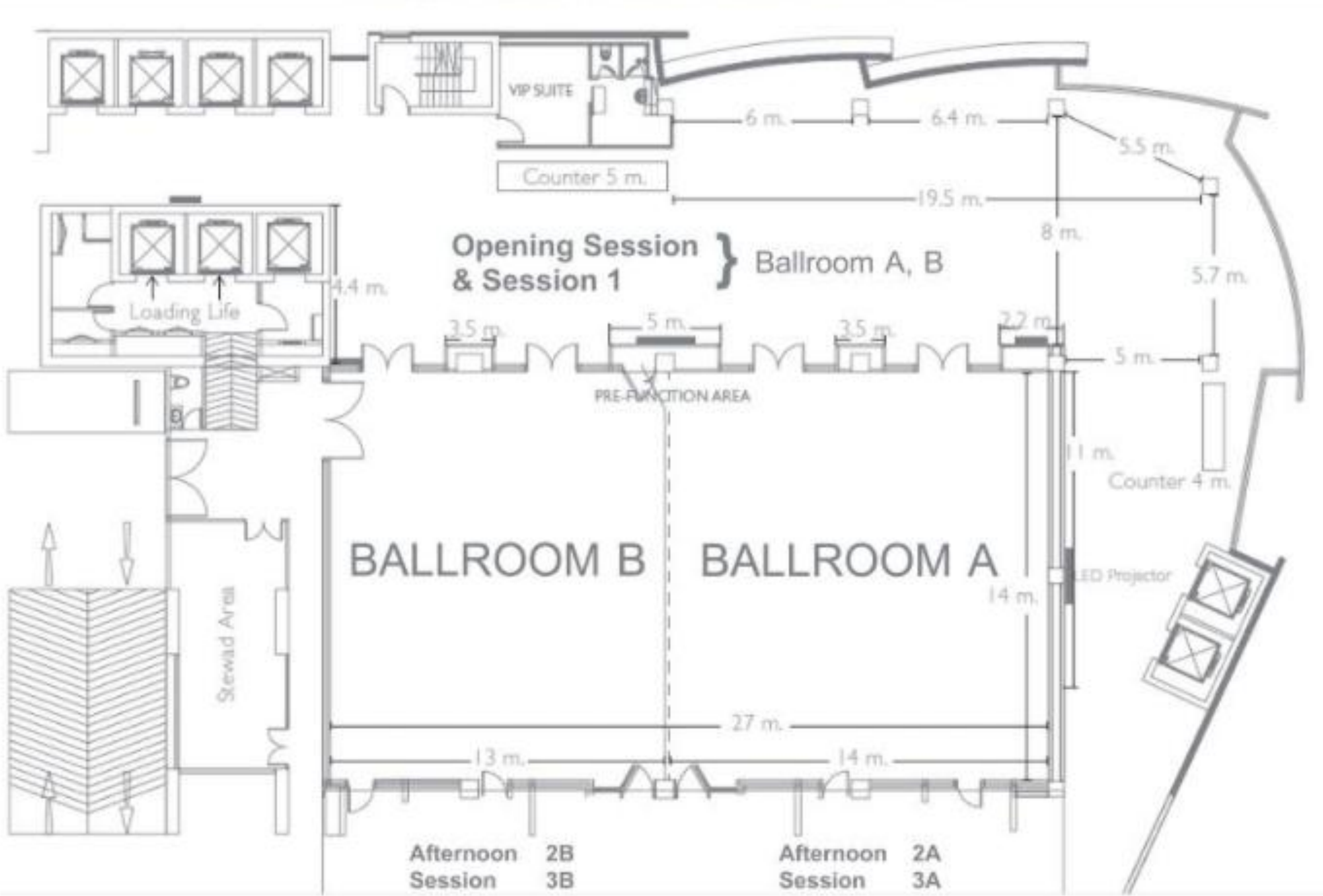
Continued Program of 11th ATRANS Annual Conference on Transportation for a Better Life: Lessons Learned from Global Experiences to Local Best Practices

17:30 – 18:00	Presents Certification to AYRF Presenters	**Presents Best Paper & Presentation Awards**	**Presents Certification to AYRF 2017 Committee**	**Closing Remark**
	By Mr. ChamroonTangpaisalkit, ATRANS Chairperson			
19:00 – 21:30	**Reception at ESC Bar by the pool, the Radisson Blu Plaza Hotel(By Invitation only)**			

Remarks:(1) Exhibition and Poster Sessions together with morning and afternoon Coffee Breaks are provided during 09:40 – 10:00 and 15:10 – 15:30.

Day 2, 25 August 2018	***Technical Visit – Transit Oriented Development (TOD) atBang Sue Central Station***	
Duration	**Program**	**Remarks**
8:20 – 8:30	Gathering at Radisson Blu Plaza Hotel	**The technical visit is under patronage of MOT.**
8:30-9:30	Departure from Hotel by Buses and arrival at Bang Sue Central Station	
9:30-10:00	Arrival at Bang Sue Central Station and have a Short break	2 buses are provided **by AP HONDA.**
10:00 – 11:30	Listen to introductory presentation &observation at the field site	**There will be an intro presentation and explanation in English only.**
11:30 - 11:45	Conclusion of technical visit & Group Photo Taken	Light meal and soft drinks are provided on board.
11:45 – 12:45	Leave Bang Sue Central Station and Back to Hotel by buses and End of the program	

Main Conference Floor located on 4th Floor



Parellel Sessions of 2C, 2D, 3C and 3D located on 3rd Floor

CONTENTS

AYRF Paper Presentations Sessions

Bridge Safety Under Extreme Hydrological Conditions

Topic number: 09 Paper Identification number: AYRF18-001

Thi Kim Chi THAI[1]

[1]Department of Urban Transport and Coastal Engineering, Faculty of Civil Engineering
University of Transport and Communications
Telephone (+84) 988 115 110, Fax. (+84.24) 37 669 613
E-mail: chittk@utc.edu.vn

Abstract

Nowadays because of climate change and global warming, number of natural disasters such as typhoons, hurricanes, storms and floods has increased. It causes the inundation and failures of transportation infrastructures including bridges which were not designed for extreme hydrological conditions. Understanding the complex turbulent flow under these critical conditions is crucial to estimate the probability of failure risks for existing bridges and optimal design of future bridges. In the present paper, flow dynamics over a submerged bridge deck with length-to-thickness ratio 1:5 is numerically investigated by using ANSYS FLUENT. The method of k-ε and volume of fraction (VOF) is applied to predict the complex water surface profiles over the bridge deck and turbulence characteristics including backwater effect upstream of the bridge. The drag coefficient is also determined to evaluate the stability of structures.

Keywords: Turbulence, Aspect ratio, Volume of fraction (VOF), Water surface, Vietnam

1. Introduction

Vietnam is a country located in the East Asia with over 3450 rivers and streams and a 3260 km long coastline. Vietnam is always at highest risk from natural disaster such as hurricanes, storms, typhoons and floods. Vietnam's transportation infrastructure was often damaged by the flooding. Flood flows from upstream rivers inundated the surrounding areas and damaged many bridges. For example, two years ago five floods during October–December 2016 caused heavy damage to the transportation infrastructure, mostly roads and bridges, in the eighteen provinces of Vietnam.

Fig. 1 Bridge in Binh Dinh was shattered by the flood, 2013

Fig. 2 A bridge collapsed in Thua Thien Hue province, Vietnam, 2016

Fig. 3 Rin River Bridge fully inundated by the

flood, 2017

During flood and other natural disasters, the water level rapidly increases and consequently the bridges are got fully or partially submerged. Hydrodynamic forces caused by flood flows have great importance in the design of bridges. It can cause the shearing or overturning of the bridge deck and failure of the bridge superstructures. The bridges subjected to inundated conditions are more liable to failure. Therefore, understanding the turbulent flow and determination the hydrodynamic loads on the bridge is crucial to evaluate the bridge safety. The proper estimation of loading caused by the flow on the structure is very important for design evaluating its vulnerability.

2. Literature review

In order to estimate the stability of bridges, the drag force plays very important role. The drag force is a combination of viscous drag and pressure drag which is dependent mainly on the geometry of the body, the location of separation and reattachment points.

In 1995, The Federal Highway Administration (FHWA) researched on the hydrodynamic loads on piers and the bridge deck. They suggested a constant value of drag coefficient within the range 2.0 to 2.2. The drag coefficient for fully or partially submerged bridge superstructure can be calculated using the following equation:

$$F_D = \frac{C_D \rho U_0^2 H}{2}$$

where:
F_D: drag force per unit length of bridge, N/m;
ρ: the water density, assumed equal to 1000 kg/m^3;
H: depth of submergence, m;
U_0: flow velocity, m/s;
C_D: drag coefficient per unit length.

Most studies in the literature have examined the hydrodynamic loading on the unsubmerged bridge deck but there are only a few studies about water flow over inundated bridges and the accompanying water surface profiles.

Okajima et. al (1997) analyzed the blockage effect on the drag coefficient for a rectangular bridge deck.

Malavasi & Guadagnini (2003, 2007) carried out experiments to examine the hydrodynamic loading on bridge decks with the aspect ratio of the cylinder was $L/D = 3$ and $L/D = 1$ (where L is the streamwise length of the cylinder and D is the height) for different submergence levels, Reynolds numbers and deck Froude numbers (Figure 4).

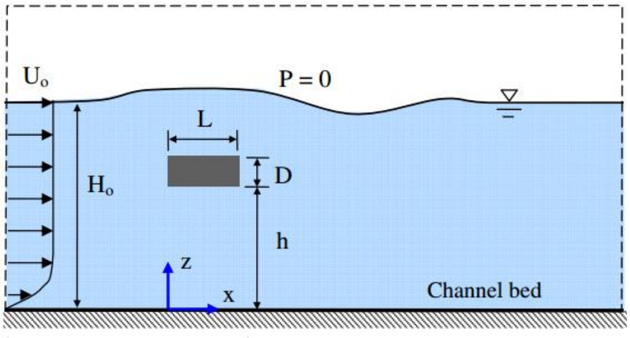


Fig. 4 A Schematic diagram of a fully submerged cylinder (Malavasi & Guadagnini, 2003)

In 2008, Malavasi with Trabucchi used a three-dimensional k-ε turbulence model to investigate the proximity effects of a solid wall on the wake flow of a rectangular cylinder (aspect ratio $L/D = 3$) placed above a solid wall with different gap ratios h/D.

Picek, Havlik, Mattas, & Mares (2007) conducted experiments to calculate of flow through partially or fully submerged rectangular bridge decks.

Lee, Nakagawa, Kawaike, Baba, & Zhang (2010) experimentally and numerically studied the water surface profiles of the flow around different bridge structures.

Chu C. et al. (2012, 2016) used a Large Eddy Simulation (LES) model to investigate the interactions between a free surface flow and fully submerged bridge decks for different Reynolds number, Froude number, submergence ratio and blockage ratio. He also conducted an experiment in a water flume on a rectangular cylinder with the aspect ratio $L/D = 3$.

All the above mentioned studies only examined the flow over the bridge deck with the aspect ratio $L/D \le 3$ through experiments and numerical simulations by using OpenFOAM. Although most of the bridge decks are quite elongated but there are no available studies the water flow over bridge decks with aspect ratios larger than 3.

Therefore, the present paper numerically studies the drag coefficient and water surface profiles of turbulent flow over the submerged bridge but with aspect ratio of the deck $L/D = 5$.

3. Methodology

In this study, numerical simulations were carried out using FLUENT package which is a strong analysis tool for modeling based on the finite volume method. The finite element method is developed for numerical solution of complex problems in different fields with varying geometries, material types and loadings. In this method, the complex models are first divided into smaller, simpler and solvable elements called finite elements. Then, by assembling the results of solving each element into larger system, the total solution of model is obtained.

The realizable k-ε model is chosen to model the turbulent flow over the submerged bridge deck with the aspect ratio 1:5. This realizable model was developed by Shih et al. (1994), and it contains a different transport equation for the turbulent dissipation rate ε, than the traditional k- ε approach.

This turbulence model differs from the standard model in that it contains a new alternative formulation for the turbulent viscosity and a new modified transport equation for the ε derived from an exact equation for the transport of the mean-square vorticity fluctuations. The term realizable means that the model satisfies some certain mathematical constraints on the Reynolds stresses consistent with the physics of turbulent flows (Shih et al. 1995).

Comparing with standard model, the realizable k-ε model has many advantages such as: more accurately predicts the spreading rate of both planar and round jets; provide superior performance for flows involving rotation, boundary layers under strong adverse pressure gradients, separation, recirculation and strong streamline curvature.

The modeled transport equations for k and ε in the realizable k-ε model are:

$$\frac{\partial}{\partial t}(\rho k)+\frac{\partial}{\partial x_j}(\rho k u_j)=\frac{\partial}{\partial x_j}\left[\left(\mu+\frac{\mu_t}{\mu_k}\right)\frac{\partial k}{\partial x_j}\right]+G_k+$$
$$+G_b+\rho\varepsilon-Y_M+S_k;$$

$$\frac{\partial}{\partial t}(\rho\varepsilon)+\frac{\partial}{\partial x_j}(\rho\varepsilon u_j)=\frac{\partial}{\partial x_j}\left[\left(\mu+\frac{\mu_t}{\sigma_\varepsilon}\right)\frac{\partial\varepsilon}{\partial x_j}\right]+\rho C_1 S\varepsilon-$$
$$-\rho C_2\frac{\varepsilon^2}{k+\sqrt{\nu\varepsilon}}+C_{1\varepsilon}\frac{\varepsilon}{k}C_{3\varepsilon}G_b+S_\varepsilon;$$

$$C_1=\max\left[0.43,\frac{\eta}{\eta+5}\right],\ \ \eta=S\frac{k}{\varepsilon},\ \ S=\sqrt{2S_{ij}S_{ij}};$$

where:
G_k - represents the generation of turbulence kinetic energy due to the mean velocity gradients;
G_b - the generation of turbulence kinetic energy due to buoyancy;
Y_M - the contribution of the fluctuating dilatation in compressible turbulence to the overall dissipation rate;
C_2, $C_{1\varepsilon}$ - constants;
σ_k, σ_ε - the turbulent Prandtl numbers for k and ε, respectively;
S_k, S_ε - user-defined source terms.

Beside the realizable k-ε model, the Volume of Fraction method was considered to determine more accurately the water surface profiles. Based on the obtained date, the drag coefficient can be determined.

The VOF method is proposed by Hirt and Nichols in 1981. It based on the concept of a fractional volume of fluid to calculate the shape and location of a constant-pressure free surface boundary. In this scheme, two or more fluids can be modeled by solving one set of momentum equations for all fluids and for turbulent flows; a single set of turbulence transport equation is solved. The Interface tracking scheme is used to locate free surface flow. It is assumed that two or more fluids in the flow domain are not interpenetrating. The Navier Stoke equations are solved in either Cartesian or cylindrical coordinates

In this method, the volume fraction α in the two-phase flow varies from 0 to 1 and is obtained from a transport equation:

$$\frac{\partial\alpha}{\partial t}+\frac{\partial}{\partial x_j}\left(\alpha\bar{u}_j\right)=0$$

The value of $\alpha=1$ corresponds to a cell full of water; and $\alpha=0$ to the cell is full of air.

Data from works carried out by Malavasi (2008) were adopted as benchmark to clarify the accuracy of the FLUENT numerical model in simulating flows over submerged bridge decks. The conditions set for the numerical simulations were the same as those used in the experiment.

Design Modeler and Meshing tool of Workbench were used to create the geometry model and to generate the mesh model.

Initial data were: thickness D = 0.06 m, distance from the underside of the deck to the channel floor was $h = 0.14$ m, upstream velocity $U = 1$ m/s, water depth of the undisturbed flow $H = 0.26$ m. The inlet is placed 15D upstream of the deck and the outlet 30D downstream to capture the whole velocity field and give accurate results.

The grid near the bridge deck was denser because the flow pattern in the region is more complex and gradually increases away from the bridge deck. The height of first layer near the surface of bridge deck is 0.005D. The minimum orthogonal quality is 0.6, which is considered as good quality.

The boundary conditions include inlet, outlet, top, bottom and walls. Considering the VOF method, the flow domain was divided into two phases, air and water. Air was considered as the secondary phase.

The operating pressure is 101325 Pascal. The operating density was set as the density of the lightest phase (air) that is 1.225 kg/m3. Respectively, the inlet has two parts: the lower part where water is coming in and upper part is for air. At the water inlet part, a uniform velocity is applied.

The outlet boundary was defined as the pressure outlet used to specify a static gauge pressure at the boundary. Top boundary is given as pressure outlet with a zero atmospheric pressure. Bottom and deck are considered as no-slip wall. The geometry of the 2D solution domain and the boundary conditions used for the numerical simulations are shown in Fig. 5.

Fig. 5 Computational domain and boundary conditions

To obtain results more accurately, in the present study, the PISO algorithm (Pressure Implicit with Splitting of Operators) is used for pressure-velocity coupling, PRESTO Scheme - for pressure discretization and QUICK - for momentum, kinetic energy and dissipation equations.

4. Results

Before employing the numerical model to study the flow over the bridge deck, the numerical simulation for the deck with the aspect ratio $L/D = 3$ have been performed and compared with the data from Chu's works in order to validate models using by author. The blockage ratio was defined as:

$$Br = D/H = 0.23,$$

the submergence ratio:

$$h^* = (H - h)/D = 2.$$

The Reynolds number was:

$$\mathrm{Re} = \frac{UD}{\nu} = 60000 \ ;$$

the Froude number of the flow:

$$Fr = \frac{U}{\sqrt{gH}} = 0.63;$$

the deck Froude number:

$$Fr_D = \frac{U}{\sqrt{gD}} = 1.3.$$

As the results, the drag coefficient equals 2.70. Comparing to the drag coefficient obtained by Chu (2016), a good agreement between them has been observed. The error was $(2.70 - 2.64) \cdot 100/2.64 = 2.3\%$ that proved the capability of the present numerical model.

Figure 6 shows the free surface water profiles of the flow over the desks with aspect ratios $L/D = 5$. The shape of water surface profiles over submerged bridge deck is quite complex.

First, a backwater effect appeared at the upstream of the deck, and then the water surface suddenly dropped and gradually recovered. For the desk with smaller aspect ratio ($L/D = 3$), the water level decreased more dramatically at the downstream.

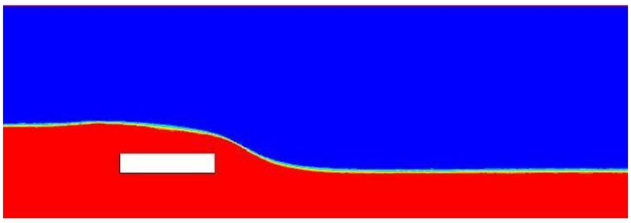


Fig. 6 Free surface water profiles

The streamlines over the bridge decks of the mean flow structures are shown in figure 7. The breadth of the body is long enough to allow reattachment of the separated flow, which significantly affects the flow characteristics such as the shedding of vortices from the trailing edge of the sections.

As we can see from figure 7, the vortices around the bridge deck are asymmetry. The main vortices acting on the lower side of bridge deck have a longer length than on the upper side. As the shear layer gets separated at the leading corner, the main vortex is formed along the cylinder side. The reattachment occurs at the end of the vortex at the upper side of the deck but not at the lower side. The flow at the upper side gets separated at the trailing corner. Lower vortices covered the whole length of the deck and no reattachment is observed.

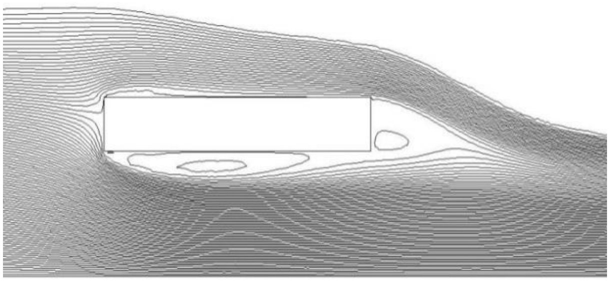


Fig. 7 Schematic of mean flow structure

A reversed flow in the wake region is generated. Two vortices are generated in the reversed flow region along the rear sides of the deck in the case of the aspect ratio $L/D = 5$. The shear layers from upper and lower side of the deck meet at the distance about 2D. In figure 8, the reversed flow in the wake region at the downstream of the bridge decks are plotted.

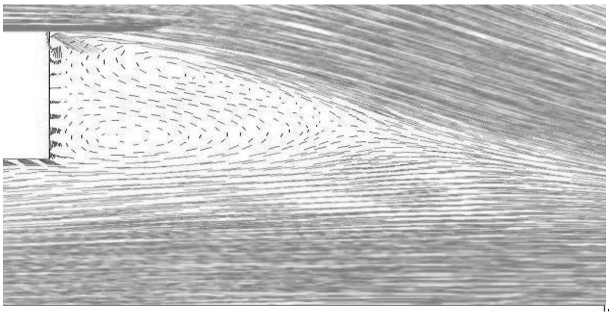


Fig. 8 Reversed flow in the wake region

The contours of velocity are shown in figure 9. As we can see, the length of the bridge deck does not affect the velocity field upstream. At the downstream, the aspect ratio clearly influences the velocity distributions.

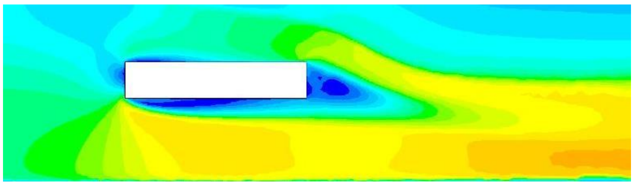


Fig. 9 The contours of velocity

The velocity contours illustrate that the pressure flow is separated by the bridge deck, resulting in the increase of flow velocity under the bridge deck. It showed low or negative velocities under the bridge deck that influence the stability of the bridge deck.

For bridge deck with aspect ratio $L/D = 5$, the reattachment of the flow allows vortices to travel further along the cylinder side surface to the trailing edge, affects the shedding characteristics of the flow in the wake region.

In the case of the aspect ratio $L/D = 5$, the drag coefficient decreased to 2.47. It can be explained by the fact that the drag force is dependent on the geometry of the body and the location of separation and reattachment points. While the pressure distribution along the side surface of the deck changes, a region of higher pressure occurs after flow reattachment. This pressure recovery region pushes the vortices further downstream. The further downstream the vortices form from the trailing edge of the cylinder, the base suction pressure decreases and the lower the drag. Besides it, friction also affects the drag force in dependent with bridge deck's aspect ratio. According to The Federal Highway Administration (FHWA), the submerged bridge deck in this case is not in safe zone but at high risk of damages.

5. Conclusion

Under extreme hydrological conditions, the water flow creates a backwater effect upstream of the submerged bridge deck and a fluctuating water surface profile over the bridge deck and then immediately downstream.

The present study showed that ANSYS FLUENT software is useful to study the turbulent flow without going for expensive and time consuming experiments. The water surface profiles and drag coefficient on submerged bridge decks with aspect ratio 1:5 can be accurately predicted with a k-ε model and VOF method.

As results, the obtained data in this study enhance the understanding of the hydrodynamic characteristics of the flow over a bridge deck section with different aspect ratio. Author hopes that it can help researchers to evaluate the bridge safety under extreme hydrological events.

References

[1] Chu Chia, Chung Chun-Hsuan, Wu Tso-Ren, Wang Chung-Yue. (2016). *Numerical Analysis of Free Surface Flow over a Submerged Rectangular Bridge Deck*. Journal of Hydraulic Engineering. 143.10.1061/(ASCE)HY.1943-7900.0001177.

[2] Federal Highway Administration (FHWA). (1995). *Stream stability at highway structures*, Rep. No. FHWA-HI-96-032, FHWA, Washington, D.C., 56 – 59

[3] Fox, R. W., McDonald, A. T., and Pritchard, P. J. (2004). *An introduction to fluid mechanics*, 6th Ed., Wiley, New York.

[4] Hamill, L. (1999). *Bridge hydraulics*, E&FN Spon, London.

[5] Hirt, C. W., and Nichols, B. D. (1981). *Volume of fluid (VOF) method for the dynamics of free boundaries*. J. Comp. Phys., 39(1), 201–225.

[6] Kreft, S., Eckstein, D., Melchior, I. (2016) Global climate risk index 2017, Who Suffers Most From Extreme weather Events? Weather-related Loss Events in 2015 and 1996 to 2015, edited by: Chapman-Rose, J., and Baum, D., Germanwatch e.V., Berlin.

[7] Lee D., Nakagawa H., Kawaike K., Baba Y., Zhang H. (2010). *Inundation flow considering overflow due to water level rise by river structures*. Annuals of Disaster Prevention Research Institute,, Kyoto University, No. 53 B.

[8] Malavasi S., Guadagnini A. (2003). *Hydrodynamic loading on river bridges*. J. Hydraul. Eng.,10.1061/(ASCE)0733-9429(2003)129:11(854), 854–861.

[9] Malavasi S., Guadagnini A. (2007). *Interactions between a rectangular cylinder and a free-surface flow*. J. Fluids Struct., 23(8), 1137–1148.

[10] NHMS. (2015). *Statistics of annual major storms (Levels from 6 to 12) struck Vietnam between 1961 and 2014*, National Hydro -Meteorological Service (NHMS), Ministry of Natural Resources and Environment, Vietnam.

[11] Picek T., Havlik A., Mattas D., Mares K. (2007). *Hydraulic calculation of bridges at high water stages*. J. Hydraul. Res., 45(3), 400–406

[12] Rapid Flood Damage and Needs Assessment (RFDNA), Vietnam 2016.

Impact of Dependency Parameters of Each Discrete-Continuous Choice on Model Estimation Results Using Frank Copula-Based Discrete-Continuous Model

Topic number: 6; Paper Identification number: AYRF2018-002

Monorom RITH[1], Jose Bienvenido BIONA[2], Alexis FILLONE[3]

[1] Doctoral student, Mechanical Engineering Department, Gokongwei College of Engineering
De La Salle University
Telephone: (+63) 966 480 9818
Email: rith_monorom@dlsu.edu.ph

[2] Professor, Mechanical Engineering Department, Gokongwei College of Engineering
De La Salle University
Telephone: (+63) 998 993 9398
Email: jose.bienvenido.biona@dlsu.edu.ph

[3] Professor, Civil Engineering Department, Gokongwei College of Engineering
De La Salle University
Telephone : (+63) 939 934 3195
Email: alexis.fillone@dlsu.edu.ph

Abstract

Upon the previous studies, Frank copula-based discrete-continuous model provides the best fit for sample selection model in term of Akaike Information Criteria (AIC) or Bayesian Information Criteria (BIC) as compared to the joint model based on the other copula types. This present paper is aimed to investigate the impact of dependency parameters of each discrete-continuous choice on the estimated results of the Frank copula-based joint model. Four different joint models with different dependency parameters were implemented for comparative studies. A sample data of vehicle type ownership and vehicle fuel consumption collected in Metro Manila in 2017 was used to fulfill the study's objective. AIC, absolute percentage bias (APB), and root mean square error (RMSE) were used as estimators of relative quality of joint model fit, estimated discrete choice component, and goodness-of-fit of continuous choice component, respectively, among different statistical models. Additionally, expected fraction of discrete choice component and mean estimated fuel consumption were also used to measure quality of model estimation results. It is highlighted that dependency parameters really have great effect on the model estimation results.

Keywords: Frank copula, Discrete-continuous model, Vehicle type ownership, vehicle fuel consumption

1. Introduction

In the real world, people might make two choices or more at the same time. If two choices have the same nature (discrete-discrete choice), we could apply Nested Logit model [see 1, 2, 3] or Bivariate Order Probit model [see 4, 5]. In some cases, the two choices have different nature (discrete-continuous choice) such as individual vehicle type holding and vehicle miles of travel [6], tourism participation and expenditure [7], neighborhood type choice for residence and vehicle miles of travel [8], and vehicle type holding and use [9]. The two choices might be inter-correlated and there might be unobserved factors affecting the two choices at the same time (called self-selection effect).

Bhat and Eluru (2009) proposed to use a Copula function to combine discrete choice equation with continuous choice equation as a single bundle of two different equations, which can capture magnitude of dependency between the two different choices for each multinomial regime [8]. A bivariate joint distribution function is used to couple two univariate distributions that are independent of each marginal distribution pattern, represented by the Copula function [10,11]. The copula-based discrete-continuous model can capture non-linear and asymmetric dependency structure between the two choices and provide flexible dependency structure via using various copula types, which provides a better goodness of fit and overcome restrictive assumptions and limitations as compared with Lee's (1983) approach [8, 12]. Evident from the previous studies, Frank copula is obtained as the dependency structure for the best fit of the joint model of vehicle type choice and usage [6, 9], but the estimated results were found less accurate [6]. An investigation of the impact of dependency parameters on model estimation results has been less investigated.

Consequently, this present paper is aimed to demonstrate the impact of dependency parameters between the two choices for each multinomial regime on the estimated results. Frank copula was chosen to couple the two choices because such a copula type provides the best fit of the joint model. A sample data of vehicle type choice and vehicle fuel consumption in Metro Manila was used for empirical analysis of the joint discrete-continuous choice. From our practical point of view, the empirical findings from this study is highly expected to be informative and helpful for analysts of discrete-continuous choice behavior to get better understanding of the impact of dependency parameters on accuracy of model estimation results for empirical analysis of sample data in the field of transportation and related disciplines.

The remainder of the paper is structured as follows. Following a brief literature review concerning the joint discrete-continuous models, the next section presents mathematical framework of the Frank-copula based discrete-continuous model. Then, the sample data for empirical analysis is described. The penultimate section presents the results and discussions. The final section concludes the empirical findings.

2. Literature Review

This section demonstrates a brief description of joint discrete-continuous models. Based on Heckman's (1974, 1976) method for binary choice situations [13, 14], Hay (1980) and Dubin and McFadden (1984) developed a sequential estimation technique, called two-step approach [15, 16]. Such approach is related to a specific form of linearity between the error terms in the discrete choice and the continuous choice rather than pre-specified bivariate distribution. However, such an approach may be unreliable and unstable in application if

explanatory variables in the discrete choice equation and the continuous choice equation are collinear at high degree [17, 18]. Lee (1983) customized Heckman's (1974) approach using full-information maximum likelihood approach with bivariate normal distribution to couple two normal univariates transformed from non-normal variables [12]. This approach has a drawback of allowing only linear and symmetric dependencies, because marginal distribution of error term of each choice have to be transformed to standard normal random variables and then the bivariate normal distribution function is used to couple such transformed random variables.

Bhat and Eluru (2009) generalized Lee's approach by adopting the "Copula" approach to couple two univariate marginal distributions that can allow non-linear and asymmetric dependency structure [8]. The integrated discrete-continuous model based on copula approach can provide a better goodness of fit and overcome restrictive assumptions and limitations as compared with Lee's approach. Some studies have applied copula-based joint model using various copula types to identify a copula type that provides the best fit in term of Akaike Information Criteria (AIC) or Bayesian Information Criteria (BIC) in order to investigate determinants of discrete choice and continuous choice and unobserved factor affecting the two choices at the same time. Bhat and Eluru (2009) proposed to use various copula types (Frank, Gaussian, Gumbel, Joe, FGM, and Clayton) to integrate discrete-continuous choices using simultaneous simulation approach to estimate the joint model [8]. Similarly, Spissu et al. (2009) and Nguyen et al. (2017) have applied the copula-based discrete-continuous model to investigate determinants of vehicle type choice and usage [9, 6]. The previous studies have showed that Frank copula is superior to the other copula types in term of best fit. However, the Frank copula-based joint model using simultaneous estimation approach does not accurately predict the results for both the continuous choice and the discrete choice components. Rith et al. (2018) employed sequential estimation approach in place of simultaneous estimation approach to estimate the Frank copula-based joint model for vehicle type choice and fuel used [19]. The results highlight that the estimated results were very close to the observed data for all the choices. Therefore, this present paper uses the sequential maximum simulated likelihood estimation approach to study the impact of dependency parameters on model estimation results. This study can find out the reasons of under-estimation or over-estimation for the continuous choice equation.

3. Methodology

3.1 Frank Copula-Based Joint Model

Discrete choice equation: This section is intended to provide a mathematical framework of the integrated multinomial logit-linear regression model based on Frank copula. Multinomial logit (MNL) model is widely used and well-known for empirical analysis of polychotomous discrete choice because the formula for probability takes the closed form and is readily interpretable [3]. In 1974, McFadden assumed the unobserved component of each alternative to be identically and independently distributed Type I Extreme-Value [3]. The indicated cumulative distribution of the random error term of a chosen alternative $F(\varepsilon_{nm})$ can be shown as equation 1 [3]. $\Pr(Alt_n = m)$ is the probability of a chosen alternative. "m" defines alternative type and "n" defines an individual who made choice decision. x_{nm} refers a column vector of observed variables of alternative "m" made by an individual "n". β'_m is a corresponding vector of coefficients of the observed variables.

$$F(\varepsilon_{nm}) = \Pr(Alt_n = m) = \frac{\exp(\beta'_m x_{nm})}{\sum_{m=1}^{M} \exp(\beta'_m x_{nm})} \quad (1)$$

Continuous choice equation: If the continuous choice is positive, we assume the continuous choice to be log-normal distributed or natural logarithm of the continuous choice is normally distributed. y_{nm} is a column vector of explanatory variables, α'_m is a column vector of the corresponding coefficients, and η_{nm} refers to the unobserved term. $f(\eta_{nm})$ and $F(\eta_{nm})$ are the probability density function and the indicated cumulative distribution of the random error term as expressed as equation 3 and 4 [20]. ϕ and Φ are the probability density function and cumulative distribution function of the standard normal distribution, respectively, with disturbance of mean zero and unit variance. "l_{nm}" refers to the continuous choice made by an individual "n".

$$\ln(l_{nm}) = \alpha'_m y_{nm} + \eta_{nm} \quad (2)$$

$$f(\eta_{nm}) = \Pr(\ln(L_{nm}) = \ln(l_{nm})) = \frac{1}{\sigma_m}\phi\left(\frac{\ln(l_{nm}) - \alpha'_m y_{nm}}{\sigma_m}\right) \quad (3)$$

$$F(\eta_{nm}) = \Pr(\ln(L_{nm}) \leq \ln(l_{nm})) = \Phi\left(\frac{\ln(l_{nm}) - \alpha'_m y_{nm}}{\sigma_m}\right) \quad (4)$$

Joint model: Based on Sklar's theorem, two univariate distributions are joint by a bivariate distribution function represented by a copula C, as can be seen as equation 5 [10, 11]. The parameter θ represents the linkage between the two univariate distributions and capture unobserved factor affecting the two choices at the same time (called self-selection effect). The two choices are correlated if the parameter θ is different from zero, and vice versa.

$$F(\varepsilon_{nm}, \eta_{nm}) = C_\theta(F(\varepsilon_{nm}), F(\eta_{nm})) \quad (5)$$

Regarding to the conditional statement of the conditional joint distribution function, the conditional probability is equivalent to a conditional copula that is derived from a partial derivation of the copula [10, 11]. The probability of discrete choice "m" conditional on continuous choice ln(L)=ln(l) is shown as equation 6.

$$\Pr(Alt_n = m | \ln(L_{nm}) = \ln(l_{nm})) = \frac{\partial C_\theta(F(\varepsilon_{nm}), F(\eta_{nm}))}{\partial F(\eta_{nm})} \quad (6)$$

Therefore, the joint probability of two choices dependent with each other can be written as equation 7.

$$\begin{aligned} &\Pr(Alt_n = m, \ln(L_{nm}) = \ln(l_{nm})) \\ &= \Pr[Alt_n = m | \ln(L_{nm}) = \ln(l_{nm})] \times \Pr[\ln(L_{nm}) = \ln(l_{nm})] \\ &= \left[\frac{\partial C_\theta(F(\varepsilon_{nm}), F(\eta_{nm}))}{\partial F(\eta_{nm})}\right]\left[\frac{1}{\sigma_m}\phi\left(\frac{\ln(l_{nm}) - \alpha'_m y_{nm}}{\sigma_m}\right)\right] \end{aligned} \quad (7)$$

The log-likelihood function of the Frank copula-based joint model can be written as equation 8. R_{nm} $[R_{nm} = 1]$ defines the dummy variable of the chosen alternative "m" made by an individual n.

$$LL = \sum_{n=1}^{N}\sum_{m=1}^{M} R_{nm}\left[\ln\left(\frac{\partial C_\theta(F(\varepsilon_{nm}), F(\eta_{nm}))}{\partial F(\eta_{nm})}\right) + \ln\left(\phi\left(\frac{\ln(l_{nm}) - \alpha'_m y_{nm}}{\sigma_m}\right)\right) - \ln(\sigma_m)\right] \quad (8)$$

Supposed $u_1 = F(\varepsilon_{nm})$ and $u_2 = F(\eta_{nm})$, thus the partial derivative of copula can be written as equation 9 [8]. Where θ is infinitive ($-\infty < \theta < \infty$) and correlation between the two choices can be calculated via Kendall's tau $=1 - \frac{4}{\theta}\left[1 - \frac{1}{\theta}\int_{t=0}^{\theta} \frac{t}{e^t - 1} dt\right]$.

$$\left[\frac{\partial C_\theta(F(\varepsilon_{nm}), F(\eta_{nm}))}{\partial F(\eta_{nm})}\right] = 1 - e^{\theta u_2}\left(e^{\theta u_1} - e^{\theta}\right)\left[e^{\theta u_1} e^{\theta u_2} + e^{\theta}\left(1 - e^{\theta u_1} - e^{\theta u_2}\right)\right]^{-1} \quad (9)$$

3.3 Data Modelling Procedure

As early stated, the objective of the study is to investigate the impact of dependency parameters on model estimation results. We selected four models with different dependency parameters for each multinomial regime. Equation (8) was used for the joint models with non-zero dependency parameters, while equation (11) was employed for independence-based joint model (zero dependency parameters). Computation procedure is expressed in Fig. 1. Firstly, the MNL model is implemented to estimate the parameters of the discrete choice equation (see equation 1). Then, the estimated parameters and the pre-specified dependency parameter of each discrete-continuous choice (for non-zero dependency parameters) are replaced into the joint model to estimate the parameters of the continuous choice equation.

The code language written in R programming was employed to estimate the model by maximizing the log-likelihood functions via applying Newton Raphson type optimization routine. The "maxLik" package developed by Henningsen and Toomet (2011) was implemented to simulate the log-likelihood function [21], while the "spcopula" developed by Graeler (2014) was employed to calculate partial derivative of Frank copula [22].

4. Sample Data

2,300 households in Metro Manila were randomly selected to participate face-to-face interviews which was conducted in April and May, 2017. Only household members who hold and use car for regular trips are encoded for data analysis. Vehicles purchased before year 2007 and vehicle for rents or used as public transport mode were not deliberately included to avoid data consistency problem. After cleaning the data, there were only 1077 available observations. Vehicles are classified into two categories based on engine size: small car and large car (see Table 1). The descriptive statistics of the explanatory variables are tabulated in Table 2. The monthly family income includes all incomes by all family members. The household income was categorized as dummy variable in the questionnaire forms to encourage responses. The dummy variable can be transformed into the continuous variable as a function of household demographic variables using Order Probit model (see Appendix I).

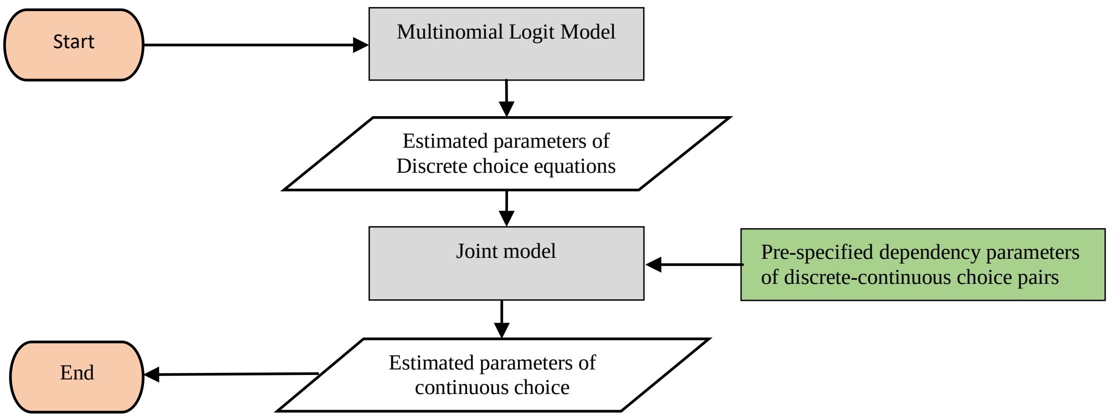


Fig. 1 Computation procedure

Table 1 Classification of vehicle types and the corresponding mean fuel consumption

Vehicle type	Small car	Large car

Engine size	≤2.0 L	> 2.0 L
Frequency (% share)	708 (65.74)	369 (34.26)
Mean fuel consumption (liters/month)	88.79	135.45

Table 2 Descriptive statistics of the explanatory variables

Explanatory variables	Minimum	Median	Mean	Maximum
Estimated household income in Php per month [10^4]	1.336	6.994	9.692	40.730
Population density km^{-2} [10^4] (city level)	0.124	2.801	3.320	7.330
Housing type (1 = Own house; 0 = Non-own house)	0	1	0.775	1
Marital status (1 = Married; 0 = Single/ divorcee)	0	1	0.878	1
Sex (1 = Male; 0 = Female)	0	1	0.811	1
Age (1 = Aged 40 years or lower; 0 = Aged above 40 years)	0	0	0.417	1
Occupation				
Employee =1 (if employee); = 0 (Otherwise)	0	1	0.758	1
Self-employed = 1 (if self-employed); =0 (Otherwise)	0	0	0.207	1
Non-working adult (reference)				
Education level (1 = At least bachelor degree; 0 = Lower than bachelor degree)	0	1	0.921	1
Number of commuters in vehicle	1	1	1.255	5
Monthly household income/(monthly fuel cost [× 10])	0.333	1.962	2.482	24.373
Annual household income/vehicle cost	0.211	1.335	2.044	15.302

5. Results

As mentioned earlier, four different models with different dependency parameters are used to study the impact of dependency parameters on model estimation results. Dependency parameters of Model 1, 3, and 4 are pre-identified, except that the dependency parameters of Model 2 are estimated. Table 3 presents the impact of dependency parameter of each multinomial regime on Akaike Information Criteria (AIC) for all the models. AIC is used as an estimator of the relative quality of different sample selection models for a given set of data because it can handle a comparison of log-likelihood values across different models. Model with lower AIC value is preferred. In this context, the traditional likelihood ratio test is not applicable, on account of that different statistical models lead to a case of non-nested models.

Columns 2 and 3 of Table 2 list the dependency parameters between the two choices for each multinomial regime. Model 1 has the highest dependency parameters, and followed by model 2, 3, and 4. This arrangement is aimed to simplify interpretation of the impact of dependency parameters on the estimated results. Look at the last column of the table, AIC value of Model 1 is found the highest, and this value is minimized at 2184.80

(Model 2) when dependency parameters decrease to 4.02 for small car and 1.43 for large car. Then, AIC value increases when dependency parameters decrease to zero for both car types. The AIC came to a standstill even though the dependency parameters are further decreased. Therefore, dependency parameters have great effect on goodness of fit for models.

The estimated parameters of each joint model are tabulated in Appendix II and those parameters were used to calculate absolute percentage bias (APB) and root mean square error (RMSE). APB is used to measure accuracy for discrete choice equations and RMSE is used to compare goodness of fit for continuous choice equations with different dependency parameters, respectively. Evident from Table 4 (see columns 2 and 3), APBs of the discrete choice component were zero, which means that the sequential maximum likelihood simulation approach performs well in prediction of the discrete choice parts. For the continuous choice component, the lowest RMSEs were found in model 2 (see the last two columns). The RMSEs of the two car types decline to minima with decrease of the dependency parameters, and then augment with further decrease of the parameters.

Table 3 Impact of dependency parameters on goodness of fit of the joint model

Joint model	Dependency parameters θ (t-value)		AIC	
	Small car	Large car	MNL model	Joint model
Model 1	8.00	3.00	1296.14	2205.24
Model 2	4.02 (5.27)	1.43 (1.63)		2184.80
Model 3	0	0		2199.37
Model 4	-4.00	-1.5		2198.29

Table 4 Impact of dependency parameters on APB of discrete choice and RMSE of continuous choice

Joint model	APB of discrete choice		RMSE of continuous choice	
	Small car	Large car	Small car	Large car
Model 1: $\theta_{1,small} = 8.00$; $\theta_{1,large} = 3.00$	0	0	34.71	67.61
Model 2: $\theta_{2,small} = 4.02$; $\theta_{2,large} = 1.43$			33.29	65.18
Model 3: $\theta_{3,small} = 0$; $\theta_{3,large} = 0$			33.29	66.42
Model 4: $\theta_{4,small} = -4.00$; $\theta_{4,large} = -1.5$			35.65	70.47

Table 5 Expected fraction and estimated fuel consumption of various models

Joint models	Percentage share (%)		Mean fuel used (liters/month)	
	Small car	Large car	Small car	Large car
Actual data	65.74	34.26	88.79	135.45
Estimated results				
Model 1: $\theta_{1,small} = 8.00$; $\theta_{1,large} = 3.00$	65.74	34.26	97.01	151.62
Model 2: $\theta_{2,small} = 4.02$; $\theta_{2,large} = 1.43$			92.34	135.53
Model 3: $\theta_{3,small} = 0$; $\theta_{3,large} = 0$			84.00	122.15
Model 4: $\theta_{4,small} = -4.00$; $\theta_{4,large} = -1.5$			76.00	108.87

Result in Table 5 demonstrates the impact of dependency parameters on the model estimation results. The estimated percentage shares for the discrete choice component are equivalent to the observed data. The estimated fuel consumptions of Model 2 were found the closest to the actual data (see row 3 and 5), which is corresponding to the lowest AIC of the joint model and RMSEs of the continuous choice equation. Total fuel consumptions of Model 1 were over-estimated, while those of Model 2 and 3 are under-estimated. The estimated continuous choice outcomes are found lower with decreasing dependency parameters.

The two figures below illustrate the differences between estimated and actual fuel consumption (continuous choice) for small car (Fig. 2) and large car (Fig. 3). The different values between actual and estimated fuel consumptions are found around zero at around mean fuel used (90 for small car and 135 for large car). The different values are negative and very large at the tail of distribution and positive at values less than the mean value for both small car and large car. These evidences imply that the copula-based MNL-Linear regression model predict the continuous choice accurately around mean value, over-estimate at points located on the left-side of the mean value, and much under-estimate at the tail of distribution. For both vehicle types, Model 1 over-estimate the fuel consumption than Model 4 at points located on the left side of the mean value, but under-estimate the fuel consumption than Model 4 at points on the right side of the mean value. This indicates that decreasing dependency parameters are associated with better goodness of fit for continuous choice located on the left side of the mean value, but poorer prediction of continuous choice located on the right side of the mean value.

The different models are applied to calculate percentage changes of output variables in response to changes in variables of interest for comparisons.

The variables of interest are gas price and vehicle purchase cost with the following scenarios: ±25% gas price and ±25% vehicle cost. Positive sing means increase and vice versa. Calculation of fuel under changes in gas price is according to specifications in [19]. The third and fourth columns of Table 6 present percentage changes of discrete choice, while the last two columns demonstrate percentage changes of fuel consumption. For all the scenarios for both car types, percentage changes of fuel consumption were slightly varied among different models.

6. Conclusions

The empirical findings are concluded as follows:

- Application of sequential maximum simulated likelihood estimation approach of Copula-based joint model can predict the discrete choice outcome accurately.
- Dependency parameters between the discrete and continuous choices for each multinomial regime have great effect on joint model fit, APB for discrete choice, RMSE for continuous choice. The lowest RMSEs are seen in the model with the lowest AIC value.
- Decreasing dependency parameters are consistent on better prediction of continuous choices located on the left side of the mean value, but poorer prediction of continuous choices located on the right side of the mean value.
- The Copula-based MNL-Linear regression model can predict the continuous choice outcomes located around mean value accurately, but not reasonably for the continuous choices located on the left side of mean value and at the tail of distribution.
- Percentage changes of continuous choice outcome were not significantly different among the joint models with different dependency parameters.
- All in all, the developed model 2 is applicable for prediction of response variables and estimation of mean responses.

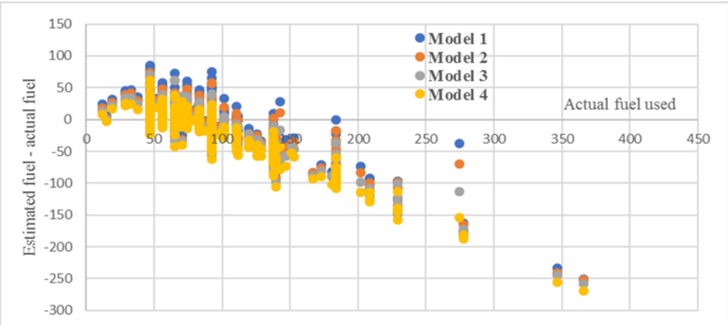


Fig. 2 Different values between estimated and actual fuel consumption for small car type (liters/month)

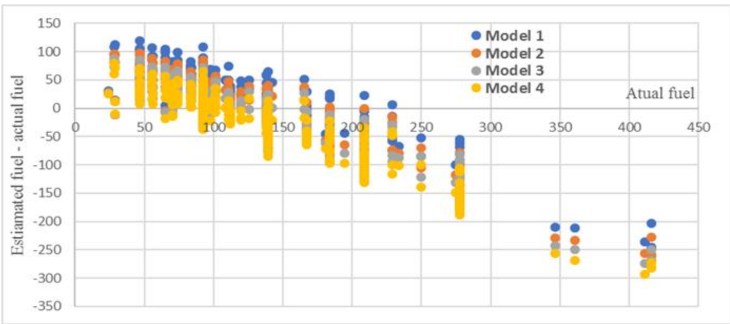


Fig. 3 Different values between estimated and actual fuel consumption for large car type (liters/month)

Table 6 Percentage changes of output variables under changes of variables of interest

Scenarios	Model	% changes of discrete choice		% changes of fuel consumption	
		Small car	Large car	Small car	Large car
+25% fuel cost	Model 1	1.53	-1.53	-7.94	-7.85
	Model 2			-8.71	-7.54
	Model 3			-9.14	-7.15
	Model 4			-9.59	-6.65
-25% fuel cost	Model 1	-2.61	2.61	5.24	5.17
	Model 2			5.80	4.95
	Model 3			6.12	4.68
	Model 4			6.45	4.32
+25% vehicle cost	Model 1	-0.70	0.70	-1.06	-0.93
	Model 2			-1.07	-0.78
	Model 3			-1.23	-0.61
	Model 4			-1.51	-0.47
-25% vehicle cost	Model 1	1.13	-1.13	1.82	1.60
	Model 2			1.84	1.32
	Model 3			2.12	1.05
	Model 4			2.61	0.79

5. Acknowledgments

This paper is upon the work mainly funded by Newton Project foundation and AUN/SEED-Net project of Japanese International Cooperation Agency for Ph.D. Sandwich Program. The authors are very grateful to Prof. Kenji DOI and Dr. Hiroto INOI for technical help and general support.

References

[1] Feng, Y., Don, F., & Li, G. (2013). Vehicle choices, miles driven, and pollution policies. Journal of Regulatory Economics, 44, 4–29. doi:10.1007/s11149-013-9221-z

[2] Zhang, H., Lu, Y., Shi, F., & Zhu, D. (2012). Overloaded vehicle choice behavior analysis based on Nested Logit model. Journal of Transportation Systems Engineering and Information Technology, 12(6), 113–118. https ://doi.org/10.1016/S15706672(11)60238-9

[3] Train, K. (2003). Discrete choice methods with simulation. New York, NY.: Cambridge University Press.

[4] Yang, J., Kato, H., & Ando, R. (2015). Comparative analysis of the household car ownership between Toyota city and Nagoya city. Journal of the East Asia Society for Transportation Studies, 11, 629–639. https:// www.jstage.jst.go.jp/article/easts/11/0/11_626/_pdf /-char/en

[5] Masiero, L., & Zoltan, J. (2013). Tourists intra-destination visits and transport mode: A Bivraiate Probit Model. Anuals of Tourism Research, 43, 529–546. http://dx.doi.org/10.10 16/j.annals.2013.05.014

[6] Nguyen, N. T., Miwa, T., & Morikawa, T. (2017). Vehicle type choice, usage, and CO2 emissions in Ho Chi Minh city: analysis and simulation using a discrete-continuous model. Asian Transport Studies, 4(3), 499–517. https://www.jstage.jst.go.jp/article/eastsats/4/3/4_499/_pdf
[7] Wu, L., Zhang, J., & Fujiwara, A. (2013). Tourism participation and expenditure behaviour: Analysis using a SCOBIT-based discrete-continuous choice model. Annals of Tourism Research, 40, 1–17. http://dx.doi.org/10.1016/j.annals.2012.09.002
[8] Bhat, C. R., & Eluru, N. (2009). A copula-based approach to accommodate residential self-selection effects in travel behavior modeling. Transportation Research Part B, 43(2009), 749–765. doi:10.1016/j.trb.2009.02.001
[9] Spissu, E., Pinjari, A. R., Pendyala, R. M., & Bhat, C. R. (2009). A copula-based joint multinomial discrete–continuous model of vehicle type choice and miles of travel. Transportation, 36(2009), 403–422. doi:DOI 10.1007/s11116-009-9208-x
[10] Trivedi, P. K., & Zimmer, D. M. (2005). Copula modeling: an introduction for practitioners. Boston, MA: Now Publishers Inc.
[11] Nelsen, R. B. (2006). An introduction to copulas. Springer. http://www.springer.com/978-0-387-28659-4
[12] Lee, L.-F. (1983). Notes and comments: generalized econometric models with selectivity. Econometrica, 51(2), 507–512. http://www.jstor.org/stable/1912003
[13] Heckman, J. (1974). Shadow prices, market wages, and labor supply. Econometrica, 42(4), 679–694. http://www.jstor.org/stable/1913937
[14] Heckman, J. J. (1976). The common structure of statistical models of truncation, sample selection and limited dependent variables and a simple estimator for such models. Annals of Economic and Social Measurement, 5(4), 475–492. http://www.nber.org/chapters/c10491
[15] Hay, J. W. (1980). Occupational choice and occupational earnings: selectivity bias in a simultaneous logit-OLS model. Rockville, Md.: National Technical Information Service.
[16] Dubin, J. A., & McFadden, D. L. (1984). An econometric analysis of residential electric appliance holdings and consumption. Econometrica, 52(2), 345–362. http://www.jstor.org/stable/1911493
[17] Leung, S. F., & Yu, S. (2000). Collinearity and tow-step estimation of smaple selection models: problems, orgines, and remodies. Computational Economics(15), 173–199.
[18] Puhani, P. (2000). The Heckman correction for sample selection and its critique. Journal of Economic Surveys, 3(2), 53–67.
[19] Rith, M., Biona, J. B., Fillone, A., Doi, K., & Inoi. H., (2018). Joint model of private passenger vehicle type ownership and fuel consumption in metro manila: analysis and application of discrete-continuous model. In the 25th Annual Conference of Transportation Science Society of the Philippines (TSSP), Cagayan De Oro, Philippines. Retrieved from http://ncts.upd.edu.ph/tssp/wp-content/uploads/2018/07/TSSP2018-14.pdf
[20] Johnson, N. L., Kotz, S., & Balakrishnan, N. (1994). Continuous univariate distributions. New York: John Wiley & Sons.
[21] Henningsen, A., & Toomet, O. (2011). maxLik: A package for maximum likelihood estimation in R. Computational Statistics, 26(3), 443-458. doi:10.1007/s00180-010-0217-1
[22] Graeler, B. (2014). Modelling Skewed Spatial Random Fields through the Spatial Vine Copula. Spatial Statistics. Elsevier.doi:10.1016/j.spasta.2014.01.001
[23] Winship, C., & Mare, R. D. (1984). Regression models with ordinal variables. American Sociological Review, 49, 512–525.
[24] Bhat, C. R. (1994). Imputing a continuous income variable from grouped and missing income observations. Economics Letters, 46(1994), 311–319.

Appendix I: Estimated Household Income

The dummy variables of household income in the questionnaire can be converted into continuous variable using Order Probit model. The procedure of the order probit model is detailed by Winship and Mare (1984) and Bhat (1994) [23, 24]. Equation (I.1) and (I.2) are applied to calculate the estimated household income. Supposed the household income has a log-normal distribution with disturbance in term of mean zero and vaiance $(\omega' w_n)$. The threshold value $a_{j,n}$ is known as the pre-specified intervals j=$\{1, 2, 3, \ldots, 12\}$, γ is a column vector of the estimated parameters (including intercept), w_n denotes a column vector of explanatory variables (including a constant). Maximum likelihood function was applied to estimate the results. The respective ϕ and Φ are the probability density function and cumulative distribution function of the standard normal distribution. Table I.1 demonstrates descriptive statistics of the household demographic variables and Table I.2 tabulates the estimated parameters of the household income as a function of the household demographic variables.

$$\Pr(\ln(I_n) = j) = \Phi\left(\frac{\ln(a_{j,n}) - \gamma' w_n}{\omega' w_n}\right) - \Phi\left(\frac{\ln(a_{j-1,n}) - \gamma' w_n}{\omega' w_n}\right) \quad (I.1)$$

$$I_n = \exp\left[\gamma' w_n + \omega' w_n \frac{\phi\left(\frac{\ln(a_{j-1,n}) - \gamma' w_n}{\omega' w_n}\right) - \phi\left(\frac{\ln(a_{j,n}) - \gamma' w_n}{\omega' w_n}\right)}{\Phi\left(\frac{\ln(a_{j,n}) - \gamma' w_n}{\omega' w_n}\right) - \Phi\left(\frac{\ln(a_{j-1,n}) - \gamma' w_n}{\omega' w_n}\right)}\right] \quad (I.2)$$

Table I.1 Descriptive statistics of household demographic variables

Explanatory variables	Min	Median	Mean	Max
Family size	1	3	3.227	9
Household employed members	0	2	1.906	6
Number of pre-schoolers	0	0	0.178	3
Number of children go to primary and high school	0	0	0.475	5
Number of children go to university	0	0	0.241	3
Number of overseas Filipino workers	0	0	0.139	3
Household income level per month (dummy variables) [a]	3	8	8.590	12

[a] Household income level: 1<Php5,000; 2=Php5,000-9,999; 3=Php10,000-14,999; 4=Php15,000-19,999; 5=Php20,000-29,999; 6=Php30,000-39,999; 7=Php40,000-59,999; 8=Php60,000-79,999; 9=Php80,000-99,999; 10=Php100,000-149,999; 11=Php150,000-299,999; 12≥Php300,000

Table I.2 Estimated results of the Order Probit model for household income

Coefficients (t-vlue)	Mean of log	Standard deviation of log
Intercept	1.364 (26.296)*	0.402 (11.532) *
Family size	0.166 (5.253) *	0.068 (3.483) *
Household employed members	0.158 (5.222) *	-0.064 (-3.615) *
Number of pre-schoolers	-0.156 (-3.670) *	-0.065 (-2.384) *
Number of children go to primary and high school	-0.208 (-6.028) *	-0.049 (-2.357) *
Number of children go to university	-0.131 (-3.605) *	-0.118 (-4.656) *
Number of overseas Filipino workers	0.539 (10.197) *	-

LL at convergence = –2300.05; * : significant at the 95% level

Appendix II: Estimated parameters of the Joint Models

Table II Estimated parameters of the joint models

Joint model	Model 1:	Model 2	Model 3	Model 4
	Coef. (t-value)	Coef. (t-value)	Coef. (t-value)	Coef. (t-value)
LL of MNL model at convergence	-636.07	-636.07	-636.07	-636.07
LL of joint model at convergence	-1076.62	-1064.40	-1073.68	-1073.15
MNL model				
Intercept	-1.265 (-2.32)*			
Population density	-0.117 (-3.43)*			
Own house	0.342 (1.99)*			
Married	0.020 (0.10)			
Male	0.225 (1.24)			

Joint model	Model 1: Coef. (t-value)	Model 2 Coef. (t-value)	Model 3 Coef. (t-value)	Model 4 Coef. (t-value)
Age: <= 40 years	-0.375 (-2.43)*			
Employee Self-employed	-0.380 (-1.03) 0.700 (1.83)			
Bachelor degree or higher	0.027 (0.10)			
Number of commuters	0.436 (3.67)*			
Household income/ fuel cost	0.151 (3.62)*			
Household income/ vehicle cost	-0.085 (-2.15)*			
Linear Regression model for Small Car				
Intercept	4.850 (48.43)*	4.811 (48.25)*	4.767 (46.93)*	4.700 (46.16)*
Population density/km^2 [$\times 10^4$]	-0.018 (-3.27)*	-0.014 (-2.45)*	-0.008 (-1.34)	0.000 (0.05)
Own house	0.021 (0.69)	0.027 (0.91)	0.005 (0.17)	-0.016 (-0.56)
Married	-0.190 (-5.69)*	-0.175 (-5.23)*	-0.174 (-5.17)*	-0.175 (-5.22)
Male	-0.077 (-2.47)*	-0.096 (-3.13)*	-0.114 (-3.65)*	-0.125 (-4.09)*
Age: <= 40 years	-0.131 (-4.94)*	-0.115 (-4.34)*	-0.094 (-3.48)*	-0.065 (-2.46)*
Employee Self-employed	-0.079 (-1.08) 0.190 (2.49)*	-0.046 (-0.65) 0.164 (2.08)*	-0.035 (-0.45) 0.106 (1.32)	-0.021 (-0.27)* 0.041 (0.50)
Bachelor degree or higher	0.121 (2.26)*	0.113 (2.21)*	0.109 (2.07)*	0.099 (1.92)
Number of commuters	0.154 (6.33)*	0.135 (5.27)*	0.104 (4.04)*	0.077 (3.07)
Household income/ fuel cost	-0.120 (-14.11)*	-0.133 (-15.12)*	-0.141 (-17.31)*	-0.149 (-18.61)*
Household income/ vehicle cost	0.026 (3.48)*	0.027 (3.82)*	0.031 (4.37)*	0.038 (5.28)*
Scale parameter (t-value)	0.385 (33.91)*	0.345 (29.00)*	0.324 (37.63)*	0.349 (35.59)*
Linear Regression model for Large Car				
Intercept	5.162 (26.12)*	5.024 (23.98)*	4.903 (25.27)*	4.771 (24.68)*
Population density/km^2 [$\times 10^4$]	-0.021 (-1.72)	-0.026 (-2.01)*	-0.030 (-2.38)*	-0.035 (-2.75)*
Own house	0.087 (1.40)	0.097 (1.56)	0.104 (1.66)	0.110 (1.75)
Married	-0.077 (-1.10)	-0.075 (-1.06)	-0.072 (-1.01)	-0.072 (-1.02)
Male	0.003 (0.05)	0.002 (0.03)	0.006 (0.10)	0.020 (0.31)
Age: <= 40 years	0.049 (0.88)	0.032 (0.55)	0.016 (0.28)	0.000 (0.005)
Employee Self-employed	-0.159 (-1.35) -0.111 (-0.91)	-0.165 (-1.38) -0.070 (-0.56)	-0.174 (-1.46) -0.029 (-0.24)	-0.201 (-1.71) -0.005 (-0.04)
Bachelor degree or higher	0.146 (1.66)	0.149 (1.77)	0.136 (1.64)	0.117 (1.38)
Number of commuters	0.090 (2.52)*	0.102 (2.80)*	0.117 (3.25)*	0.140 (3.90)
Household income/ (fuel cost×10)	-0.102 (-8.23)*	-0.097 (-7.83)*	-0.092 (-7.67)*	-0.084 (-6.96)*
Household income/ vehicle cost	0.024 (1.88)	0.020 (1.52)	0.016 (1.21)	0.012 (0.90)*
Scale parameter (t-value)	0.494 (25.30)*	0.461 (21.78)*	0.453 (27.17)*	0.468 (26.57)

Small car: reference category for MNL model; * : significant at the 95% level

Automated Car and Public Acceptance in Developing Countries – Case Study in Viet Nam

Topic number: 9; Paper Identification number: AYRF2018-003

Hoang Phuc Hai [1], Zhao Shengchuan [2]

[1] MSc student, School of Transportation and Logistics,
Faculty of Infrastructure Engineering, Dalian University of Technology.
Phone: +86 183 4223 1579. Email: hph.transport@hotmail.com.

[2] School of Transportation and Logistics,
Faculty of Infrastructure Engineering, Dalian University of Technology.
Phone: +86 138 8958 2295. Email: szhao@dlut.edu.cn.

Abstract

In many developing countries, with the increase of private vehicles, lack of transportation infrastructure and low quality roads, traffic congestions, carbon dioxide emissions and road accidents are a serious issue nowadays. Statistic data from the World Health Organization (WHO) in 2015 showed that almost 90% of all traffic accidents occur in low- and middle-income countries, and in the same year, data from National Highway Traffic Safety Administration (NHTSA) showed that 94% of car accidents were caused by human error. Therefore, recently there have been many studies on automatic techniques and automated vehicles or self-driving vehicle which are expected to bring many benefits to people and the transportation system, in order to reduce accidents caused by human error, reduce traffic congestions, save energy, and so on.

This study examines the level of people acceptance on automated cars (AC) in a developing country, Viet Nam. We desired to know that whether automatic techniques are available, and amount of people who will accept AC. The discrete choice model showed that alternative specific variables such as travel time and confidence level had the most impact to the probability of AC choice. Also, individual specific variables such as income and education background are closely related to choice. Through the process of analysis, the nested logit model fit the data.

Keywords: Public acceptance, Automated car, MNL model, Nested logit model

1. Introduction

Road transport is an important part in the transportation system of any country in the world. Rapid development in road transport leads to an increase in road vehicles as well as many problems such as traffic accidents and pollution. In 2015, statistic from WHO showed that road crashes killed 1.25 million people a year, with about 3400 road fatalities and up to 50 million injures per day. For the recent situation in Viet Nam, statistic from National Traffic Safety Committee showed that nationwide in 2016, there were 21,094 crashes, killed 8,417 peoples and injured 19,035 peoples. In the US, in 2015 data from National Highway Traffic Safety Administration (NHTSA) showed that 94% of car accidents were caused by human error and over 40% crashed were caused by the use of stimulants, drunken behavior, distractions, or fatigue, with a total of nearly 38,300 fatalities and 4.4 million injures.

There are so many solutions that have been suggested for improving safety and efficiency in road transport. One of them is the use of automated vehicles or self-driving vehicles which are expected to bring many benefits to the transportation system in the future. It's expected to increase road safety, decrease traffic congestions, emissions, fuel consumption and potentially solve many traffic problems (Kyriakidis et al., 2015). Automated driving technology will have a great impact on traffic problems, such as traffic jams, traffic accidents or driving behavior since automatic functions are integrated on vehicles and communicate with intelligent transportation systems (ITS), vehicle to vehicle (V2V), vehicle to infrastructure (V2I) communication systems. In order to reduce traffic accidents and increase safety for the user, automated vehicles have an intelligent automation system installed, combined with sensor detectors, cameras, and are integrated with early warning technology and smart systems. The equipment has powerful support for driver and includes a partial or full monitor/driving process. Automated tasks like steering, accelerating and braking will be executed when activated, and the system can be deactivated when recognizing critical risk conditions. Daniel et al., 2015 also mentions that automated vehicles can contribute to reduce congestions and reduce emission by saving energy – fuel consumption.

There have been various previous research studies about the public opinion on automated cars. Sommer et al., 2013 conducted a survey in 4 developed countries: Germany, China, Japan, and the US. The result showed that 59% of the people considered automation driving technology as a serviceable advancement, 31% of the people were unnerved with the development of automation systems in vehicles, and 54% did not believe that automated vehicles will function reliably. In detail, 67% of the respondents in Germany and 64% in China were more aware of automation driving technology compared to 29% in Japan. Approximately, 40% of the people expected that automated vehicles will be popular during the next 10 to 15 years, while most of the people expressed 67% of intention to use the AC for long freeway journeys, 52% in congestion cases, 36% on rural roads and 34% for urban traffic (Kyriakidis et al., 2015).

Howard and Dai (2014) examined people's opinions on self-driving cars in Berkeley. The results showed that two factors, are safety (75%) and convenience (61%), were the most attractive features about self-driving or automated cars, whereas liability (70%) and cost (69%) were the least attractive elements. On the other hand, 46% of the respondents believed that self-driving cars should operate normally in normal traffic conditions, 38% believed they should operate in separate lanes, while 11% had no opinion. More than 40% of the respondents gave positive reviews to self-driving cars when they expressed that they will purchase self-driving technology for their next vehicle or they will equip their current vehicle with self-driving technology. Finally, 35% of the respondents were in favor of a subsidized scheme for such technology, whereas 22% of respondents who were against it.

Kyriakidis et al., 2015 implemented an online survey with 63 questions, accessed by 5000 respondents in 109 countries. Their results showed that the respondents found manual driving as the most enjoyable mode of driving. Responses were divided: 22% of the respondents did not want to pay more than $0 for a fully automated driving system, whereas 5% indicated they would be willing to pay more than $30,000.

Ricardo A. Daziano et al 2017 used data from 1260 respondents who answered a discrete choice experiment survey about vehicle-purchase in the US. The results showed that the average household is willing to pay about $3500 for partially automated cars and $4900 for fully automated cars. A significant share of the respondents was willing to pay above $10,000 for full automation technology. Moreover, there were many people who were not willing to pay any amount of money for this technology.

In developed countries, automated vehicle companies have tested and initially launched some models which installed some in-vehicle automatic functions of Tesla, Volvo, or Google, etc. However, in developing countries, traffic accidents due to human factors and vehicle errors occupy the biggest part. Therefore, highly safe vehicles are being advertised and welcomed in Viet Nam nowadays. A typical example is Volvo XC 90 released last year in Vietnam. Volvo XC90 is considered as a safest partially automated car in Viet Nam at the present, as well as, Volvo S90, Tesla Model X P100D and many other partial automated models. With the rapid expansion and competition in Viet Nam's car market, many models of automated cars will keep appearing in the next years and will attract the attention of many users.

2. Methodology

2.1 Survey design

A stated preference (SP) survey was designed. The questionnaire includes two parts. Part 1 for people who had a car and part 2 for people who do not have a car and they intend to buy a new car in the future.

There are 6 levels of driving automation with the corresponding definitions in the roles of drivers and systems (J3016™ Issued JAN2014). In the case of Viet Nam, in the recent few years, several partially automated driving cars have been released and only some drivers have had experiences with them, however, not many people are aware of the definition of automation driving. Hence, to help respondents to understand, a summary of 3 categories of cars was suggested: non-AC, partially AC and fully AC.

The values of attributes are referenced from many sources, and the SP design is based on the assumption for partially AC and highly AC.

The values of energy consumption were referenced from driver's forum in Ho Chi Minh City. Discussion about how many litter of gasoline did their car consume per 100 km. Almost users confirmed that for normal case, the car consumes 17-20 liters of gasoline per 100km – equivalent about $15 - $20 per 100km. Consider the case of traffic jam or worse condition, other cars could consume up to $35 per 100km. Based on these values for non-automated cars of users in forum, we assumed that Partially AC will consume gasoline lesser than non-AC, and highly AC will consume gasoline lesser than Partially AC because of technique levels which integrated inside AC.

The values of car price are referenced from the internet with the difference of car brands. Car market in Viet Nam is variety with the cheapest price start from $20,000. We separated popular car (or non-AC) in 3 segments: Normal segment with cheapest price is from $20,000, Medium segment: Price is from $50,000; Luxury segment price is from $100,000. The values for Partially AC and Highly AC based on the same assumptions: Partially AC is more expensive than non-AC, and highly AC is more expensive than Partially AC because of technique levels which integrated inside the car.

For travel time, 3 levels are present for purpose of their trip: inner city trip (20'), intercity trip (45') or long trip (90') in addition to trip purpose, such as working trip, business trip or other trip for visiting. With the assumption that AC will support driver to choose the route with ITS, automated accelerate or braking, smooth travelling then result of AC is faster than Non-AC.

Maintenance cost + Upgrade cost: for non AC, we referenced the maintenance cost per month at 3 levels: low ($100), medium ($200) and high ($500) per month. And for partially AC and fully AC, this cost includes upgrade cost (to install automation system, sensors, camera….)

From the above partition, the survey was designed to include three alternatives and 4 attributes with 3 levels (Four three-level experiments design). Using Orthogonal – Taguchi design, we had 27 scenarios (27 runs)

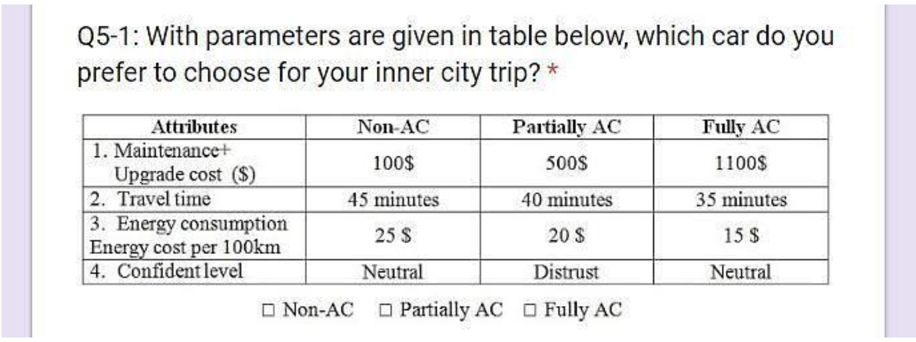
To access the respondents, the survey was conducted online. Finally, we accessed 433 respondents from Viet Nam.

Table 1 Survey attributes and values in design of questionnaire for people who do not have a car

Attributes	**A-Non AC**	**B-Partially AC**	**C-Fully AC**
Car price ($)	20,000 50,000 100,000	22,000 55,000 110,000	25,000 60,000 120,000
Travel time (minutes)	20 45 90	20 40 85	18 35 80
Energy consumption ($/100km)	15 25 35	12 20 30	10 15 20
Confidence level	Distrust Neutral Trust	Distrust Neutral Trust	Distrust Neutral Trust

Table 2 Survey attributes and values in design of questionnaire for people who had a car

Attributes	**A-Non AC**	**B-Partially AC**	**C-Fully AC**
Maintenance + Upgrade cost ($)	100 200 500	500 1000 2000	1100 3200 5500
Travel time (minutes)	20 45 90	20 40 85	18 35 80
Energy consumption ($/100km)	15 25 35	12 20 30	10 15 20
Confidence level	Distrust Neutral Trust	Distrust Neutral Trust	Distrust Neutral Trust



Q5-1: With parameters are given in table below, which car do you prefer to choose for your inner city trip? *

Attributes	Non-AC	Partially AC	Fully AC
1. Maintenance+ Upgrade cost ($)	100$	500$	1100$
2. Travel time	45 minutes	40 minutes	35 minutes
3. Energy consumption Energy cost per 100km	25 $	20 $	15 $
4. Confident level	Neutral	Distrust	Neutral

☐ Non-AC ☐ Partially AC ☐ Fully AC

Fig.1 An example of a choice question in the survey for people who had a car

2.2 Multinomial logit model

Multinomial Logit Model (MNL) is widely used to analyze the choice behavior in travel as mode choice, route choice etc. The MNL equation (1) is given below:

$$U_{ni} = V_{ni} + \varepsilon_{ni} \qquad (1)$$

Where: U_{ni} is the true utility of the alternative i to the decision maker n, ε_{ni} is the error or portion of the utility unknown.

The mathematical structure of the Multinomial Logit Model (MNL):

$$\Pr(ni) = \frac{\exp(V_{ni})}{\sum_{j=1}^{J} \exp(V_{nj})} \qquad (2)$$

Where: $V_{in} = \alpha_{i0} + \alpha_i X_n + \beta_i W_{ni}$

Since, we constructed 2 specifications of utility equations for a three alternative car choice. Non-AC was selected as a reference level and the utility functions were separated in different coefficients of individual specifics between partially AC and fully AC.

Specification 1: Utility equations for a three alternative car choice for decision maker who had a car (questionnaire part 1):

$V_A = \alpha_{A1}\times$Gender $+ \alpha_{A2}\times$Age $+ \alpha_{A3}\times$Education$+ \alpha_{A4}\times$Tdriving $+ \beta_1 \times$ A- *cost* $+ \beta_2 \times$ A-*Ttime* $+ \beta_3 \times$ A-*Energy* $+ \beta_4 \times$ A-*Confidence*

$V_B = \alpha_{B0} + \alpha_{B1}\times$Gender $+ \alpha_{B2}\times$Age $+ \alpha_{B3}\times$Education$+ \alpha_{B4}\times$Tdriving $+ \beta_1 \times$ B-*Upgr-cost* $+ \beta_2 \times$ B-*Ttime* $+ \beta_3 \times$ B-*Energy* $+\beta_4 \times$ B-*Confidence*

$V_C = \alpha_{C0} + \alpha_{C1}\times$Gender $+ \alpha_{C2}\times$Age $+ \alpha_{C3}\times$Education$+ \alpha_{C4}\times$ Tdriving $+ \beta_1 \times$ C-*Upgr-cost* $+ \beta_2 \times$ C-*Ttime* $+ \beta_3 \times$ C-*Energy* $+\beta_4 \times$ C-*Confidence*

Table 3 Interpretation of the included variables in the utility function

Variable	Parameter	Description
Gender	Male, female	1 if male, otherwise 0
Age	Age	18 to 24 = 0, otherwise 1
Education	Education background	High school or lower = 0, otherwise 1
Income	Income	Less than 300 $ = 0, otherwise 1
CarType	Type of car owned	Non AC = 0, otherwise 1
Tdriving	Driving time per week	Less than 6 hours = 0, otherwise 1
AC-Aware	Aware of automated car	Never heard about AC = 0, otherwise 1
Cost	Maintenance And Upgrade Cost	Maintenance And Upgrade Cost
Price	Car price	Price of car ($)
Ttime	Travel time	Travel time for a single trip (minute)
Energy	Energy assumption cost	Energy consumption cost per 100 km
Confidence	Confidence	Distrust = 0,

level	otherwise 1

Specification 2: Utility equations for a three alternative car choice for decision maker who do not have a car (questionnaire part 2):

$V_A = \alpha_{A1} \times Gender + \alpha_{A2} \times Age + \alpha_{A3} \times Education + \alpha_{A4} \times Tdriving + \beta_1 \times A\text{-}\mathit{Price} + \beta_2 \times A\text{-}\mathit{Ttime} + \beta_3 \times A\text{-}\mathit{Energy} + \beta_4 \times A\text{-}\mathit{Confidence}$

$V_B = \alpha_{B0} + \alpha_{B1} \times Gender + \alpha_{B2} \times Age + \alpha_{B3} \times Education + \alpha_{B4} \times Tdriving + \beta_1 \times B\text{-}\mathit{Price} + \beta_2 \times B\text{-}\mathit{Ttime} + \beta_3 \times B\text{-}\mathit{Energy} + \beta_4 \times B\text{-}\mathit{Confidence}$

$V_C = \alpha_{C0} + \alpha_{C1} \times Gender + \alpha_{C2} \times Age + \alpha_{C3} \times Education + \alpha_{C4} \times \times Tdriving + \beta_1 \times C\text{-}\mathit{Price} + \beta_2 \times C\text{-}\mathit{Ttime} + \beta_3 \times C\text{-}\mathit{Energy} + \beta_4 \times C\text{-}\mathit{Confidence}$

After using the discrete choice model to analyze the data, some individual variables may not be present in the function because the correlation between those 2 variables was very close.

2.3 The nested logit model

The nested logit model is based on the idea that some alternatives may be joined in several groups. The probability of choosing the alternative j that belongs to the nest l is:

$$Pr(ni) = \frac{\exp\left(V_{ni}/\lambda_k\right) \times \sum_{j \in B_k} \exp\left(V_{nj}/\lambda_k\right)^{\lambda_k - 1}}{\sum_{l=1}^{K} \left(\sum_{j \in B_k} \exp\left(V_{nj}/\lambda_l\right) \right)^{\lambda l}} \quad (3)$$

B_k is the nest which alternative was be joined.

From the theory of nested logit model, this model is appropriate when the set of alternatives faced by a decision maker can be partitioned into subsets. In figure 2, we structured the choice of people by 2 subsets: Non-automation and automation. Automation nest also can divide by 2 subsets (noted as nests): partially AC and Highly AC. The nest of the model is constructed as below:

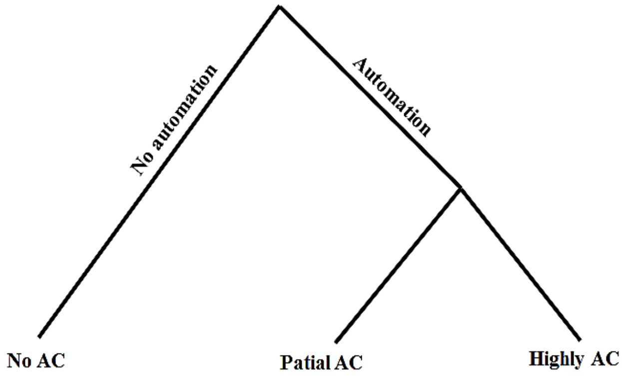


Fig.2 The structure of nested logit model

2.4 Maximum Likelihood Estimation

Maximum likelihood estimation is used in this study to estimate the parameters of a logit model. The likelihood function for a sample of 'T' individuals, each with 'J' alternatives is defined as the following equation:

$$L(\beta) = \prod_{\forall t \in T} \prod_{\forall j \in J} (P_{jt}(\beta))^{\delta_{jt}} \quad (4)$$

Where:

- δ_{jt} = is the chosen indicator (=1 if j is chosen by individual t and 0, otherwise)
- P_{jt} is the probability that individual t chooses alternative j

The parameters which maximize the likelihood function are obtained by finding the first derivative of the likelihood function and equating it to zero. The value of these parameters is found by expressions for the log-likelihood function and its first derivative, as shown below:

$$L(\beta) = Log(L(\beta)) = \sum_{\forall t \in T} \sum_{\forall j \in J} \delta_{jt} \times \ln(P_{jt}(\beta)) \quad (5)$$

$$\frac{\partial(LL)}{\partial \beta_k} = \sum_{\forall t \in T} \sum_{\forall j \in J} \delta_{jt} \times \frac{1}{P_{jt}} \times \frac{\partial(P_{jt}(\beta))}{\partial \beta} \quad \forall k \quad (6)$$

3 Responses analysis

Figure 3 shows the percentage of car choice decision of people in Viet Nam. According to data collected in Viet Nam, 433 respondents consisted of 165 respondents (38.11%) who had a private car, of which 154 (93.33%) respondents were male, and 268 respondents (61.89%) who did not have a car, with 155 (57.84%) is male.

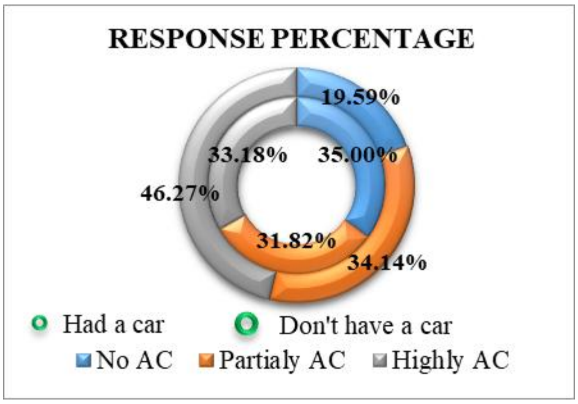


Fig.3 Response percentage of people in Viet Nam

unaffected by these factors. Through parameters of log-likelihood, the model of specification 1 for people who had a car (-651.62) is more reasonable than the model of specification 2 (-1003.4) due to this parameter's value is being higher and the Rho parameter not being too different. Since, Rho in table 4 is low, the values of rho-squared between 0.2 - 0.4 are considered to be indicative of good model fits (Louviere et al 2000). Hence, we continued with nested logit model (table 5)

As considered before, awareness about AC by people who don't have a car is a big issue that affects choice decision makings. Lack of awareness and information about AC led to the reflection in

Table 4 Result of MNL model

	Respondents who had a private car			Respondents who do not have car		
	Estimate	t-value		Estimate	t-value	
B:(intercept)	-1.9744e+00	-3.7018	***	-3.1143e-02	-0.0821	
C:(intercept)	-1.4922e+00	-2.5836	**	2.9066e-01	0.5941	
Cost/Price	2.0603e-04	3.0739	**	-1.2250e-06	-0.0484	
Ttime	-1.2209e-01	-3.4381	***	-1.4606e-02	-0.4212	
Energy	-1.2662e-01	-1.8052	.	-3.7780e-02	-0.7489	
Confidence	3.5057e-01	2.7261	**	2.8329e-01	2.6400	**
B: Education	-8.6904e-01	-2.0343	*	3.3543e+00	5.2607	***
C: Education	-1.7243e+00	-4.5216	***	3.8336e+00	6.1047	***
B: Income	1.9979e+00	3.8697	***	6.0379e-01	2.9617	**
C: Income	1.1674e+00	2.7169	**	1.2541e+00	5.9809	***
B: Tdriving	-5.2033e-02	-0.1674				
C: Tdriving	-5.2893e-01	-1.6604	.			
B: Gender				-1.3502e+00	-5.9359	***
C: Gender				-1.4032e+00	-6.2187	***
B: Age				-2.3131e+00	-3.6398	***
C: Age				-3.7192e+00	-5.8906	***
Log-Likelihood:	-651.62			-1003.4		
McFadden R^2:	0.10069			0.10249		
Likelihood ratio test:	chisq = 145.92 (p.value = < 2.22e-16)			chisq = 229.14 (p.value = < 2.22e-16)		
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1						

In this part we attempt to clarify the relationship between car choices and influence factor which led to people's decisions. Since, there are 2 different data tables, so MNL and nested logit model will be used to compare the fit of data.

Table 4 shows the result of the response analysis by MNL models of 2 specifications for people who had private car and for people who don't have a car. There are 2 specifications with each of them having several factors with absence values, therefore we can say that the model is

consideration of influence factors (attributes) of the model. In our survey, a question "Have you ever heard about automated cars, driverless cars or self-driving car before?" was asked to people who don't have a car, 3% of the respondents have never heard about AC, 18% of respondents were aware about AC and 79% of respondents have just heard hearsay somewhere and lack of information about AC. (Figure 4)

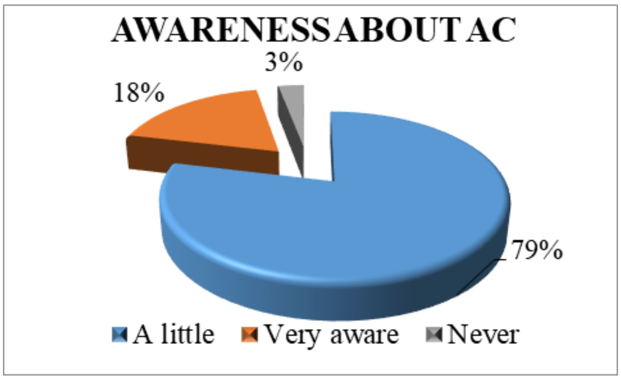


Fig.4 Awareness about AC of respondents who don't have a car

almost respondents are students or just graduated from university. They have not driven yet or do not have any experience about cars. Therefore, they are careless about the price of a car since they owned a motorcycle already and they are expecting a car in the future. It's possible that they haven't considered when they will have enough money to buy an AC or an expensive car; it's just a dream at the present.

Additionally, almost of them have not had a car driver's license yet, but they cared about the confidence level, which implies that they are also concern about their safety and prefer to choose AC if they are safer and trustable.

Table 5 Result of Nested logit model

	Respondents who had a private car			Respondents who do not have car		
	Estimate	t-value		Estimate	t-value	
B:(intercept)	-3.2568e-01	-0.7710		1.1167e+00	3.5958	***
C:(intercept)	-7.7403e-01	-1.8038	.	1.1226e+00	3.5754	***
Cost/Price	1.8923e-04	4.9399	***	1.8364e-06	0.1490	
Ttime	-1.3928e-01	-4.2220	***	-1.4205e-02	-0.4054	
Energy	-4.9008e-02	-1.2117		8.2437e-03	0.4557	
Confidence	1.9835e-01	2.5837	**	5.5450e-03	0.0934	
B: Education	-1.1317e+00	-3.8460	***	3.5829e+00	5.5148	***
C: Education	-1.5343e+00	-5.3577	***	3.6073e+00	5.5153	***
B: Income	1.3447e+00	3.2096	**	8.9801e-01	4.5856	***
C: Income	1.1624e+00	2.5467	*	9.3598e-01	4.7683	***
B: Tdriving	-1.2116e-01	-0.4269				
C: Tdriving	-2.6045e-01	-0.8232				
B: Gender				-1.3669e+00	-6.1401	***
C: Gender				-1.3664e+00	-6.1398	***
B: Age				-3.0280e+00	-4.9630	***
C: Age				-3.1103e+00	-4.9798	***
iv	2.8163e-01	28.6537	***	5.5285e-02	0.8625	
Log-Likelihood:	-612			-994.42		
McFadden R^2:	0.15537			0.11048		
Likelihood ratio test:	chisq = 225.16 (p.value = < 2.22e-16)			chisq = 247.03 (p.value = < 2.22e-16)		
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1						

Regarding the decision making process of respondents who had a car, the individual factors are age and gender which had no impact in their choices. However, for respondents who don't have a car, it's the completely opposite for the influence factors. Individual specifics, like income, education background, gender, age are the most affected factors (significance code of 0.01, 99.9% CI) since

Influence factors were related to the choice of car upgraded. Generally, 3 alternative specifics: upgrade cost, travel time and confidence level, and individual specifics: income, education background have significant impact on people's choices. Expected signs are presented in the variable travel time (negative), confidence level (positive) and monthly income (positive). It's easy to see that the probability of choosing automated cars will be decreased when travel time increases, which implies that people are very interested in the travel time and want to reduce it with an automated car of their choosing (significant at 99.9% CI). The automated choice probability increases when the monthly income increases (significance code of 0.1, 99 % CI) for the partial AC's choice with a significance level of 0.5 (95% CI) for choice of fully AC. The increase of upgrade cost lead to the increase in choice of automated cars, contrary to our initial expectations. It's possible that with a higher upgrade cost, they will have good quality equipment and feel safer when driving their car. Or in some cases, rich people do not care about upgrade costs and only want to get the experience of a new AC. There was a negative sign with the education background variable for both choices: partial AC and fully AC. It implies that the choice of AC is decreased with people who have an educational background of bachelor or higher, maybe due to them having a higher education level, and wanting to be sure and careful about their decision. It seems that they always have many considerations about costs what they have to pay, then their choice is normally the cheapest and more benefits.

The parameter of log-likelihood in table 5, for the model of specification 1 is -612, which higher than the model of specification 2 (-1002.2). The Rho parameter of specification 1 is 0.15537, therefore, it is likely not a terrible model. Since we can say that nested logit model is a goodness of fit model with data that we collected from respondents who had a car.

For the modeling, the influence factors of choice for the respondents who don't have a car, the attribute that we expected, did not present their effect in our 2 models. Otherwise, individual specifics are affected the choice to buy a car. We are so disappointed by these results, however, this issue can be explained with the accessibility of the online survey being limited and performed in a narrow area. Almost of the respondents are students or workers, there is a lack of awareness about AC, and they even have no experience with popular cars. Finally, we agreed that the data of the respondents who don't have car misses our expectations and is not a good fit for the purpose of this study.

The result showed that the modeling of the influence factors which affect AC choice for people who had a car is reasonable and nested logit model is a good fit with the data.

Rebuild the nested logit model after removed insignificant factor from table 5, we have the results in table 6. Since, we have some discussions about influence factors which relate to choice to upgrade the car in final results of nested logit model. Generally, 3 alternative specific variables (upgrade cost, travel time and confident level) and individual specific variables (income and education background) have significant impact to people's choices. Expected signs are presented in travel time (negative), confident level (positive) and income (positive) variables, did not change compare with old model which presented in table 5 above. However, significance levels had a small change when the model is changed after removed insignificant variables (Travel time: significant at 95%, confidence level significant at 90% CI, see table 6). Therefore, from table 6 we can say that for people who had a car, they are expecting and willing to upgrade their car to become an AC.

This study pointed out 5 variables: 2 individual specifics: Education background and Income, and 3 alternative specifics: Maintain +upgrade cost, Travel time and Confidence level, which is an impact component to AC choice modeling in a developing country, Viet Nam.
Results also showed that with a high level of confidence, people preferred to choose a partial AC or fully AC (positive sign, significant at 95% CI). Up to 65% of respondents believe in AC. This amount can imply that if 65% of people in Viet Nam use AC, the problem of traffic jams, traffic accidents could be reduced quickly with the condition that AC are available and its functions are perfect.

Table 6 Result of rebuild the Nested logit model

Respondents who had a private car			
	Estimate	t-value	
B:(intercept)	-2.8730e-01	-0.6112	
C:(intercept)	-5.1860e-01	-1.2789	***
Cost	1.8978e-04	4.1235	***
Time	-1.4853e-01	-4.9526	*
Confidence	1.9642e-01	2.1604	.
B: Education	-1.1465e+00	-3.8515	***
C: Education	-1.4754e+00	-5.2313	***

B: Income C: Income Iv	1.4017e+00 9.9417e-01 3.2190e-01	4.0200 2.9944 5.2109	*** ** ***
Log-Likelihood:	-614.34		
McFadden R^2:	0.15214		
Likelihood ratio test:	chisq = 220.48 (p.value = < 2.22e-16)		
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1			

4. Conclusion

This study examines people's acceptance of automated cars in a developing country, Viet Nam. We expected that with automation technology, automated cars can improve traffic problems, reduce congestion and traffic accident due to human error. Besides, we estimated the influence factors on the decision to upgrade their cars or buy a new car. Finally, the results showed that for people who had a private car, 33.18% in Viet Nam are willing to upgrade fully AC, with approximately 50% of them agreeing to pay $5500 for upgrading costs. The nested logit model pointed out that travel time and confidence levels have significant impact on the probability of AC choice, (travel time increase – choice decrease, confidence increase – choice increase). Also, individual specific factors, such as income and education background are closely related to choice, people with high income prefer to choose.

Vietnam is a developing country, one of low-income and middle-income countries, but not because of that, the demand for safety, comfort and utility in transport is constrained. Moreover, the price of the cars in Vietnam, compared with developed countries, is higher, more expensive than double, even triple when compare with developed countries.

Therefore, we expect that automatic vehicle dissemination is quite possible in the near future and many people will be willing to own one. The demand for safety and a comfortable trip is a right demand of every person.

5. Acknowledgment

This research is supported by the National Natural Science Foundation of China (No. 51478085).

References

[1] Global Status Report on Road Safety 2015, supporting a decade of action, WHO, Geneva, 2015
[2] European Commission, 2015: Road fatalities in the EU since 2001
[3] Road Safety In The South-East Asia Region 2015, WHO, 2016
[4] Kyriakidis .R.Happee..J.C.F.de Winter, Public opinion on automated driving: Results of an international questionnaire among 5000 respondents, Traffic Psychology and Behaviour Volume 32, July 2015, Pages 127-140
[5] Daniel J.Fagnanta, KaraKockelman, Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations
[6] Casley, S. V., Jardim, A. S., & Quartulli, A. M. (2013). A study of public acceptance of autonomous cars (Bachelor of Science), Worcester Polytechnic Institute, Worcester, MA, USA.
[7] Sommer, K. (2013). Continental mobility study 2013.
[8] Howard, D., & Dai, D. (2014). Public perceptions of self-driving cars: The case of Berkeley, California. In Paper presented at the 93rd Annual Meeting TRB, Washington, DC.
[9] Taxonomy and Definitions for Terms Related to On-Road Motor Vehicle Automated Driving Systems, J3016TM, SAE
[10] Koppelman and Bhat 2006 Self Instructing Course in Mode Choice Modeling-Multinomial and Nested Logit Models
[11] McFadden (1978) Modelling the choice of residential location
[12] Anderson, J. M., Kalra, N., Stanley, K. D., Sorensen, P., Samaras, C., & Oluwatola, O. A. (2014). Autonomous vehicle technology a guide for policymakers. RAND Corporation.
[13] Ricardo A. Daziano, Mauricio Sarrias, Benjamin Leard. Are consumers willing to pay to let cars drive for them? Analyzing response to autonomous vehicles, Transportation Research Part C 78 (2017) 150–164
[14] Adriano Alessandrini, Andrea Campagna, Paolo Delle Site, Francesco Filippi, Automated

Estimating Effects of Fuel Price Hikes on the Transport Sector

Topic number: 6 Paper Identification number: AYRF 2018-005

Krister Ian Daniel ROQUEL[1], Alexis FILLONE[2], Krista Danielle YU[3]

[1]PhD Candidate, Civil Engineering Department
De La Salle University
Telephone: (+63) 02 524-4611
Email: krister.roquel@dlsu.edu.ph

[2]Full Professor, Civil Engineering Department
De La Salle University
Telephone: (+63) 02 524-4611
Email: alexis.fillone@dlsu.edu.ph

[3]Associate Professor, School of Economics
De La Salle University
Telephone: (+63) 02 524-4611
Email: krista.yu@dlsu.edu.ph

Abstract

With the interconnected nature of the economy, in which outputs of each sector is taken as an input by some or all other sectors to produce its own output, it follows that a price increase on a commodity (e.g. fuel) will result to an increase in the production cost of all sectors using that commodity as an input. Ultimately, these additional cost increases are passed over to the buyers. Because of the importance of fuel in the production, marketing, and transportation of goods, increases in these costs result to increases in prices of goods, forcing more households to fall below the poverty line. This paper employed the Input-Output framework to estimate the effects of a change in fuel prices to all sectors of the economy. It was found that the Transport sector is most impacted. It was estimated that a 10%, 20%, and 30% change in fuel prices will result to total output changes of approximately PHP 175 billion, PHP 350 billion, and PHP 525 billion, respectively, or around 1.66%, 3.32%, and 4.97% of the GDP. Of these, 13% was estimated to be incurred by the Transport sector, where 'Bus line operation', 'Air Transport', and 'Jeepney and other land transport service' sectors make up more than half with 3.23%, 2.89%, and 2.31%, respectively. Comparing the estimated changes in Total Output with the original, while assuming constant quantities, the percentage change in costs of commodities produced by each sector was estimated. These can then be taken as a measure of how much change can be expected in the output costs of the rest of the economy.

Keywords: Input-Output, Cost-Push, Energy, Economy

1. General Introduction

The economy can be seen as a network of interconnected sectors, in which outputs of each sector is taken as an input by some or all other sectors to produce its own output. With this, it follows that a price increase on a commodity (e.g. fuel) will result to an increase in the production cost of all sectors using that commodity as an input. Moreover, these additional cost increases are passed over to other sectors, and ultimately, as the economy principally functions to produce its outputs and satisfy consumer demand, to the buyers of the products.

There is much research in the effects of fuel price changes to the economy. Hamilton (1983) found a strong inverse correlation between oil price changes and real economic activity, but in the United States of America and other OECD countries, Mork (1989) and Mork (1994) found asymmetry. Lilien (1982) and Hamilton (1988) argues that this could be due to the producers' reluctance to change prices as it poses potential for increased operational costs. Bernanke et al. (1997) and Barsky and Kilian (2001), on the other hand, attributes it to the possibility of restrictive monetary policy responses.

Valadkhani and Mitchell (2001), however, acknowledges that even when a rise in gross output, Gross Domestic Product (GDP) deflator, and consumer price index (CPI) was indicated from empirical simulations of a hypothetical petrol price increase, these price rises were regressive in impact. Edelstein and Kilian (2007), likewise, concluded that the effects of these price changes will be small, in the absence of a major disruption in spending by consumers.

Hui-Siang et al. (2011), on the other hand, established that fuel price is able to influence the movement of the agriculture, trade, and other services sectors over a long period. Setyawan (2014) also found that increasing fuel prices would have a devastating impact on the transportation sector.

Rangasamy (2017) continues that the contribution of fuel price changes to headline inflation has not only increased, but has also exceeded its weight in the CPI. It was also found that with the importance of fuel in the production, marketing, and transportation of goods, fuel prices have an important bearing on the prices of other commodities in the economy.

Increases in these costs result to increases in prices of goods, which ultimately burdens the households, especially those who are already poor. As early as 2006, the World Bank (2006) has estimated a 5.6% increase in poverty incidence due to fuel price increases.

In the Philippines, though households generally spend a relatively small portion of the budget on fuel itself (Reyes et al., 2008), as the effects of fuel prices seep into the prices of food and other commodities, the overall fuel budget share of the poorest group of households become higher than the richest. This forces more households to fall below the poverty line.

To dampen its impact on the economy, government subsidies can be introduced. However, in the case of fuel subsidies, where complications on impacts for efficiency and interests arise at different levels (e.g. consumers, producers, and the public sector), assessing the expenditures of such can be quite complicated. Thus, the purpose of this paper is to identify the key sectors that are most heavily impacted by fuel price hikes, using an Input-Output (IO) model.

The next section contains a brief discussion on the IO model, while Section 3 presents the linkages between the Petroleum and Transport Sectors. Section 4 shows the estimated effects of fuel price hikes on the various sectors of the economy. Lastly, Section 4 contains the conclusions and recommendations for future research.

2. Input-Output Modeling

Together with the aforementioned inter-sectoral purchases, primary inputs (PI) (e.g. compensation of employees, consumption of fixed capital) make up the total inputs (TI) for a sector to produce its output. Conversely, on top of inter-sectoral deliveries, final demand (FD) (e.g. exports, household final consumption expenditure) round out the total outputs (TO) produced by each sector. The economy, henceforth, can be expressed in an input-output table as in Table 1, where x_{ij} denotes the intermediate deliveries from industry i to industry j, f_i denotes the FD for products of industry i, w_j denotes the total use of PI for industry j, and x_i denotes the TO of industry i.

Table 3 Input-Output Table

	Sector				FD	TO
Sector	x_{11}	x_{12}	…	x_{1n}	f_1	x_1
	x_{21}	x_{22}	…	x_{2n}	f_2	x_2
	⋮	⋮		⋮	⋮	⋮
	x_{n1}	x_{n2}	…	x_{nn}	f_n	x_n
PI	w_1	w_2	…	w_n		w
TI	x_1	x_2	…	x_n	f	

From this table, two accounting equations are obtained as follows,

$$\mathbf{x} = \mathbf{Xe} + \mathbf{f} \tag{1}$$
$$\mathbf{x^T} = \mathbf{e^T X} + \mathbf{w} \tag{2}$$

Where: **e** : n-element summation vector, consisting of ones

Defining the input coefficients as follows,

$$a_{ij} = x_{ij}/x_j \text{ or } \mathbf{A} = \mathbf{X\hat{x}^{-1}} \tag{3}$$

Where: $\hat{\mathbf{x}}$: diagonal matrix with the elements of x on its main diagonal

Eq. (1) can be rewritten as,

$$\mathbf{x} = \mathbf{Ax} + \mathbf{f} \tag{4}$$
$$\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}(\mathbf{f}) = \mathbf{L}(\mathbf{f}) \tag{5}$$

Where: **I** : identity matrix
L : Leontief inverse

corresponding to the standard Leontief demand-driven quantity model (Leontief, 1936). This equation gives the production output needed from every sector to satisfy both the demands from internal and consumer utilization.

With matrix ***A*** consisting of elements a_{ij}, denoting input requirements of sector *j* from sector *i*, normalized with respect to the total input requirement of sector *j*, the model encapsulates the interdependence of different economic sectors. Furthermore, following the linear relationship of matrix equations, the model allows for the analysis of changes in final demands due to external causes, and its system-wide effects on the interconnected network of the economy.

Assuming ***A*** is fixed and that all prices remain constant, it follows that a change Δf in the final demand, referred to as "demand-pull", has a corresponding effect Δx on the production of each sector, shown as follows,

$$\Delta\mathbf{x} = \mathbf{L}(\Delta\mathbf{f}) \quad (6)$$

From this, element l_{ij} of ***L***, thus, gives the increase of the output in industry *i*, in monetary terms (e.g. PHP), due to a one-unit (e.g. PHP 1.00) increase of the final demand in industry *j*. This reflects the backward linkage between the buying industry *j* on the selling industry *i*.

On the other hand, defining the output coefficient as follows,

$$b_{ij} = x_{ij}/x_i \text{ or } \mathbf{B} = \hat{\mathbf{x}}^{-1}\mathbf{X} \quad (7)$$

Eq. (2) can be rewritten as,

$$\mathbf{x}^{\mathbf{T}} = \mathbf{x}^{\mathbf{T}}\mathbf{B} + \mathbf{w} \quad (8)$$

$$\mathbf{x}^{\mathbf{T}} = \mathbf{w}(\mathbf{I} - \mathbf{B})^{-1} = \mathbf{w}\mathbf{G} \quad (9)$$

Where: **G** : Ghosh inverse

corresponding to Ghosh's (1958) "supply-driven" IO model, or more recently referred to as the Ghosh price model (Dietzenbacher, 1997).

Similarly, assuming fixed output coefficients ***B***, changes in output Δx^T due to a change Δw can be calculated as follows,

$$\Delta\mathbf{x}^{\mathbf{T}} = (\Delta\mathbf{w})\mathbf{G} \quad (10)$$

Dietzenbacher and Miller (2015) discusses that this model, however, is not a quantity model (i.e. an alternative to Leontief's demand-driven model) but is rather an equivalent to the standard price model. Similar to the Leontief quantity model assumes fixed prices, the Ghosh price model assumes that all quantities remain constant instead. Thus, Eq. (10) shows the effects of changes Δw in the PI on the TO values Δx^T.

The change Δw is referred to as "cost-push", which describes an exogenous change in PI that results in a change Δx^T in the TO. Following the original assumption of constant quantities, the resulting change in TO of a sector can be expected as a change in unit cost of said sector's commodity. With increasing unit costs come inflation potential, where there is a reduction in the purchasing power per unit of money.

3. Petroleum and the Transport Sectors

In estimating what a change in a component has on the overall system, one must first characterize its position in the bigger scheme of things. With the interconnected nature of the economy, it is important to examine both the size and "economic distances" of the linkages between sectors. For example, when a sector largely depends on another, knowing whether this dependence is direct or via one, two, or more other sectors is critical in analyzing the overall production structure. With production chains playing a significant role in supply-chain management as the combination of primary and intermediate inputs from all steps of the production process adds to the value of the product, characterizing the petroleum sector's role in the economy is critical.

This was done by determining the "economic distance" between the sectors of the economy. Using the Leontief and Ghosh inverses, ***L*** and ***G***, respectively, quantified from Eqs. (5) and (9), a matrix of the average propagation lengths (APLs), ***V***, between sectors was constructed. Its elements, measuring the number of "steps" it takes for a change Δf in sector *i* to affect the rest of the economy, were estimated as follows,

$$v_{ij} = \begin{cases} h_{ij}/(g_{ij} - \delta_{ij}) & \text{if } g_{ij} - \delta_{ij} > 0 \\ 0 & \text{if } g_{ij} - \delta_{ij} = 0 \end{cases} \quad (11)$$

$$\mathbf{H} = \mathbf{G}(\mathbf{G} - \mathbf{I}) \quad (12)$$

Where: δ_{ij} : Kronecker delta, with a value of 1 when *i* is equal to *j*, and 0 otherwise.

APL's limitation, however, is that the size, and thus, the relevance, of inter-sectoral transaction is neglected. Matrix ***F***, whose elements are calculated as follows,

$$\mathbf{F} = \frac{1}{2}[(\mathbf{L} - \mathbf{I}) + (\mathbf{G} - \mathbf{I})] \qquad (13)$$

on the other hand, indicates the size of transactions and points at the relevance of the linkages. As propagation length is the same whether considering a demand-pull or a cost-push, in the sense that the number of forward steps required to from sector i to sector j should be equal to the number of backward steps required from j to i, both forward and backward linkages were considered by taking the average. $\boldsymbol{F}$, however, does not distinguish whether the effect is mainly direct or indirect. Thus, the 2 types of indicators were combined as follows,

$$s_{ij} = \begin{Bmatrix} \mathrm{int}(v_{ij}) & \text{if } f_{ij} \geq a \\ 0 & \text{if } f_{ij} < a \end{Bmatrix} \qquad (14)$$

Where: a : threshold value, where higher values correspond to more simplified views of the economy.

For example, when a was set at 0.1, a complex configuration of the Philippine economy was developed, based on the 2012 IO Accounts of the Philippines, where each arrow represents a significant linkage and gives the rounded APL. Solid arrows have an APL of 1 while broken arrows have an APL of 2. Figs. 1 and 2 show the configurations when a was set at 0.1 and 0.2, respectively.

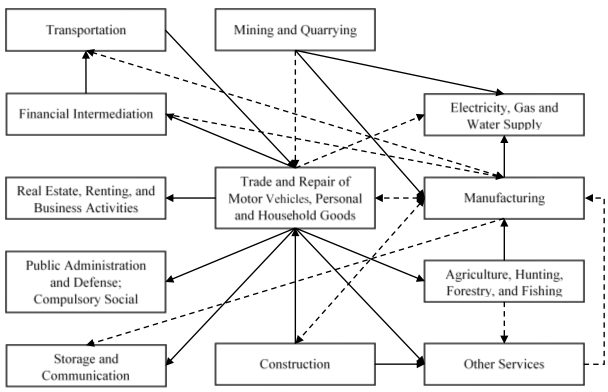


Fig. 1 Economic Configuration (a = 0.1)

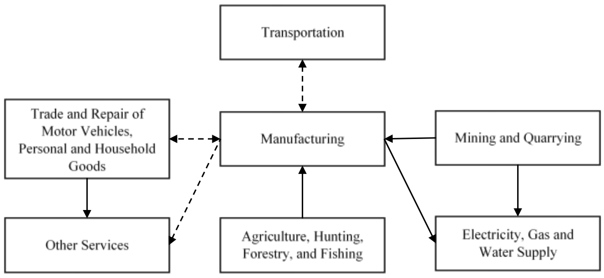


Fig. 2 Economic Configuration (a = 0.2)

Based on Fig. 2, the Transportation sector interacts principally with the Manufacturing sector. To look more closely into these linkages, the IO table can be disaggregated further. Originally a 65 x 65 matrix, the 2012 IO table was converted into a 24-sector matrix. Using a conversion matrix, $\boldsymbol{C}$, with n rows and m columns, where n denotes the original disaggregation (i.e. 65) of the matrix to be transformed, m denotes the intended dimensions of the converted matrix (i.e. 24), and c_{ij} denotes the value allocations (e.g. c_{21} with a value of '1.00' for 100% of both $x_{21,old}$ and $x_{12,old}$ to go to $x_{11,new}$; c_{52} and c_{53} with values of '0.30' and '0.70' for 30% of both $x_{52,old}$ and $x_{25,old}$ to go to $x_{52,new}$ and $x_{52,new}$, respectively, while the remaining 70% goes to $x_{53,new}$ and $x_{35,new}$, respectively), matrix reaggregation can be done as follows,

$$\mathbf{x}_{\mathbf{new}} = \mathbf{C}^{\mathbf{T}}(\mathbf{x}_{\mathbf{old}}\mathbf{C}) \qquad (15)$$

Table 2 shows the sector disaggregation used for this study, where the 'Manufacturing of Petroleum and other products' (MPO) sector was isolated and the Transportation subsectors were kept disaggregated to show a more detailed configuration. Using the new IO table, a more-detailed view of the MPO's position in the economy can be illustrated, as shown in Fig. 3, based on the new matrix of APL values, as shown in Table 3.

From this, the MPO sector can be seen to have significant input linkages to 10 sectors, with all but the 'Electricity, Gas, and Water Supply' (EGW) sector not being a Transportation subsector. From this, it follows that a change $\boldsymbol{\Delta x^T}$ in TO stemming from a change $\boldsymbol{\Delta w}$ in MPO's PI can be expected to be incurred mostly by the Transportation Sector. On another note, MPO was also found to serve as an indirect input to the 'Rest of Manufacturing', Construction, and 'Trade and Repair of Motor Vehicles, Motorcycles, Personal, and Household Goods' sectors, which tells that these will likely be impacted as well.

Table 4 Sector Disaggregation

No.	Economic Sector
1	Agriculture, Hunting, Forestry, and Fishing
2	Mining and Quarrying
3	Manufacturing of Petroleum and other fuel products (MPO)
4	Rest of Manufacturing (ROM)
5	Construction (CO)
6	Electricity, Gas and Water Supply (EGW)
7	Bus line operation
8	Jeepney and other land transport services
9	Railway transport
10	Public utility cars and taxicab operation
11	Tourist buses and cars including chartered and rent-a-car
12	Road freight transport
13	Sea and coastal water transport
14	Inland water transport (including renting of ship with operator) and other water transport services
15	Air transport
16	Supporting services to transport
17	Tour and travel agencies and tour operators; tourist assistance activities, n.e.c.
18	Activities of other transport agencies (including custom brokerage, n.e.c)
19	Storage and Communication
20	Trade and Repair of Motor Vehicles, Motorcycles, Personal, and Household Goods (TAR)
21	Financial Intermediation
22	Real Estate, Renting, and Business Activities
23	Other Services (OS)
24	Public Administration and Defense; Compulsory Social Security

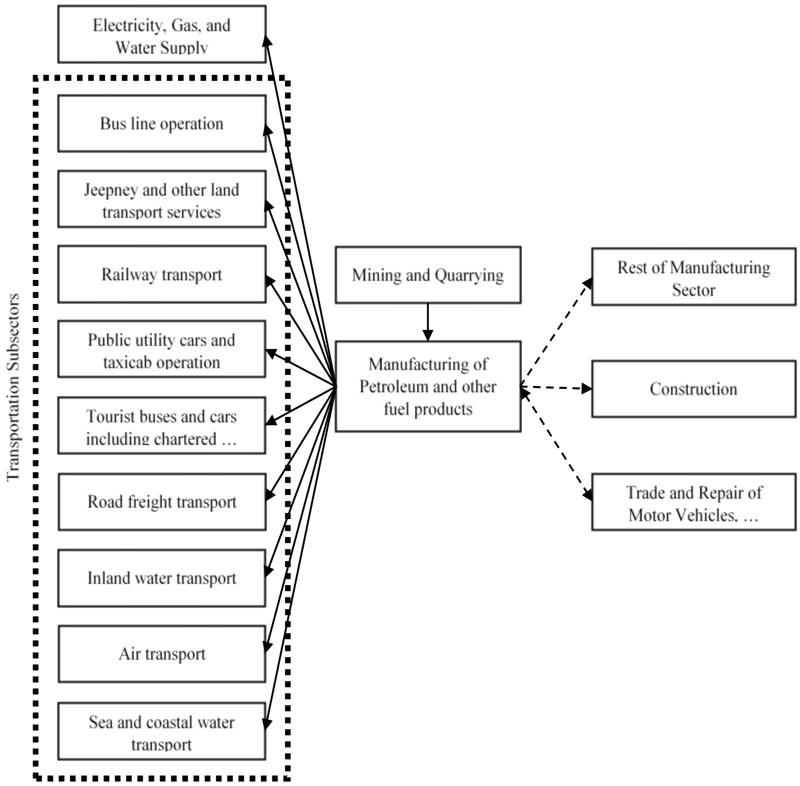


Fig. 3 Economic Configuration (a = 0.2)

Table 5 S Matrix of APL Values

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
2	0	0	1	2	1	2	2	0	0	0	0	0	0	0	2	0	0	0	0	3	0	0	3	0
3	0	0	1	2	2	1	1	1	1	1	1	1	1	1	1	0	0	0	0	2	0	0	2	0
4	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	2	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
7	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
8	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
9	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
17	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
18	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	1	0	2	2	2	0	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1
21	0	0	0	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	2	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

4. Cost-Push Estimation

For this paper, the effects of a 10%, 20%, and 30% change in fuel prices were estimated. By introducing a change Δw to the IO model, a change Δx^T in the TO can be interpreted as a cost-push across the economy. Table 4 shows the estimated changes in TO in each sector of the Philippine economy where, a 10%, 20%, and 30% increase in fuel prices were shown to result in an estimate of approximately PHP 175 billion, PHP 350 billion, and PHP 525 billion as a change in TO for the whole economy, accounting for around 1.66%, 3.32%, and 4.97% of the GDP, respectively. Of these, over 38% is incurred by the MPO, as it serves as a direct input to itself to produce its output (i.e. APL = 1). First of the most impacted sectors, the ROM sector incurred almost half of that at 16%, while the TAR, OS, and EGW sectors round out the top 5, incurring over 8%, 7%, and 5%, respectively, of the overall impact to the economy. CO follows shortly with over 4%.

Collectively, though, the Transport subsectors incurred almost 13%, highest among those outside the Manufacturing sector. This shows that aside from the Manufacturing sector, it is, indeed, the Transport sector that is most impacted. Of this 13%, Bus line operation, Air Transport, and Jeepney and other land transport service sectors make

Table 6 Change in Total Outputs of Sectors in 2012 Prices [Billion PHP/year]

Sector	10	20	30	%
1	3.89	7.79	11.68	2.23
2	0.84	1.69	2.53	0.48
3	67.30	134.60	201.90	38.44
4	27.97	55.95	83.92	15.98
5	7.37	14.75	22.12	4.22
6	9.04	18.08	27.12	5.16
7	5.65	11.31	16.96	3.23
8	4.04	8.07	12.11	2.31
9	1.29	2.57	3.86	0.73
10	0.50	1.00	1.50	0.29
11	0.47	0.94	1.41	0.27
12	2.62	5.24	7.85	1.50
13	1.21	2.43	3.64	0.70
14	0.11	0.23	0.34	0.07
15	5.06	10.13	15.19	2.89
16	0.62	1.24	1.86	0.35
17	0.30	0.61	0.91	0.17
18	0.36	0.72	1.08	0.21
19	1.69	3.38	5.07	0.97
20	14.21	28.43	42.64	8.12
21	3.76	7.51	11.27	2.15
22	1.29	2.57	3.86	0.73
23	12.52	25.03	37.55	7.15
24	2.89	5.78	8.67	1.66
Total	175.00	350.05	525.04	100.00

up more than half with 3.23%, 2.89%, and 2.31%, respectively.

Comparing the estimated changes in TO with the original, while assuming constant quantities, the percentage change in costs of commodities produced by each sector was estimated as shown in Table 5. On top of the initial 10%, 20%, and 30% change in the PI of the MPO sector, an additional 2.50%, 5.01%, and 7.51%, respectively, were estimated to come from indirect changes from other sectors it uses as an input.

Table 7 Percentage Change in Cost of Outputs

Sector	2012 TO [Billion PHP]	10%	20%	30%
1	2,145.32	0.18	0.36	0.54
2	183.18	0.46	0.92	1.38
3	538.29	12.50	25.01	37.51
4	5,829.01	0.48	0.96	1.44
5	1,026.11	0.72	1.44	2.16
6	821.06	1.10	2.20	3.30
7	207.65	2.72	5.45	8.17
8	148.23	2.73	5.44	8.17
9	47.28	2.73	5.44	8.16
10	18.37	2.72	5.44	8.17
11	17.30	2.72	5.43	8.15
12	96.14	2.73	5.45	8.16
13	41.74	2.90	5.82	8.72
14	3.94	2.79	5.84	8.63
15	175.31	2.89	5.78	8.66
16	71.12	0.87	1.74	2.62
17	34.97	0.86	1.74	2.60
18	41.31	0.87	1.74	2.61
19	551.39	0.31	0.61	0.92
20	3,165.56	0.45	0.90	1.35
21	1,453.96	0.26	0.52	0.78
22	727.05	0.18	0.35	0.53
23	3,110.20	0.40	0.80	1.21
24	1,223.54	0.24	0.47	0.71
Total	21,678.02			

Next to the MPO, sectors 7 to 15 each incurred around 2.77% change in costs, while the all other sectors, except the EGW sector, have estimates lower than 1%. This further illustrates that the Transport sector incurs the biggest change stemming from that in the output cost of the MPO. These values, conversely, can also be taken as a measure for how much change can be expected.

For example, a 10% increase in fuel prices is expected to push the output cost of the 'Bus line operation' sector by 2.72%; hence, a bid for an increase in fare rates by bus line operators should not be more than that amount. Otherwise, it will only cause a spread of further cost-pushes across the economy, illustrating the inflation potential due to a cost-push in one sector of the economy.

Moving a step further, another policy application may be on the setting of public transport fares, depending on the current fuel prices. As such, the currently implemented fare matrix can be expanded to accommodate the estimated changes in production costs, where fares also vary with respect to different ranges of fuel prices. Potentially, this could alleviate the need for the public transport operators and drivers' frequent plea for fare hikes and that for rollbacks by the consumers, especially with how the latter does not come as often as the other.

5. Conclusions and Recommendations

This paper employed the Input-Output framework to estimate the effects of a change in fuel prices to all sectors of the economy. It was found that the Transport sector is most impacted, as fuel is a critical input in the production of its output. It was estimated that a 10%, 20%, and 30% change in fuel prices will result in changes in Total Outputs of approximately PHP 175 billion, PHP 350 billion, and PHP 525 billion, respectively, or around 1.66%, 3.32%, and 4.97% of the GDP. Of these, 13% was estimated to be incurred by the Transport sector, while Sector 4 incurred 16%. Sectors 20, 6, and 23 round out the top 5, incurring over 8%, 7%, and 5%, respectively.

Furthermore, on top of the initial 10%, 20%, and 30% change in the Primary Inputs of the 'Manufacture of Petroleum and other fuel products' sector, an additional 2.50%, 5.01%, and 7.51%, respectively, were estimated to come from indirect changes from other sectors it uses as an input. Next, Sectors 7 to 15 each incurred around 2.77% change in costs, while the all other sectors, except the Sector 6, have estimates lower than 1%. Sectors 16, 17, and 18, follow shortly afterwards at almost 0.9%.

With this information, fuel subsidies can be allocated in consideration of which sectors are expected to incur the biggest impacts. As different sectors carry different shares of the changes, so should the policy interventions to be made by the government. Knowing where the changes can be expected, appropriate solutions can be proposed to dampen the far-end impact on commodity prices and affordability.

References

[1] Barsky, R. and Kilian, L. (2001). Do we really know that oil caused the great stagflation: A monetary alternative (with comments). *NBER Working paper 8289.* National Bureau of Economic Research. Cambridge.

[2] Bernanke, B., Gertler, M. and Watson, M. (1997). Systematic monetary policy and the effects of oil price shocks. Brookings papers on economic activity, economic studies program. *The Brookings Institution*, 28, 91-157.

[3] Dietzenbacher, E. (1997). In vindication of the Ghosh model: A reinterpretation as a price model. *Journal of Regional Science*, 37, 629-651.

[4] Dietzenbacher, E. and Miller, R. (2015). Reflections on the inoperability input-output model. *Economic Systems Research*, 27(4), 478-486.

[5] Edelstein, P. and Kilian, L. (2007). Retail energy prices and consumer expenditure. *CEPR Discussion Papers 6255*, C.E.P.R. Discussion Papers.

[6] Ghosh, A. (1958). Input-output approach in an allocation system. *Economica*, 25, 58-64.

[7] Hamilton, J. (1983). Oil and the macroeconomy since world War II. *Journal of Political Economy*, 91, 228-248.

[8] Hamilton, J. (1988). A neoclassical model of unemployment and the business cycle. *Journal of Political Economy*, 96, 593-617.

[9] Hooker, M. (2002). Are oil shocks inflationary? Asymmetric and nonlinear specifications versus changes in regime. *Journal of Money, Credit and Banking*, 34, 540-561.

[10] Hu-Siang, J., Evan, L., Chin-Hong, P., and Shazali, A. (2011). Domestic fuel price and economic sectors in Malaysia. *Journal of Economic and Behavioural Studies*, 3(1), 28-41.

[11] Kilian, L. (2008). The economic effects of energy price shocks. *Journal of Economic Literature*, 46, 871-909.

[12] Leontief, W. (1936). Quantitative input and output relations in the economic system of the United States. *Review of Economics and Statistics*, 18(3), 105-125.

[13] Lilien, D. (1982). Sectoral shifts and cyclical unemployment. *Journal of Political Economy*, 90, 777-793.

[14] Mork, K. (1989). Oil and the macroeconomy when prices go up and down: An extension of Hamilton's results. *Journal of Political Economy*, 97, 740-744.

[15] Mork, K. (1994). Business cycles and the oil market. *The Energy Journal*, 15, 15-38.

[16] Rangasamy, L. (2017). The impact of petrol price movements on South African inflation. *Journal of Energy in Southern Africa*, 28(1), 120-132.

[17] Reyes, C., Sobrevinas, A., Bancolita, J., and De Jesus, J. (2008). Analysis of the impact of changes in the prices of rice and fuel on poverty in the Philippines. Retrieved from: https://www.pep-net.org/sites/pep-net.org/files/typo3doc/pdf/CBMS-food-prices/Philippines_Impact_of_Rising_Prices_051710.pdf.

[18] Setyawan, D. (2014). The impacts of the domestic fuel increases on prices of the Indonesian economic sectors. *Energy Procedia*, 47, 47-55.

[19] Valadkhani, A. and Mitchell, W. (2001). Assessing the impact of changes in petrol prices on inflation and household expenditures in Australia. Centre of Full Employment and Equity. Retrieved from: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.578.3572&rep=rep1&type=pdf.

[20] World Bank. (2006). Venezuela: Efficiency repricing of energy. *Sector Report No. 13581* (Washington: World Bank).

Good practices on freight transport management: Lessons-learned and applicability for Vietnam

Topic number: 9. Paper identification number: AYRF2018-010

Dr. Nguyen Thi Binh

Section of Transport Planning and Management
University of Transport and Communications, VIETNAM
Telephone +84 24 3766 4053, Fax. +84 24 3766 6496
E-mail: ntbinh1907@gmail.com

Abstract

Freight transport is playing a crucial role for economic development in any country. Effective freight transport management can enhance the economic structure of a country. As a rapidly growing economy in transition, Vietnam has been facing various freight transport problems related to emission, safety, and energy. This necessitates a better management of freight transport system to address these problems. The main objectives of this study is to comply freight transport management measures identified from the literature review and analyse their application in order to show what is working and what is not, identifying underlying causes of success or failure. Besides, the increasing problems related to freight transport system in Vietnam are also presented. Based on that, lessons-learned from good practices on freight transport management will be discussed in detail to set a solid ground for recommending freight transport management policies and interventions in Vietnam.

Keywords: Freight transport management, logistics cost

1. Introduction

Freight transport development has for long seen as a key element of ensuring a successful economy. According to General Statistics Office of Vietnam (2014), economic growth rises with positive correlation of freight transport growth during the period of 2005-2014. Freight transport infrastructure in Vietnam has been improved remarkably with the current constrains. Freight infrastructure not only refers to roads, railways, and inland waterway systems, but also refers to facilitating the handling of goods or multimodal freight facilities. However, the rapid development of freight transport system in Vietnam revealed many limitations related to emission, safety, and economic efficiency. This necessitates better management of freight transport system to address these problems, thus maintaining the role of the freight transport in the future.

The main objectives of this study are to gain an in-depth understanding of freight transport management measures identified from the literature review and the existing issues of freight transport system of Vietnam. Based on that, lessons-learned and the potential policies addressing these issues will be discussed. The structure of this paper includes

four parts. The second part presents the theoretical foundation of the study. It consists of basic concept and compilation of practices on freight transport management (FTM) in the world. The third part presents existing situation of freight transport development of Vietnam, with an emphasis on the deficiencies of freight transport activities. Finally, the lessons-learned and policy considerations are discussed to help formulate a decision-support system for freight transport management. The last part concludes and recommends a further study.

2. Literature review on FTM measures

2.1. Basis concepts

The study employs the concepts of "traffic management" and "freight transport management measures" developed by Boltze (2003) and Boltze et al., (2012). Traffic management can be interpreted as "to influence the transport system with a bundle of measures to bring transport demand and supply in an optimized balance". *Freight transport management is a part of traffic management aiming at influencing freight transport by implementing a bundle of measures with the target of optimizing the positive and negative impacts of traffic and transport*.

While following the concept, the freight transport management measures in this study are specifically addressed from the perspective of transport engineering and classified by its potential impacts, namely avoiding traffic, shifting traffic, and controlling traffic. This is presented in detail in Fig.1 below.

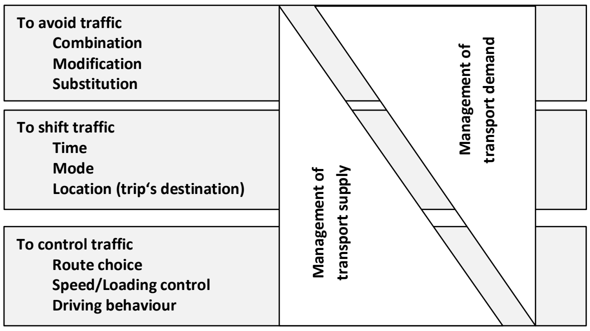


Fig. 1 Classification of FTM measures by their potential impacts
Source: Adapted from Boltze (2003)

Measures to avoid freight traffic are aiming at reducing freight transport demand in the targeted area by combining, modifying and substituting trips. Mechanisms for combining trips are applied to reduce the number of trips and trip length. Modifying trip is related to the trip chain and multi-purpose trips. Freight traffic demand can be also reduced by e-commercial transport. **Measures to shift freight traffic** try to move freight traffic demand between different modes, times and destinations. Mechanisms for shifting traffic involve shifting to high capacity freight transport modes, shifting to off-peak hours to reduce the peak period traffic, and shifting destination closer to trip origin to reduce the average trip length. **Measures to control freight traffic** are usually part of the traffic supply management but they also have an influence on traffic demand. These measures include truck route restriction, controlling speed or loading of vehicle, and the enhancement of driving behaviour to stabilize traffic condition of a specific area.

2.2. Compilation of FTM measures

There are a number of studies on FTM measures and their application. Based on the classification in the previous section, the study compiles FTM measures identified from the literature review. In particular, eighteen FTM measures have been complied, which are categorised by their potential impacts such as avoiding traffic, shifting traffic, and controlling traffic. The measures are numbered from M1 to M18.

Some of the described measures are already applied in practice while others are currently the subject of research. Therefore, the following table will present some examples for the application of FTM measures in over the world.

Table 1: List of examples for the application of FTM measures

No	List of candidate FTM measures	Examples for relevant case studies	Source	Application level: Study	Application level: Trials	Application level: Operational schemes
M1	Freight centres and consolidated deliveries	Multimodal freight centre in Bremen Germany	Browne et al. (2005) https://www.wfb-bremen.de			x
		Bologna and Vicenza freight village, Italy	Boile et al. (2009) Ville et al. (2010)			x
		Urban freight centre in Kassel, Germany	Browne et al. (2005) Wisetjindawat (2011)			x
		Consolidation centre in Heathrow Airport	Browne et al. (2005)			x
M2	Co-operative freight transport system	Tenjin co-operative delivery system in Japan	Taniguchi, E and Nemoto, T (2003)			x
M3	Harvesting time	Research on potential impacts of climate change on freight transport	Caldwell et al. (2002)	x		
M4	Time window for truck entering the city	Governmental time-window schemes in the Netherlands	Quak and De Koster (2006)			x
		Truck ban in Manila, Philippine	Castro, J.T and Mario, R (2010)		x	
M5	Time window for loading/unloading at curb-side parking places	The case of London and Norwich, England	Allen et al. (2000) Browne et al. (2007)			x
M6	Incentive for off-peak delivery	Off-peak deliveries in New York City	Holguín-Veras et al. (2007)			x
M7	Promotion of intermodal transport	A study of FTM measures in selected European countries	Nemoto, T et al. (2006)			x
M8	Image campaigns, concept for "Green Logistics"	Green Logistics at Eroski (food distribution sector in Spain)	Ubeda, S et al. (2011)	x		
		Green Logistics management in Chinese manufacturing exporters	Lai, K. and Wong, C.W.Y. (2012)	x		
M9	Low-emission zones	Application in Austria, Denmark, Italy, the Netherland, and Germany	Allen and Browne (2010)		x	
M10	Vehicle weight-based /width-based restriction	Limited accessibility of large trucks to enter certain areas in the Netherlands	Browne et al. (2007) Quak and De Koster (2006)			x
		Truck ban in Manila, Philippine	Castro, J.T and Mario, R (2010)		x	
M11	Promotion of regional products	The development of Japanese regional products	Januszewska, R et al. (2005)	x		
M12	Business cooperation	The project of co-operation between fashion shop retail chains in Amsterdam	Visser et al. (1999)	x		
M13	Provision of loading/unloading areas	Loading/unloading zone restriction in London, Paris, Fukushima cities	Browne et al. (2005) Wisetjindawat (2011)			x
M14	Truck routes/Freight – exclusive lanes	Case studies on some freeways of the United States and Canadian urban areas	Allen and Browne (2010)			x
M15	Infrastructure capacity improvement	The development of multimodal freight facilities and railway system in European countries including Germany, Italy, France	Nemoto, T et al. (2006)			x
M16	Road pricing schemes	Distance-based charging system for heavy goods vehicles in selected European countries	Vrtic, M et al. (2009)			x
M17	Load factor control (LFC)	LFC in Amsterdam and Copenhagen	Taniguchi, E and Nemoto, T (2003)			x
M18	Technology-based route planning and fleet management	The case of IT applicability or e-commerce in Hong Kong and Taiwan	http://www.pland.gov.hk/	x		
		Application of ITS such as Electronic Toll Collection (ETC) and the Global Positioning System (GPS) in Singapore	Chan and Al-Hawamdeh (2002)			x

A summary of the most important findings from each case study is provided in the following texts.

In essence, crucial benefits from practical application of **freight centre and consolidated** delivery and **co-operative freight transport system** are the reduction in the number of commercial vehicles via promoting consolidation and multimodal transport. Meanwhile, the application of **time-window for truck entering the city** and **for loading and unloading at curbside parking places** and **incentive for off-peak delivery** could bring positive impacts on shifting truck traffic into off-peak hours (night time for instance) and better protect pedestrianized areas located in the city. However, these measures are not always successful in practice, for example freight centre and consolidated delivery in the form of urban freight centre (UFC). There are a number of reasons behind this failure. One reason is inaccurate estimation of potential demand for UFC. Unsuccessful initiatives usually assume a far higher level of demand for UFC, often resulting in not enough goods handling at the UFC (Takahasi and Hyodo, 1999). Furthermore, failure is associated in a deficiency in strict delivery regulation, and in some cases, transport and forwarding companies are reluctant to use the facilities due to the fear of losing competiveness.

There is a very little literature focusing on the application of **harvesting time measure**. This is likely because this approach requires consideration of many complex conditions such as weather condition, geological condition, and custom production

The implementation of the **intermodal transport framework** has been an important part of public policy aimed at encouraging a modal shift from road freight traffic to rail and coastal shipping. The concept of "**Green Logistics" and "Low-emission zones**" has recently been recognised as a new research trend in FTM literature, dealing with the integration of environmental management and supply chain operation. These measures can potentially contribute to safer and cleaner freight transport modes in the economy.

Reviewing the literature has shown that the main function of **vehicle weight-based /width-based restriction** is to restrict large vehicles (up to certain weight) entering specific urban areas, where there are many pedestrians and road users, thereby reducing commonly perceived impacts of trucks such as noise, pollution, safety concerns and vibration (Browne et al., 2007). Alongside with this restriction, **the provision and efficient usage of loading/unloading areas** in city centre has become an urgent need for many European countries. Loading/unloading zone restriction can, however, bring a spatial shift in traffic flows since delivery vehicles are only allowed to perform their activities in regulated areas in the city; therefore, high traffic density may occur in and around these areas. Furthermore, this approach increases the total number of vehicle trips and vehicle kilometres necessary to deliver goods at any one time.

The **promotion of regional products** has long been regarded as a tool for regional development (Januszewska et al., 2009). So far, there has been very little research on the impacts of this measure on traffic and transport activities. **Business cooperation measures** have been investigated using case studies on the cooperation of different interest groups involved in the supply chain. The co-operation initiative between fashion shop retail chains in Amsterdam is an example (Visser et al., 1999). The results of this project is expected to brings spatial shift to traffic since it promotes cooperation among fashion retail shops for upstream consolidation purposes, thereby potentially reducing independent transport by fashion shop owners.

Truck routes or freight-exclusive lanes are considered as another infrastructure measure deployed to control freight traffic in the city. The concept of freight-exclusive lanes can be understood as a traffic lane dedicated to trucks only, and trucks are separated from other traffic either through physical or operational techniques (TAC, 2014). **Infrastructure capacity improvement** is a common supply side measures but has quite a strong influence on freight transport demand in term of facilitating the handling of goods and reducing transport cost. **Road pricing schemes** differentiated by time, space and/or emission have long been seen as ideal measures for traffic control by urban planners. The aim of such schemes is to reduce the negative impacts of road transport (including passenger and freight transport) on the environment, society and the economy. **Load factor schemes** are often employed by policy makers alongside other schemes in traffic management such as vehicle weight-based /width-based restriction or road pricing scheme. Application of **technology-based route planning and fleet management** for process of production, logistics, transport and traffic has become an attractive option for both private and public sector through identifying vehicle real-time position on the network map, giving the exact location of vehicles and guiding vehicles on the most efficient routes.

To sum up, all the case studies above are typical examples of the application of FTM measures employed worldwide. Many of them have been implemented within the boundaries of cities or urban areas, therefore, in some contexts; they are recognized as City Logistics measures. Obviously, there are many commonalities between FTM and City Logistics measures, since both aim to improve safe and efficient freight movement in balance with environmental, and social, economic issues. However, the range of activities that comprise freight transport management is broader than those associated to City Logistics. Specifically, freight transport management focuses not only on urban areas but also on long-distance deliveries.

3. Freight transport sector in Vietnam

Vietnam is located in the Southeast Asia Region and shares its border with China, Laos, and Cambodia. The country includes *331.212* square kilometer of mainland and about *1 million* square kilometers of territorial sea. The current population of Vietnam is about *94 million* (GSO, 2016), ranked the 15th in the most populous countries in the world. Vietnam has entered "the golden population structure" since 2007 with the median age about *30.9* years. During the last decades, the country economy grew by *6.3 %* per year (GSO, 2016).

As freight transport and logistics sector is playing a crucial role to investment- and export-led economic models like Vietnam's, the Government of Vietnam has placed strong emphasis on developing this sector entire country.

➢ *Freight transport growth rate*

The Vietnamese freight transport system has gone a sustainable change during a last decade moving Vietnam from a primarily agriculture-based economy to an industry and export based economy. According to the official statistics office the growth rate of freight transport volume (in ton) is averagely 9.8 % in the period of 2005-2016.

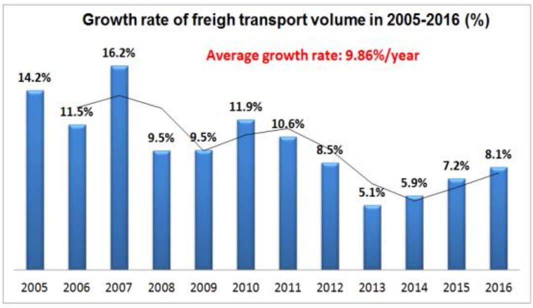


Fig.2 Growth rate of freight transport volume in 2015-2016
Source: GSO (2016)

➢ *Freight modal share by tonnage*

Looking at the freight modal split of Vietnam (Fig. 3) it reveals that inland waterway (IWT) and road are two dominant modes of freight transport with the rate of 48% and 45%, respectively. Although, railway has been setup for over one hundred years it still plays a very limited role in the development of freight transport system in Vietnam. Its modal share is less than 2%.

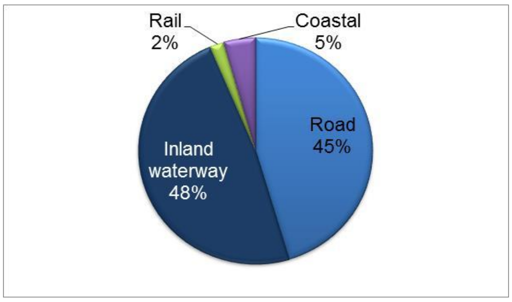


Fig 3 Freight modal share by tonnage
Source: VITRANSS-2 (2009)

➢ *Freight modal share by trip length (%, km)*

Fig. 4 shows the freight modal share by trip length. Each transport mode takes different responsibility in freight transport at different distances. The freight trip of less than 100km is completely dominated by truck while IWT mostly works for 100 to 200km. Costal freight is the dominant mode for longer trip (over 1000km) and only taking care of 4.4% of freight movement. Rail freight takes place scattered at different trip lengths.

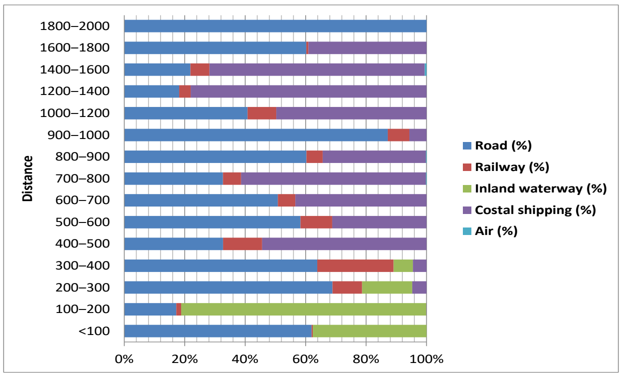


Fig.4 Freight modal share by trip length (%,km)
Source: VITRANSS-2 (2009)

➢ *Freight flow by major commodity type*

Vietnam's freight flows heavily concentrated in low-value bulk commodities which less depends on reliability. Most heavy raw materials, such as construction materials are shipped using inland waterways while truck has a big responsibility for transporting the bulk of manufactured goods.

Recently this picture has been changing very quickly since Vietnam has become a more manufacturing-intensive economy and traded with high-valued added commodities.

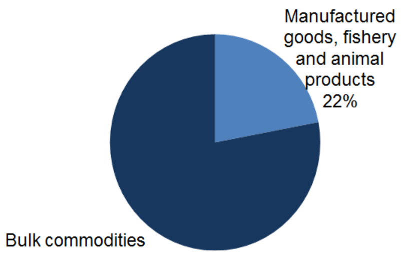


Fig. 5 Freight flows by major commodity types
Source: VITRANSS-2 (2009)

As a result, containerized trade has been growing faster than bulk trade. It is estimated that average annual growth rate for ocean container throughput in Vietnam is nearly twice as high as bulk volume's (MOT, 2014).

➢ *The 3PLs industry*

The 3PLs industry in Vietnam has been developed impressively with average annual growth rate about 21% in term of revenue-wise and active firms.

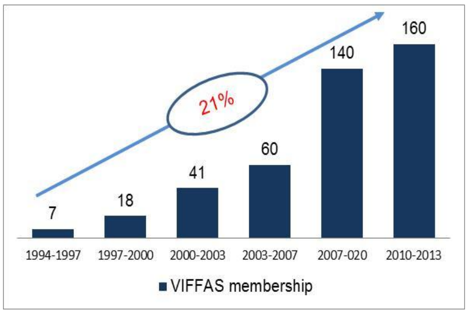
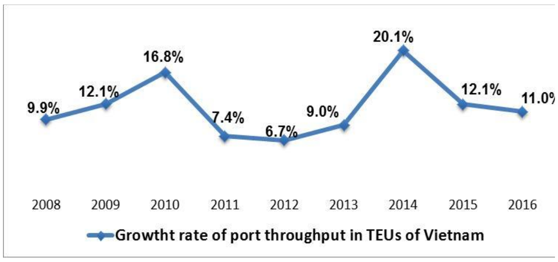


Fig. 6 Growth rate of Vietnamese 3PLs firms
Source: VIFFAS and World Bank (2014)

However, the majority of Vietnamese 3PLs are small-scale providers with average capital of US$18,750 – US$31,250 which much lower compared to US$100,000 of 3PLs companies in peer countries. Given this situation, it is very hard for Vietnam's 3PLs provide competitive logistics service even within the domestic market, not to speak of international or global markets.

➢ *Vietnam container port-handling volume in 2008-2016*

Vietnam's nationwide container volumes has experienced very impressive growth rate mirroring the economy as a whole.



More specifically, annual growth rate for container flow in Vietnam is averaged 20% in the period of 2000-2007 and 12% in the period of 2008-2016. Going forward, Vietnam's nationwide container volumes is estimated to grow at an average annual rate of 9 percent through 2020 (MOT, 2014).

➢ *Logistics cost*

The logistics cost in Vietnam is evaluated and considered as comparatively high, when it is compared to its Asian neighbors as illustrated in the following table

Table 2: Logistics cost as a percentage of GDP of some Asian countries

Country	**Logistics cost (percentage to GDP)**
Thailand	15% (2013)
Cambodia	18% (2014)
Vietnam	**20.9%-25% (2014)**
Indonesia	24% (2013)
Singapore	8% (2014)
Malaysia	13% (2014)

Source: National Economic and Social Development Board (NESDB) of Thailand, Vietnam Business Forum (2014)

More specifically, spending on logistics services in Vietnam is accounting for up to 25% of the national GDP (US$ 15.8 billion, 2016) compared to 8% in Singapore, 13% in Malaysia, 15% in Thailand and 18% in Cambodia. The costlier logistics operation is hindering competitiveness of Vietnam's logistics sector in the world. Looking more closely in the components parts of logistics cost, it is apparent that Vietnam's relative logistics underperformance does not originate from the transport costs side but primarily from the warehousing and inventory carrying costs side. There are a number of reasons behind this fact. One reason is unreliability throughout the supply chain caused by highway congestion, time consuming and unpredictable process of custom procedure, informal facilitation payment and so forth. As a consequence, manufacturers tend to carry more inventories to keep production lines operating, which would increase inventory and warehousing costs.

➢ *Logistics performance*

Logistic Performance Index (LPI) developed by the World Bank is often used to measure overall logistic performance of a country. According to the 2016 International LPI rankings, Vietnam's Logistic Performance Index (LPI) was 2.98 and ranked as 64th position in 161 surveyed countries. This rank is equal to Indonesia's, outperformed regional peers such as Cambodia, Myanmar and Lao PDR but underperformed Thailand, Malaysia and China.

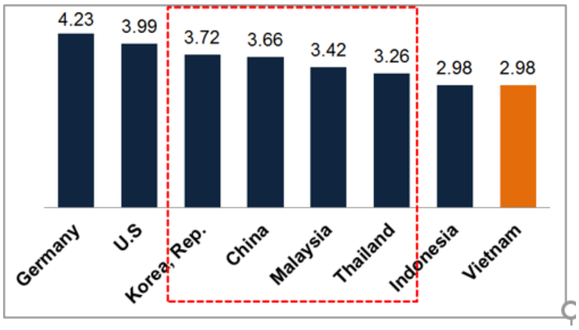


Fig.7 World Bank LPI 2016
Source:https://data.worldbank.org/income-level/lower-middle-income

Although there are much room to improve freight transport and logistics sector, recently logistics performance of Vietnam reflects some salient points from global perspective. More specifically, the country improved its LPI score by 3.1% from 2007 to 2016 (Fig.8), at a time of high fluctuation in freight markets. Vietnam also earned the top 5 performer among countries classified as "lower-middle income" ranked by WB LPI in 2016.

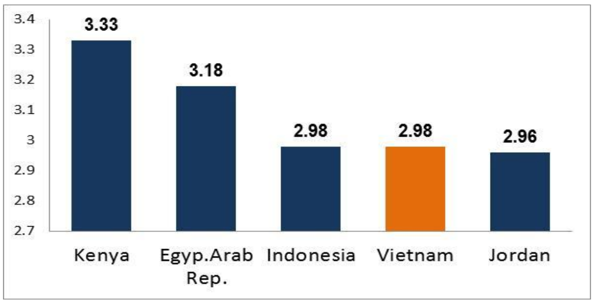


Fig.8 Top 5 LPI highest scores among "Lower-middle income countries": 2016
Source: https://lpi.worldbank.org/international/global

These benchmarks reflect the country's ability to reach double-digit growth rates (closer to 20% than to 10%) in logistics sector for many years. They, at the same time, indirectly reflect Vietnam's advantageous geographical location for intercontinental shipping lanes and transshipment, and attractive labor and energy cost.

➢ *Human resources in freight transport and logistics sector*

It cannot be denied that young and comparative less expensive workforce is one of the main drivers for the economic development of Vietnam, especially in the freight transport and logistics sector. However, the lack of adequately trained staff is a critical issue adversely affecting the development of the logistics development Vietnam. The issue has been highlighted at a number of professional logistics staffs accounting for about 5%-7% of total labor force in freight transport and logistics sector (about 1million labor). More importantly, Vietnam is now in the early-stage of logistics development and logistics is not considered as an independent sector, often under the management of the Ministry of Industry and Trade and the Ministry of Transport. As a result, Vietnam has not built up a professional and skilled labor force in the field of logistics. The existing situation of logistics skilled training method at businesses in Vietnam is presented in the following figure.

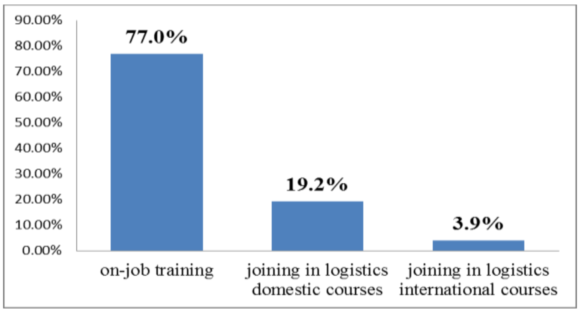


Fig 9 Logistics skilled training methods at businesses in Vietnam
Source: Report on the existing situation on human resource development in logistics sector in Vietnam given by the Ministry of Transport (2014)

Until now, there is no established university in Vietnam offering a full-time course on professional logistics. Most businesses have been carried out actual training for their logistics staffs. Lack of sufficient training and education in the field of logistics is a challenging issue for the local as well as multinational hire the right talent.

4. Challenging issues of freight transport and logistics sector

In the previous section, an analysis of the current situation of logistics sector in Vietnam has been presented. This analysis indicates some challenging issues facing the freight transport and logistics sector in Vietnam. These challenges could be divided into three groups as follow:

- *High reliance on trucking as a mode compared to less expensive rail or IWT for longer distance*

Apparently, the heavy dependence on road transportation will lead to an increase of GHG emissions as road freight transport generally generates much higher CO2 emission rate than IWT. It is the fact that within the transport sector of Vietnam, about 92% of the CO2 emissions originated from road transport and about 5% from waterborne transport (IWT and coastal shipping). Based on Blancas & M. Baher (2014), the emission factor for road and IWT freight transport in Vietnam is estimated as bellow:

Table 3: Estimated emission rates by freight transport modes

CO_2 Emission Factors	2010	2030
Truck (gCO_2/ton. km)	110	80
IWT (gCO_2/ton. km)	71	50

Source: Data from Blancas & M. Baher (2014)

Furthermore, the road-intensive situation could become a potential danger of the increase of traffic accidents. The statistics on traffic safety of Vietnam has shown that the road traffic is much more dangerous than waterway traffic as total number of road accidents is approximately 65 times higher than IWT accidents.

Generally speaking, the tendency of IWT-to-road modal shift has been challenging the sustainable development of the freight transport and logistics sector in Vietnam. To solve this problem in the long term, measures to improve performance of waterway sector should be introduced.

- *Logistics operations in Vietnam, to the extend, are costly relative to key regional peers like China, Malaysia, and Thailand*

As mentioned above, logistics cost in Vietnam is evaluated as comparatively high, when it is compared to its Asian peer region. This problem arises from the fact that firstly there is a strong belief among shippers and logistics service providers that facilitation payments are made to Customs and police officials are necessary to avoid delays in supply chains. Secondly, the worsening congestion on highway system and lack of adequate access to marine ports and inland container ports could lead to longer cut-off times for manufacturers to deliver containers to carriers. This in turn would increase company's inventory carrying costs, which drives up total logistics cost.

- *Lack of multi-modal freight transport network as a total system and frequency traffic jam to the main port*

The Government has so far only focused on planning transport mode in silos without having a multimodal perspective. Multimodal connections linked among road, inland waterway and railway system have not been considered in transport infrastructure planning. Unlike many peer countries, railways system in Vietnam plays a very limited role in freight transport. Its modal share is less than 2%. Company rarely uses rail due to the poor and inefficient handling equipment and low reliability. In addition, the railroad offers no tracking of cargo during transit. Inland waterway network in Vietnam often offers limited geographical coverage, which critical limits door-to-door service. As a result, road freight volume grows faster than those hauled by other transport modes over the recent pasts and projected to continue to do so for next years. However, the development of road transport still seems not sufficiently which leads to long transit times and contributing to the increase in operating cost of companies. Hanoi-Haiphong or Hochiminh-Vung Tau freight corridors are an example. The distance from Hanoi to Hai Phong is about 100km. It typically takes about four hours for truck containers to/from Haiphong port. Meanwhile, this is about two hours in non-congested period. Normally, company's drivers can make one or two trips per day from factories to Haiphong Port. But in congested season, productivity decreased to 0.8 trips per day. Traffic congestion results in lots of time wasted during transit via truck within or outside the city and around the ports.

- *Lack of adequate logistics parks alongside major highways and ports*

The establishment of logistics parks is seen as instruments for expanding and modernizing an economy through the attraction of Foreign Direct Investment (FDI), technology transfer, and employment generation (ESCAP, 2005). Therefore, there is a need to support the development of logistics parks in the country if Vietnam wants to improve its overall logistics system. However, the concept of logistics park has so far not well-understood in Vietnam. We have not had any real logistics park and there is no proper logistics park strategy and planning. Vietnam has many industrial parks rather than logistics parks. Cargo handling facilities are usually stand-alone near factories, ports, or inside industrial parks. The lack of such a modern logistics facility in Vietnam can be partly explained for the missing link in integrating the Vietnamese logistics system into the world economy

➢ *Cumbersome government regulation*

In order to bring certain products into Vietnam, company often has to deal with many ministries and much documentation is required. In particular, company has to work with Customs, Ministry of Health, Ministry of Information and Technology, Ministry of Agriculture, and Ministry of Culture and Communication. It is cumbersome to deal with all these ministries and this provides many opportunities for delay and facilitation payments.

➢ *Inconsistent interpretation, implementation, and enforcement of government regulations across provinces and among government officials*

Inconsistent interpretation of rules often occurs among Custom agents across Vietnam. This includes commodity classification and valuation, product inspection, and licensing and certification of certain products. Road traffic rules and regulations are also often interpreted inconsistently by police and other authorities in term of enforcing the weight and height limits of vehicles on highway system. This leaves the door open for unpredictable stops for trucks along their routes and informal payments. The informal facilitation payment rate in Vietnam is believed twice as high (as a percentage of total operating cost) as India's (WB, 2010). Therefore, trucking companies rank brides/informal payment as a biggest problem for long-distance freight movement in Vietnam

5. Lessons-learnt for freight transport management in Vietnam

To solve the increasing issues associated with freight transport problems in Vietnam, various traffic management measures need to be considered and applied. Based on literature review on practice of freight transport management in the world, some lessons-learned and freight transport management measures that can be drawn for a sustainable freight transport development in Vietnam are as follows:

Issue 1: High reliance on trucking as a mode compared to less expensive rail or IWT for longer distance

- *Lessons-learnt to deal with the issue:* It is strongly recommended to promote modal shift away from truck through increasing the capacity and service quality of IWT and railway transport sectors.

- *Measure references from the literature review:*

M7. Promotion of intermodal transport

M15. Infrastructure capacity improvement

It is the fact for Vietnamese government that most of the transport infrastructure projects are currently face serious problem of efficiency and lack of funds. Therefore, Public Private Partnership (PPP) is the most recommended organizational structure for freight facilities. The Public sector should subsidize and/or organize the facilities together with private sector entities.

Issue 2: Logistics operations in Vietnam, to the extend, are costly relative to key regional peers like China, Malaysia, and Thailand

- *Lessons-learnt to deal with the issue:* Reduction in undocumented facilitation payments and other form of corruption is very important to reduce total freight logistics cost in Vietnam.

- *Measure references from the literature review:*

M18. Application of information technology and technology-based route planning and fleet management

Application of technology-based route planning and fleet management can help to reduce unnecessary delivery trips, hence potentially reduce total logistics cos of the whole supply chain. Especially, this measure might easily get strong support from freight stakeholders since the benefits of reduced cost can clearly be seen.

Issue 3: Lack of multi-modal freight transport network as a total system and adequate logistics parks alongside major highways and ports, frequency traffic jam to the main port

- *Lessons-learnt to deal with the issues:*

Development of multimodal freight facility, for example in the form of freight center and consolidated delivery or Logistics Park, is very necessary to connect efficiently between rail and/or IWT to road transport.

- *Measure references from the literature review:*

M1. Freight centres and consolidated deliveries

M2. Co-operative freight transport system

M15. Infrastructure capacity improvement

Currently, there is no true logistics park in Vietnam. Since logistics park are often set up close to intermodal transport, industrial zones and highway system, some potential locations in Vietnam could be suitable for that is Hochiminh City, near Cai Mep, Bac Ninh, Danang, and Hanoi, Nha Trang, Lam Dong, Mekong Delta, Dong Nai, VungTau, and Central Vietnam. Such proposed measures are widely applied in many countries over the world, for example Japan, Germany, Italy.

Issue 4: Cumbersome government regulation

- *Lessons-learnt to deal with the issue:* Promotion of the involvement of freight transport stakeholders in draft new law and regulations.

- *Measure references from the literature review:* Bring together officials from the highways, ports, waterways, rail, and air transport functional departments to produce comprehensive and interdisciplinary transport and logistics planning. This process will also need to include input from key freight stakeholders-marine terminal operators, ocean carriers, LSPs, trucking companies and shippers.

Issue 5: Inconsistent implementation, and enforcement of government regulations across provinces and among government officials

- *Lessons-learnt to deal with the issue:* Strong application of information technology for process of production, logistics, transport and traffic, for example Electronic Toll Collection (ETC), Global Positioning System, E-Custom, E-commerce, could promote transparency in the supply chain transaction.

- *Measure references from the literature review:*

M18. Application of information technology and technology-based route planning and fleet management

Apart from that, education and training improvement for officials, who work directly with shippers and LSPs, such as Customs, has become an urgent need for Vietnam.

6. Conclusions

The performance of freight transport system has played one of the most important roles for the socio-economic development of Vietnam. The rapid-growing freight transport is revealing some limitations related to economic efficiency, traffic safety and environmental pollutions, which require better management of freight transport system to address these problems. Based on practices of various FTM measures implemented in several countries, the study drew some key lessons-learned that could be applied in the Vietnamese freight transport sector. In particular, the development of multimodal freight facilities; increasing the capacity and service quality of IWT and railway transport sectors; reduction in undocumented facilitation payments, technology based service improvement and promotion of the involvement of stakeholders in draft new law and regulations can be seen as key

ideas for improving the efficiency and sustainable development of the Vietnamese freight transport in the future. It should be emphasized that stakeholders may have different perspectives regarding to social, environmental and economic goals. Therefore, win-win policies, both from those different perspectives, could be hard in practice. Combined schemes are highly recommended in order to achieve the best results.

6. Acknowledgment

This research was supported by ATRANS Young Researcher's Forum 2018, grant number AYRF2018-010

References

[1] Botlze, Manfred. (2003) *Transport planning and traffic engineering - Part C, Lecture of Technische Universität Darmstadt* .

[2] Boltze, Manfred; Frederik, Rühl and Hanno, Friedrich (2012) *Freight transport demand management – A contribution to urban traffic management and sustainability of logistics.* World Conference on Transport Research Society (WCTR), 14th -16th March 2012, Austria.

[3] Blancas, L.C. and M. Baher, E.H. (2014) *Facilitating Trade through Competitive, Low-Carbon Transport. The Case for Vietnam's Inland and Coastal Waterways*, Report of the World Bank.

[4] Browne, M., Sweet, M., Woodburn, A. and

Allen, J. (2005) *Urban freight consolidation centres*, Report of University of Westminster

[5] Fornauf, L. (2015) *Entwicklung einer Methodik zur Bewertung von Strategien für dadynamische Straßenverkehrsmanagement*, Dissertation at Technischen Universität Darmstadt (Germany

[6] GSO (2011, 2014, 2016) General Statistics Office, *Ministry of Planning and Investment, Vietnam.*

[7] Loc, V. (2010) Value chain analysis of rice product in the Mekong Delta, *Scientific Journal, Can Tho University, Vol.19a, pp.96-108.*

[8] MOT (2014) *Development strategy on transport service of Vietnam to 2020 and 2030*, Ministry of Transport, Vietnam.

[9] National Economic and Social Development Board (NESDB) of Thailand, Vietnam Business Forum (2014)

[10] Sinha, K.C. and Labi, S. (2007**).** *Transportation decision-making: Principles of project evaluation and programming*, John Wiley & Sons, Inc.

[11] Taniguchi, E. (2014**).** Concepts of city logistics for sustainable and liveable cities, *Procedia-Social and Behavioural Sciences*, Vol.151, pp.310-317.

[12] Taniguchi, E. and Tamagawa, D. (2005a) *Evaluating city logistics measures considering the behavior of several stakeholders*, Journal of the Eastern Asia Society for Transportation Studies, Vol.6, pp.3062-3076.

[13] VINAMARINE (2016): *Vietnam Maritime Administration under the Ministry of Transport*

[14] Wilasinee, S., Imran, A. and Athapol, N. (2010) *Optimization of Rice Supply Chain in Thailand: A Case Study of Two Rice Mills, Sustainability in Food and Water*, Alliance for Global Sustainability Book series, Springer Netherlands, pp.263-280.

[15] World Bank (2010): *Vietnam urbanization review-Technical assistance report, the World Bank Vietnam*

[16] https://lpi.worldbank.org/international/global

[17] https://data.worldbank.org/income-level/lower-middle-income

A Study on The Trips Generation in Southville 7 Integrated into The Planning of a Shuttle Service System

Topic number: 3 Paper Identification number: AYRF2018-013

Reil Dominic Z. CATOLOS[1], Angelo Josh E. CUSTODIO[2], Jacob D. LAYUG[3], Jonathan M. UY[4], Maria Cecilia R. PARINGIT[5]

[1]Department of Civil Engineering, Faculty of Engineering
De La Salle University Manila
L18 B6 PC Sunflower St. Greenland Exec. Vill., Cainta, Rizal, Philippines
E-mail: nico.catolos@gmail.com

[2]Department of Civil Engineering, Faculty of Engineering
De La Salle University Manila
26 Sto. Nino St., Rodfer 2, Barangay San Andres, Cainta, Rizal, Philippines
E-mail: angelojoshcustodio@gmail.com

[3]Department of Civil Engineering, Faculty of Engineering
De La Salle University Manila
396-B., H. Lozada street, San Juan, Metro Manila, Philippines
E-mail: jacob.d.layug@gmail.com

[4]Department of Civil Engineering, Faculty of Engineering
De La Salle University Manila
19 San Jose Street, Taal, Batangas, Philippines
E-mail: jonathanuy27@gmail.com

[5]Department of Civil Engineering, Faculty of Engineering
De La Salle University Manila
E-mail: maria.cecilia.paringit@dlsu.edu.ph

Abstract

Southville 7, a relocation area in Laguna, Philippines is a haven for victims of calamities that struck the country over the previous years. Residents in this area were forced to evacuate Metro Manila but retained their jobs in the Philippine capital. The income generated by the residents is insufficient to sustain their family's daily necessities and in addition, there is also a significant increase in their transportation expense since its relocation. To help reduce the families' overall cost, a new transportation scheme focused locally on the relocation site was proposed to alleviate this problem. The aim of the research was to provide a systematized shuttle service scheme to the residents of the site, now referred to as the community. Various research methods were performed, such as the floating car technique, shortest path analysis, basic analysis of survey results and linear regression modelling, to determine the factors considered in designing the transit model. These factors included the income generated per household, time of departure, location of existing tricycle stops and arrival of transfers in the final drop-off point of the shuttle service. With these factors, correlations were established to determine the influence of each factor to the resulting changes in the trips generated by the community. The outcome of the research was a point-to-point shuttle service which significantly reduced the local transportation expense by ninety percent, while increasing the time of travel by only twenty-five percent. The shuttle service system provided a scheduled, low-cost alternative to their current mode of transportation enabling the community to reach their destinations while also allowing them to allocate their expenses for the improvement of their social upbringing.

Keywords: Transit planning, Trip generation, Systematized shuttle service

1. Introduction

Southville 7, seen in Fig 1, located in Calauan, Laguna, serves as a resettlement area for those affected by the destruction brought upon by Typhoon Ketsana in late 2009. This calamity resulted to the sudden evacuation of the residents living in the affected areas, especially in Metro Manila. Since the establishment of Southville 7, residents continue to work in Metro Manila, most of which were employed at before the typhoon struck.

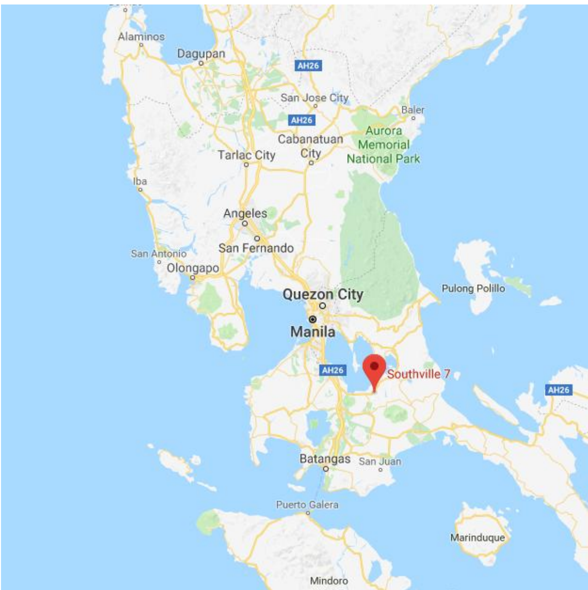


Fig. 1 Location of Southville 7

With the resettlement area being 60 kilometers away from their place of work, the current income of the working residents does not meet the living standards to support their family's daily necessities since the transportation cost greatly increased. This resulted to a decline in progress to better their current economic status since the allotment of a significant fraction of their income is dedicated to transportation purposes, which could have been used for the support their families and themselves. Therefore, it is imperative for the researchers to propose a new transportation plan that will significantly lessen the transportation cost spent by the employed residents to their respective work areas.

The study would also promote the use of an efficient and systematized mode of transportation that will provide the residents transportation from the community to the main terminal point, *Itikan*, wherein workers would transfer to different modes of transportation leading to their respective work areas. The local transportation cost will also be maximized as an effect of the strategically planned trips and the maximized accommodation of passengers ensuring the trips to be economical.

2. Literature review

In the initial stages of this study, the group referred to a research conducted by Noble- Tabiolo (2013) to properly assess the poverty status of the site. The research presented numbers on families residing in the site, community concerns (e.g. jobs, electricity, water), and other statistics that further emphasize the issue of poverty prevalent in the site. This information was used by the group as their preliminary background information about the community's situation.

In the study of Griffin (2014), a transportation plan for a rural setting in Central Texas was developed with the use of available literature and public engagement. The study was inclined to dealing with geographic specificity of responses from surveys and research as a major factor affecting results of the study. The results led to routes, factors affecting transportation per area, and other valuable data. The attention given to geographic specificity was emulated by the researchers as this current study deals with three different sites within Calauan, Laguna.

Aloc and Amar (2013) conducted a study by trip generation in Lipa City. Their study made use of the regression analysis and the trip rate method. Regression analysis determined significant parameters influencing trip generation. Trip rate method, on the other hand, determined the trip generation rates per trip purpose. Trip generation is the first step in the four-step model of travel demand forecasting and was also used in this current study.

3. Methodology

The research is based on first step in the four-step method of transportation planning, namely trip generation. Basic analysis of survey results and linear regression modelling using STATA, were performed to determine the factors considered in the design of the transit plan. The floating car technique and shortest path analysis were conducted to determine the recommended route of the proposed transit. Additionally, the operating and maintenance costs of a bus were obtained for reference.

Conducting a survey yielding an 8% margin of error and a 95% confidence level, the researchers determined the number of employed residents in each site, as well as their skillsets, monthly income, mode preference with the equivalent transportation cost, and several other factors that could affect the trips generated by the community. STATA was used to verify the relationships between factors that displayed relevance to trips generated in the community such as income, time of departure, and location of existing tricycle stops.

After which, the economics of operating a shuttle service are determined to meet the criteria needed to breakeven with the income gained by the shuttle service. The medium used as the mode of transportation for the transit plan is a 30-seater bus that is present but unused in the relocation site. Lastly, an operating schedule is designed based from the peak hours of travel obtained from the gathered surveys. This is then integrated into the designated route passing through the three sites, which accommodates the most number of passengers heading towards final drop-off point of the shuttle service.

4. Results

To properly represent the survey results for Southville 7, the community was deconstructed into the three designated sites as shown in Fig 2.

Fig. 2 Location of the three sites of Southville 7, *Itikan*, and *Kurba* in Calauan, Laguna

It was determined that there are currently two ways of going to the main access point, to Manila and other provinces, known as Masapang or also referred to as *Itikan.* A person may go from any site to *Itikan* by riding either a tricycle or "trike" straight to the destination or a jeepney to *Kurba* as indicated in the Fig 2 and then a trike. Their corresponding costs can be seen in Fig 3.

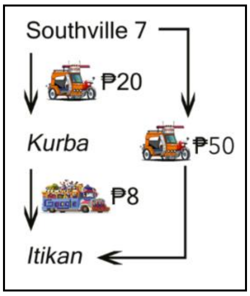


Fig. 3 Cost and existing modes of transportation available in Southville 7 going to *Itikan*

Survey results showed that for all three sites, 75 to 80 percent of working residents use the tricycle to get to and from *Itikan*. This finding was significant since the trike is the most expensive mode of transport available to them, costing up to Php 50 per person, per trip with a total travel time of 12 minutes. This is followed by the 10 to 15 percent of the working residents with the use of a trike and jeepney, which would have a total cost of Php 28 per person per trip with a total travel time of 20 minutes. Upon establishing the trike as the main mode of transportation, it was suggested that the demand for convenience and comfort is a priority amongst the residents as the tricycle minimizes travel time and provides the passenger a point to point transportation system at a higher cost.

Furthermore, it was also established that the least demand for travel was in site two. Aside from having the lowest population among the three sites, most of the residents in this site work within Southville 7 by means of agricultural work or as professional drivers stationed in the nearby municipalities.

Sites one and three have the highest demand for travel since both sites have dense populations and with majority working in Metro Manila as construction workers. Also, it was found that these construction workers stay in dormitories during the week within the city to minimize the cost of travel. As a result, the highest transportation demand would only be on Mondays at it is the day at which these commuters travel to Metro Manila. This would suggest that the most efficient way of operating a shuttle service would only be during the peak hours of travel demand, which was determined to be at the start of the week between 03:00 and 06:00 in the morning as seen in Fig 4.

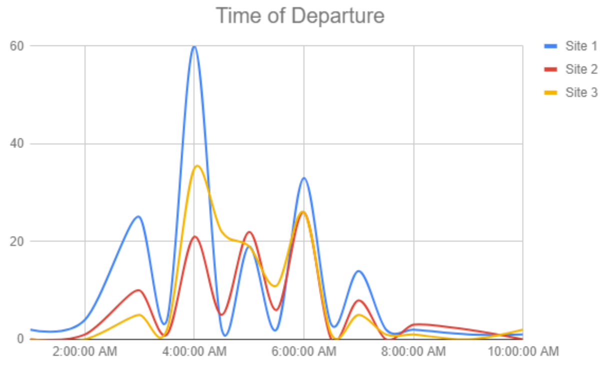


Fig. 4 Amount of people departing each site in the morning

With time of departure as a factor, the trip generation model indicates that there is no pattern in travel behavior during the peak hours of travel. This suggests that the shuttle service will operate with the same schedule of pick up and drop off in all stations in every trip. With the total income as the factor, the trip generation model also indicates that both low and high-income earners commute in all three sites. This would aid in the placing of bus stops in the community showing no bias in high-income earning sites.

With the regression model generated along with the other factors obtained, such as the travel route and corresponding time and distance, approximate fuel cost, driver's salary, and maintenance cost, the researchers were able to design the economic characteristics of the proposed shuttle service.

A single bus unit consists of three factors for operating cost, namely: fuel, maintenance and driver's allowance. For fuel, the basis of which depends on the number of liters consumed within 7 kilometers of distance traveled. With the round-trip distance of 6.2 kilometers and an average fuel cost of Php 29.00, the fuel cost per trip is equivalent to Php 25.70. Driver's salary would be based on minimum wage set by the Philippine standard, which is Php 350 per day with the total operating time of 4 hours (3:00 A.M. to 7:00 A.M.). The driver's salary will amount to approximately Php 35 per trip. With an additional 13 percent for maintenance cost based from the operating cost referenced from Eagle Star Transit Corporation, the total operating cost per trip then would be approximately Php 70.00. Computing the cost with a minimum passenger capacity of 5 persons and a maximum of 40 persons, this would result to an average cost of Php 6.00 per person per trip. This is to assume that all values used are of the minimum standard, meaning the cost per person per trip can still increase in value if the number passengers accommodated does not meet the optimal capacity.

5. Conclusion/Discussion

The researchers developed a scheduled transit plan which would transport the users from Southville 7 to *Itikan*. The said transit would operate on Mondays. This would run from 3:00 A.M. to 7:00 A.M, the peak hour for travelling commuters. The shuttle would be waiting for two minutes per station of the five stations shown in Fig 5. Each round trip would take a maximum of around twenty-five minutes if the bus would run on a speed of approximately 30 to 40 kph. Each station was determined based on accessibility of the road and distance from the main road as going deeper into each station may extend the travel duration.

Fig. 5 Proposed transit line with labeled stations

The table below summarizes the proposed schedule.

Table 1 Proposed Shuttle Service Schedule

Proposed Shuttle Service Schedule			
Trip	Time	Trip	Time
1	3:00 AM	6	5:03 AM
2	3:24 AM	7	5:27 AM
3	3:49 AM	8	5:52 AM
4	4:14 AM	9	6:17 AM
5	4:38 AM	10	6:41 AM

The shuttle service would accommodate a maximum of forty passengers per trip. The cost of each trip would be six pesos, inclusive of breakeven with the operating and maintenance costs and total capacity losses. A breakdown of the summary of cost is shown in Table 2.

Table 2 Summary of cost

Item	Cost (Php/trip)
Fuel (with roundtrip distance of 6.2 km)	26
Driver's pay	35
Maintenance	8
Total operating cost	70
Fee to breakeven:	6 Php/trip

The headway results for each transportation mode passing *Itikan* showed no need for minimizing the waiting time of residents in access point. The comparison between the proposed plan and the currently existing modes of transportation from Southville 7 to *Itikan* is shown in Table 3. It was proven that the planned transit was more economic than the other commonly used modes of transportation and the tradeoff would be only a few minutes added time to get to *Itikan*.

Table 3 Comparison between transit and trike

Mode	Cost (Php)	Travel time to *Itikan (minutes)*
Trike	50	12
Trike & Jeep	28	20
Shuttle Transit	6	15

The results of the proposed transit led to a significant difference in the transportation expenses, in which the working class would be able to save more than half of what they normally spend in their usual travel expenses through the research group's proposed shuttle service. This research will entice the working class to patronize the researchers' proposed plan since the former could benefit from it by saving more income for their day to day expenses.

References

[1] Alivia, M., Poblete, P., & Que, M. (1998). Transportation network analysis of capitals and cities in The Philippines. 9-16.

[2] Aloc, D., & Amar, J. A. (2013, April 15). *Trip Generation Modeling of Lipa City* (Undergraduate thesis). Retrieved October 7, 2016, from ResearchGate: https://www.researchgate.net/publication/264240455_Trip_Generation_Modeling_of_Lipa_City

[3] Cabato, J., Cheng, R., Hizon, J. & Sameon, K. (1996). A probability estimation of travel mode choice in Metro Manila (Undergraduate thesis). Retrieved October 7, 2016 from DLSU Business and Economics Department. (Call No. TU14229)

[4] Cascetta, E., Pagliara, F. (2012). Public engagement for planning and designing transportation systems. *Procedia – Social and behavioral sciences*, 87, Retrieved July 11, 2016, from http://0-www.sciencedirect.com.lib1000.dlsu.edu.ph/science/article/pii/S1877042813040421

[5] Baig, K., Shaw-Ridley, M., Munoz, O. (2015). Applying geospatial analysis in community needs assessment: Implications for planning and prioritizing based on data. *Evaluation and Program Planning*, 58, Retrieved July 11, 2016, from http://0-www.sciencedirect.com.lib1000.dlsu.edu.ph/science/article/pii/S0149718915300628

[6] Ding, L. & Zhang, N. (2016). A travel mode choice using individual grouping based on cluster analysis. *Procedia Engineering: Green Intelligent Transportation System and Safety*, 138, Retrieved October 8, 2016 from http://0-www.sciencedirect.com.lib1000.dlsu.edu.ph/science/article/pii/S1877705816003441

[7] Dye Management Group Inc. (2001). Planning for Transportation in Rural Areas. Prepared for the Federal Highway Administration in Cooperation with the Federal Transit Administration, July 2001, 1-96.

[8] Griffin, G. (2014) Geographic specificity and positionality of public input in transportation: a rural transportation planning case from Central Texas, Urban, Planning and Transport Research, 2: 1,407-

422, DOI: 10.1080/21650020.2014.969442

[9] Guillermo, G., Lagmay, A. & Marinduque,C. (2010). Urban transport planning of General Santos City (Undergraduate thesis). Retrieved October 7, 2016 from DLSU Civil Engineering Department. (Call No. TU15933)

[10] Minal, & Ravi Sekhar, C. (2014). Mode Choice Analysis: The Data, the Models and Future Ahead. *International Journal for Traffic and Transport Engineering*, 269-285.

[11] Murphy, E. (2012). Urban spatial location advantage: The dual of the transportation problem and its implications for land-use and transport planning. *Transportation research part A: Policy and Practice*, 42, Retrieved July 10, 2016, from http://0 www.sciencedirect. com.lib1000.dlsu.edu.ph/science/article/pii/S0965856411001509?np=y

[12] National Statistical Coordination Board. (23 April 2013). Republic of the Philippines. Retrieved November 6, 2016 from http:// www.nscb.gov.ph/poverty/defaultnew.asp

[13] *National Wages and Productivity Commission*. (n.d.). Retrieved October 30, 2016, from Department of Labor and Employment: http://www.nwpc.dole.gov.ph/

[14] Noble-Tabiolo, C. (2013). *Accelerating Forward - Unlad Bayan.* Honolulu: The University of Hawaii at Manoa.

[15] Oral, L., & Tecim, V. (2016). Analyzing public transportation for the effects of individual characteristics on mode choice with multi agent simulation. *Procedia technology*, 22, Retrieved from http://0-www.sciencedirect.com.lib1000. dlsu.edu.ph/science/article/pii/S2212017316001018

[16] Schroeder, B. (2016). Highway Engineering. *Planning, design and operations*, Retrieved August 3, 2016 from http://0-www.science direct.com.lib1000.dlsu.edu.ph/science/article/pii/B 9780128012482000022

[17] Shay, E. et al. (2016). Identifying transportation disadvantage: Mixed-methods analysis combining GIS mapping with qualitative data. *Transport policy*, 48, Retrieved June 10, 2016, from http://www. sciencedirect.com/science/article/pii/S0967070X16300932

[18] Sousan, F. (2014). Mode choice analysis of urban trips in Iloilo City, Philippines (Graduate thesis). Retrieved October 8, 2016 from DLSU Civil Engineering Department. (Call No. CDTG006383)

[19] Sowjanya, D., Tahlyan, D., & Ravi Sekhar, C. 2013, April 15). *Travel Demand Modelling for a Metropolitan City* (Undergraduate thesis). Retrieved October 7, 2016, from ResearchGate: https://www.researchgate.net/publication/269987967_Travel_Demand_Modelling_for_a_Metropolitan_City

[20] Starkey, P. (2007). A methodology for the rapid acquisition of the key understanding required for informed transport planning. *The rapid assessment of rural transport services*, Retrieved August 20, 2016 from https://www.ssatp.org/sites/ssatp/files/pdfs/Toolkits/SSATPWP87-A5B1%5D.pdf

[21] Talpur, M., Napiah, M., Chandio, I., & Khahro, S. (2012). Transportation Planning Survey Methodologies for the Proposed Study of Physical and Socio-economic Development of Deprived Rural Regions: A Review. Retrieved August 2, 2016, from http://dx.doi.org/10.5539 /mas.v6n7p1

[22] Wear, A. (2009). Improving local transport and accessibility in rural areas through partnerships. OECD LEED Forum on Partnerships and Local Governance HANDBOOK no. 1, retrieved July 12, 2016, from http://www.oecd.org/

Advantages and disadvantages of transport infrastructure connectivity at seaport – a case study of Haiphong (Viet Nam)

Topic number: 9. Paper Identification number: AYRF2018-014

PhD Candidate Nguyen Thi Nhu

Faculty of Transport and Economics
University of Transport and Communications, VIETNAM
Telephone +84977064589
E-mail: nhunguyen@utc.edu.vn

Abstract

Haiphong Port is one of the two largest container ports in Vietnam with hundreds of industrial parks and clusters, considered as sea gateway to the North Economic Region. Due to the daily increase in im-exported goods amount there, intensification of stable association in many transportation infrastructure systems as haulage, rail transport, waterage, air transport is required in order to boost the rate of delivery process, contributing working-load decrease in Haiphong port. However, transport measures have not take their advantages, that hindered participation in multimodal goods transportation lines (main value – Haulage). The study investigates transportation connection infrastructure systems in Haiphong port, points out advantages and challenges in goods transit process. The findings are reference for the Government and Haiphong port administrator in promoting the advantages or repairing disadvantages in order to facilitate the transportation of goods.This study is not only significant for Haiphong seaports but also for other seaports in Vietnam and the region.

Keywords: Transportation, seaport, goods

1. Introduction

Vietnam is a peninsula located in the center of Southeast Asia, with 3260 km of coastline stretching from north to south, and more than one million square kilometer of sea area, Vietnamese marine connects to the seas and oceans all over the world. Therefore, seaports and maritime routes have been formed very early. Of which, Haiphong seaport is one.

Along with Saigon seaport, Haiphong is one of the two largest port areas in Vietnam. Much of the logistics center, the enterprises using logistics services have thus been formed here. Haiphong seaport is not only meaningful in the logistics development strategy of the Red River Delta but also significant in the country and internationally.

Over the past few years, Haiphong authorities and the government have been up grading and renovating seaports, linking transport infrastructure to ports in order to create a smooth, fast and safe transportation system, serving cargo demand, exploiting logistics services, meeting the maximum demand of the whole society. Based on that practice, the article *"Advantages and disadvantages of transport infrastructure connectivity at seaport – a case study of Haiphong (Viet Nam)"* was conducted to study and clarify problems in linking sea transport infrastructure with other modes of transport at Haiphong port and propose some solutions to enhance the synchronous connection between modes of transport. The paper first analyzes both advantages and disadvantages of inside and outside transport connectivity at Haiphong seaport. Based on them, some solutions are proposed to enhance transport integration, and thus contribute to foster operating effectiveness of the seaport.

2. Content:

2.1 An overview about seaport

a. Definition and the role of seaport

According to Vietnam's Maritime Law (2015), *"Seaports are areas that contain port land and port water areas, which are constructed of infrastructure and equipment for in-and out-going ships to load and unload cargo, to pick up and release passengers and perform other services; It is an integral part of the operation of open economic zones, free trade zones, industrial parks and export processing zones, where the land crosses sea. Seaports are also the link of multimodal transport, where sea transport, rail transport, inland waterway transport or air travel through, where* *there is a change of goods from this means of transport to other means of transport and vice versa, so the rear of the port is often large".*

The port system plays an important role in the economic development of both domestic and international countries, in detail:

- Seaports ensure handling, transshipment of goods to meet the needs of the economy. This will facilitate the process of production, circulation and distribution of goods; strengthen local, national and international economic development.

- It is one of the important factors contributing to the formation of industrial parks, industrial clusters, export processing zones, distribution centers, trade centers, etc., thus attracting investment capital both domestic and abroad for the development of production, science, technology and economy.

- Strengthen activities of goods import and export, external economic relations; thereby help to shift the economic structure of the country.

- Create jobs and contribute to GDP of the country.

b. Classification of seaport

According to Article 75, Vietnam's Maritime Law (2015), Seaports are classified as follows:

- Seaports especially large seaports serve the socio-economic development of the whole country or inter-region and have the function of international transshipment or international gateway ports;

- Type I seaports are big seaports serving the socio-economic development of the whole country or inter-regions;

- Type II seaports are medium-sized seaports serving the socio-economic development of the region;

- Type III seaports are small seaports serving the socio-economic development of localities.

c. Requirements for national seaport

In the research on port operation (Nguyen Thi Phuong, 2010) and models and solutions to establish logistics center for LachHuyen port (Le Dang Phuc, 2017), a national seaport which is meaningful at both regional and international levels must meet the following requirements:

***Firstly*, seaports should be located in favorable geographic location.**

- There should be water connection to the sea: This is a prerequisite, deciding whether a port is a seaport or not. It is shown through the port entrance and exit system.

- Have natural geographic conditions meeting the requirements of building wharf, docks, anchorage areas, transshipment and navigable channels for incoming and outgoing ships, safe operation.

- Have the advantage of maritime traffic. In addition to the water connection to the sea, the position of the seaport should be favorable for international vessels to enter and transport goods. This is expressed through the parameters of the navigational access channel, such as thread depth, thread width, curve radius, etc.

Secondly, it must meet the requirements of port infrastructure, port facilities including berths, warehouses and yards; the water in front of the wharf, the waters for the return ship and the waters waiting for the ship. In addition, the harbor infrastructure including embankments, dams... for seaports where natural conditions are not permitted. Modern seaports require relatively large port land, with at least multiple piers to accommodate multiple vessels at the same time. The area of the port also depends on the trend of increasing ship size of the shipping industry. As the size of the ship is increasing, the port must increase the length of the wharf and expand the warehouse system.

Thirdly, there must be equipment and technology. This is the most important factor for the development of seaport service. While the current demand for handling and loading operations is high, improving the quality of equipment will increase productivity, thereby increasing cargo throughput. Singapore is a typical country for applying information technology to maximize productivity with Portnet and CITOS - Computer Integrated Terminal Operations System. The work from warehouse management to layingout, loading and unloading, controlling container at Port facilities are also invested differently for each type of seaport and should be appropriate for the infrastructure in that port area. This will determine the loading and unloading capacity of the ships of international ports, mother ships or feeder vessels, river vessels.

Fourth, seaports must ensure the connectivity, it is not the end point of a transport process but a traffic hub for the domestic transportation of goods; Cargo export, import and transshipment by sea.

As a link between multimodal transportation, where goods are transferred from the mode of shipping to other modes of transport, one of the indispensable requirements at these seaports is the connection between transport infrastructures. A national seaport, the gateway to meet the needs of freight, serving the development of logistics, serving the needs of the economy should have many possible modes of transport which can connect to and from the port. Because seaports are not the first or the end of the transport process, they are the points of rotation of goods and passengers from the means of sea transport to the remaining means of transport.

2.2 An overview about Haiphong Port

a. A watery area connecting to the sea with its marine advantages

Haiphong is a harbor city as well as an important junction for commodity circulation as it is considered a major economic center of Red River Delta, the North of Vietnam particularly and the world generally. Having its geographically advantages (bordering South China Sea) and being invested with harbor infrastructure since 1874, Haiphong Port has been recognized on the marine world map for more than 140 years. It is also the second largest port in the country in terms of capacity, competence, and the volume of goods circulated. It offers main services namely stevedoring, shipping and receiving, storing, supporting ships, transloading, freight forwarding, distributing, collecting, and other supporting services.

Haiphong Port system is built on the Cam River connecting to South China Sea where there are several international freight carried out.

Fig. 1 Haiphong seaport

Haiphong Port is located on the marine routes which join Singapore to Hong Kong and the ports in East Asia and Northeast Asia. It has a favorably marine area which is beneficial for transportation. These are the conditions:

Fig. 2 Marine access channels in Haiphong
Scoure:http://haiphongport.com.vn

Length of access channel from buoy number 0 to Binh pieris 42.8 km long.

Depth of the channel: in Tan Vu area is -7m, in Hoang Dieu area is -5m.

Tidal regime: Diurnal Tide.

The maximum tidal oscillations 3m- 4m.

The largest ship to dock: 55000 DWT

b. Material facilities and equipment:

Details about material facilities and equipment in Haiphong Port are tables as below:

Table 1: Summary of technical facilities of some major ports in Haiphong

No.	Port	Number of pier	Depth of landing *(m)*	Number of equipment *(cranes, forklifts)*	Number of means of transport *(vehicle, barge)*	Warehouse area *(10^3 m^2)*	Area of the storing lot*(10^3 m^2)*
1	VatCach	06	3.9-4.1	24	10	15	130
2	HoangDieu	26	5	71	21	36.579	142
3	ChuaVe	5	5-7	31	23	3.300	202
4	Haian	1	8.7	8	10	3.840	151
5	Transvina	1	7.8	12	20	1.200	50
6	DoanXa	1	8.4	12	12	1.200	65
7	CuaCam	4	5-7	10	12	1.800	25
8	Green Port	2	7,8	25	45	4.650	95
9	DinhVu	10	8.7	16	15	3.600	200
10	TanVu	7	7-11	60	35		510

Source: Nguyen Thi Nhu (2017)

In addition, there are 13 anchoring points and buoy area with 4 lifting cranes and 12 forklifts in Haiphong.

LachHuyen, the deep port with its fairway depth of 14m and two freight elevators, is going to be the biggest and deepest port in the North, making Haiphong the economic gateway of specific fields like electrical engineering, automation, and mechanical engineering. It is estimated to attract 80% of domestic and foreign companies in the North namely Samsung Corporation, Nomura, Trang Due Industrial Zone …

c. Capability to handle ships:

Haiphong Port is a combination of national ports with 28 harbors, some of which are Hoang Dieu, Green Port, Chua Ve, Dinh Vu, Tan Vu, LachHuyen, PTSC… They are categorized into specific-purpose harbors and muti-task ones. The capabilities of the three representatives namely HoangDieu, ChuaVe, and TanVu are shown as below:

Table 2: Capability of some ports

No.	Terminal	Types of cargo	Capacity	Ship's maximum size
1	Hoang Dieu	Merchandise mix	6000000 tons/year	50000 DWTload reduction
2	Chua Ve	Merchandise mix and container	1.250.000 tons/year, (500.000 TEUs/year)	50000 DWT
3	Tan Vu	Merchandise mix	7.250.000 tons/year, (1.000.000 TEUs/year)	50.000 DWT load reduction

Scoure: Haiphong port (2017)

2.3 The current status of transport infrastructure in Haiphong Port

a. International navigation

Based on the research on Models and solutions to establish logistics center for LachHuyen port (Le Dang Phuc, 2017), the marine transport system connecting Haiphong Port is divided into two branches.

The first one is the coastal and domestic freight such as Haiphong – Ho Chi Minh, Haiphong – Da Nang – Ho Chi Minh, etc.

The second one is the international freight namely:

(1) Haiphong – Ho ChiMinh City – Tanjung Pelepas (Malaysia)
(2) Haiphong - Hong Kong - Busan
(3) Haiphong - Davao - Singapore
(4) Haiphong - Hong Kong - Kaohsiung
(5) Haiphong- China- Japan ports
(6) Haiphong - Shanghai - Busan
(7) Haiphong (Vietnam) - Singapore - Thailand
(8) HoChiMinh - Haiphong - HongKong
(9) Haiphong - Hong Kong – Shenzhen

These are mostly short lines carried by small ships with the carrying capacity of around 20000 DWT. More specifically, feeder ships are used for travelling and collecting goods from Haiphong to both regional and international transit ports known as Singapore, Shanghai, Hong Kong, Busan, Yokohama, and Nagoya Port. This fact is on account of the shallow- water entrance at Haiphong Port caused by sediment. Regarding Tan Vu Port's architecture, the port was designed to be able to handle 50000 DWT – sized ship, however, such vast ships actually rarely exploit goods here.

b. Connectivity to domestic railway and international transport system

Haiphong port is the only one in Vietnam which has a direct rail connection to the port. The Haiphong - Hanoi railway line is 102 km long, which plays the role of connecting Haiphong as an "edge" of the economic development triangle (Hanoi - Haiphong- QuangNinh) in the northern key economic region.

The Vietnam Railways Company operates special rail lines with a daily running schedule from Haiphong to Hanoi and two days from Haiphong to Lao Cai (Vietnam- China border).

Haiphong railway station is the first class railway of Vietnam railway, services at the railway station, Haiphong port, ChuaVe port and Viconship port. The station is capable of regularly volume of goods from 3000 - 4000 tons loading per day; 2000- 3000 tons unloading/ day with the total area of 6000 m^2, closed storage area of 500 m^2 and the equipment for uploading and unloading. However, now the railways mainly serve passengers, the volume of goods transported on the route is very low, less than 1 million tons of cargo per year. This is also the common trait of the railway industry in Vietnam due to backward equipment and technical facilities, causing time- consuming and ineffective procedures.

Fig. 3 Transport infrastructure connection in Haiphong port

c. Connectivity to the air transport system

Cat Bi Airport in Haiphong is 15km from Tan Vu seaport. This is the first airport in the North built in the French colonial period, originally designed for military purposes. It is now commercialized with such operating airlines as: Vietnam Airlines, Jetstar and Vietjet Airline operating flights from Haiphong to HoChiMinh City with 42 flights a week. Haiphong - Da Nang with seven flights a week. These are domestic passenger transport routes and there are no international cargo transport lines.

In the future, the airport will contribute to facilitate the carriage of goods by air, combining cargo transport between sea - road - air.

d. Connectivity to road-based transport system

Currently, road transport is the main mode of transporting goods to and from Haiphong port with the arterial routes of the northern economic region such as Hanoi - Haiphong expressway, QuangNinh– Haiphong- NinhBinh expressway; National Hightway 5, 10, 37; Haiphong - Cat Ba road, in addition to other provincial roads, etc.

Highway 5 is the main traffic link connecting Haiphong port to Ha Noi capital, running through HaiDuong, HungYen province. It is part of the AH14 expressway linking with National Highway 1A at the beginning of Hanoi. On the route, there are dozens of big industrial parks such as TrangDue, Nomura, DaiAn, PhoNoi, many factories of FDI enterprises such as Ford Vietnam, so traffic density on the road is always high, especially trucks, vehicle container freight, resulting in technical downgrade status, frequent traffic jams.

Highway 37 is the third ring road of the northern region, extending from ChiLinh (HaiDuong) to DiemDien Port (ThaiBinh) connecting to National Highway 5, 10, 18 and HaNoi, Haiphong expressway, NoiBai - HaLong in the future. This is an arterial route serving transportation needs between Haiphong and HaiDuong with neighboring areas in the northern key economic region such as ThaiBinh and QuangNinh.

Highway 10 is an inter-provincial road running along the northern coast through 6 provinces: QuangNinh, HaiPhong, ThaiBinh, NamDinh, NinhBinh, ThanhHoa with a total length of 228km, connecting with National Highway 1A, 5, 10. Traffic volume on the highway is from 700-900 vehicles/ day night.

HaNoi - Haiphong Expressway (Highway 5B) is one of six expressways under construction in the North of Vietnam, which is 105.5 km long from Hanoi, through HungYen, HaiDuong and connected to the deep water port of Haiphong.

Road across the island of Haiphong - CatBa is a linear road and marine combined route of 35km long from DinhVu island connected to CatHai district, Haiphong.

The QuangNinh - Haiphong - NinhBinh expressway (Highways Round the Sea) is a 160 km long highway, which is part of the program to develop the highway network of Vietnam and is the bottom of the delta economic triangle in Red River delta with cross-section for 6 lanes, design speed of 100-120 km/h, (Le Dang Phuc, 2017).

e. Connectivity to inland waterway transportation system connects and Haiphong port

Main inland waterways from Haiphong port including Haiphong - Hanoi through Luoc river, Red river; Haiphong - QuangNinh via Chanh River, BachDang River; Haiphong - HaiDuong via Cam river, KinhMon river; Haiphong - HungYen - ThaiBinh - HaNam - NamDinh - NinhBinh through the Luoc river, Day river, NamDinh river and Haiphong - Hanoi - Viettri - Sonla river crossing Luoc river and Red river; Haiphong - BacNinh, mainly transport some small, low-value cargoes.

Up to present time, there is a container line service by barge freight importing and exporting goods from the port of Haiphong to HaiLinh, VietTri, PhuTho port and vice versa. (Nguyen Thi Nhu, 2017)

It is expected that in 2018, the second inland container port of the northern area of TriPhuong port in TienDu district, BacNinh will be put into operation to reduce the load on the road from Haiphong to these high - density industrial zones.

2.4 Assessment on the ability to integrate transport infrastructure at Haiphong Port

In terms of an integrated transport infrastructure, there are four means of transport which directly serve freights including sea transport, domestic waterage, rail transport, and road transport. However, when considering real carriage capability of the three means of transport from the rear to the port, particularly international freight, it is the road transport that appears to be the core part of the integrated transport system connecting to Haiphong Seaport. On the other hand, considering other ports in Vietnam such as HoChiMinh, BaRiaVungTau, and Chinese and Japanese ports… it is domestic water transport that can maximize the effectiveness in its integrating role.

Challenges in the integrated transport infrastructure in Haiphong port and the reason:

- Rail transport is less competitive than road transport in terms of cost and delivery time. As HaNoi – Haiphong railway is parallel to National Highway 5 which is only 102km, this distance is not enough for rail transport to take advantage of the price and delivery time. Besides, the railway in

Haiphong Port which is connected to Hoang Dieu – a small port – mainly serves bulk cargos, while the most modern seaports in Haiphong, Dinh Vu, TanVu, and LachHuyen, haven't been connected yet.

Mostly none of the intermediate rail station along Hanoi – Haiphong railway is capable of approaching and handling containers. Both processing time and costs in Hanoi – Haiphong railway, Haiphong – LaoCai are of high amount, while door-to-door delivery is not applicable. By comparing the costs and excluding lift on-lift off, we have the following data:

Table 3: Compare beetween rail and road freight on some routes.

Route	Criteria	Transportation mode	Unit	Container 40'
HaiPhong – HaNoi-Haiphong	Transportation freight	Railway	*1000 đ*	4,500
		Road	*1000 đ*	3,500
	Time of transportation	Railway	*hour*	2.5
		Road	*hour*	2.5
	Number of loading / unloading	Railway	*time*	2/2
		Road	*time*	1/1
HaiPhong – LaoCai-Haiphong	Transportation freight	Railway	*1000 đ*	12,000
		Road	*1000 đ*	10,500
	Time of transportation	Railway	*hour*	10.5
		Road	*hour*	12
	Number of loading / unloading	Railway	*time*	2/2
		Road	*time*	1/1

Scoure: Nguyen ThiNhu (2017)

- The integrated traffic system connecting Haiphong Port to stations, airports, and Inland Container Depot, logistics centers… has not been synchronized diversified correspondingly to demand and capacity of the system. The only means of transport connecting the port to the mentioned locations is road transport. Currently, Haiphong has two logistics centered known as Green and Damco. Inland Container Depots (ICDs) in the North include ICD HaiDuong, ICD GiaLam (located on Hanoi – Haiphong railway); ICD TienSon (located on HaNoi – Lim, BacNinh) – BacGiang – LangSon); ICD ThuyVan (PhuTho) and ICD Lao Cai (located near HaiPhong – HaNoi - LaoCai railway). However, these logistics centers and ICDs (except ICD Lao Cai) do not have any connection to rail transport as well as domestic water transport; instead, there is only one means that carries freight which is road transport. (Nguyen Thi Nhu, 2014)

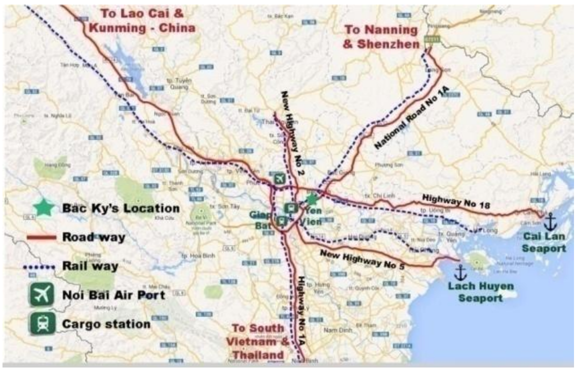


Fig. 4 Transportation system in the North of Vietnam

Scoure: Report on logistics service of ICD Tien Son (Backy investment joint stock company, 2014).

- Means of transport have not been synchronously integrated and improved in order to form a multimodal transport that can reduce transport expense.
- Projects investing in traffic infrastructure do not have synchronous scales and processes.
- The advantages of sea transport, domestic water transport, rail transport are not optimally utilized, which lead to traffic congestion and detrimental effect on the roads.
- The majority of imported and exported goods in the North have to be received and returned directly at the port because of the lack of connection between ICDs, logistics centers and ship brands. Only Tien Son ICD is able to deal with giant ship companies like MCC, Yang Minh so that they allow enterprises to take down empty containers to serve exported transportation. Accordingly, ICDs and logistics centers have not exploited their potential and geographical strengths, therefore, their duty to act as an intermediate party and to decompress of goods for Haiphong Port has not been fulfilled.
- River routes in the North are restricted by the fairway depth and width, sediment and a number of constructions built across the rivers. Therefore, aperture and height are also big obstacles for domestic water transport.
- Depot and warehouse system in the North generally and Haiphong specifically is not planned and arranged appropriately. Focusing too much on the port areas but the depots here are sparse and independently develop also shows an improper strategy.

2.5 Solutions for transportation infrastructures connection at Haiphong port:

- Deep-water port, gateway of LachHuyen area, was inaugurated and operated in May 2018. However, the services and transportation infrastructures have not yet completed. The deep-water port needs more policies on pricing, loading equipments and policies to attract vessels to land here instead of landing at ports in China, Korea, Singapore and then using feeders to transship to Haiphong as usual.

- Develop inland container depots (ICD), logistics centers, goods centers etc. There are at least two modes of transportation needed to connect from those depots to ports i.e. road and railway, road and waterway. Encourage research and development of efficient connections between railway and industrial zones, ICD and logistics center.

PhuTho inland waterway container depot has been operated and inland container depot Tri Phuong, 15 kilometers from ICD TienSon (BacNinh), the largest ICD in the North of Vietnam and the hub and destination of many inland, Vietnam – China, Asean – Vietnam – China transportation routes, is planned to open in 2018.

- Quickly put Haiphong – HaLong highway into service, extend highway number 10 to transport goods among provinces, decline traffic jam around Haiphong area.

- Repair connecting routes between ports around Haiphong port.

- Efficiently manage BOT projects, build non-stop toll-booths.

- Implement projects to upgrade railway routes and lengthen railway routes to TanVu, LachHuyen deep-water container port.

- Build junction stations, upgrade loading and transshipping equipment as implemented at YenVien, DongAnh station. Socialize railway system.

- Develop inland waterway transportation, increase vertical height of some bridges on important inland waterway routes such as Duong Bridge from Haiphong, Hanoi to BacNinh.

- Build inland waterway ports, warehouse centers at hubs in BacNinh, ThaiNguyen, NamDinh, HaiDuong.

- Promote barges, especially North – South route. Promote inland waterway container transportations.

- There are at least two modes of transportation used to connect between airports. Improve airway transportation by building logistics centers at NoiBai and CatBi. Encourage investors to develop hub ports at NoiBai area in order to increase logistics at CatBi. Design both passengers and goods flights at CatBi airport.

- Information technology must be implemented in transportation to decline empty vehicles. Effectively operate vinatrucking made by Vietnam automobile transportation association and Directorate for roads of Vietnam in 2015.

- Increase the management of vehicle capacity.

- Set up Haiphong port authorities to create policies, healthy business environment and to co-operate ports at Haiphong area to increase specialization, loading capability, transportation services etc.

3. Conclusion:

Transportation connecting sea ports, inland container depots, logistics centers with goods in the area is extremely important. It is not only helps to increase transportation speed but also decline transportation cost, augment human, goods and vehicles safety. Therefore, solutions must be implemented to decompress, safely and quickly release goods by large-scale, low-cost and safe transportation modes such as railway, inland waterway rather than road. At the same time, with ASEAN open sky and air logistics development strategies, airway transportation should be paid attention and more invested.

If the transportation infrastructure connection issue is fully solved, the flow of goods and the number of customers using services at Haiphong ports will be increased. The goods will be transported not only to destinations in Vietnam but also transshipped to neighbor countries like China, Lao.

This research and solutions to enhance transportation connection for Haiphong port can be used as hints for the authorities of Haiphong port in particular and other ports in Vietnam in general.

4. Acknowledgment

This research was supported by ATRANS Young Researcher's Forum 2018, grant number AYRF18-014

References

[1] Backy investment joint stock company. (2014) *Report on logistics service of ICD TienSon*.

[2] Congress of Vietnam. (2015*) Maritime law.*

[3] Le Dang Phuc. (2017) Dissertation o*n Models and solutions to establish logistics center for LachHuyen port*, Vietnam Maritime University.

[4] Ministry of transportation. (2018) *Country report on logistics and solutions to decline cost and effectively connect transportation infrastruture system.*

[5] Nguyen Thi Nhu. (2017) *Survey report on ports at Haiphong, Vietnam railways, Vietnam automobile transportation association, Haiphong Transportation Department, Hanoi Transportation Department*

[6] Nguyen Thi Nhu. (2014) Master Thesis on *Research for the logistics service development- a case study of Inland Container Depot (ICD) TienSon*. Univerisity of Transport and Communication.

[7] Nguyen Thi Phuong. (2010*)* Textbook on *Port operation,* Transport and Communication Publisher.

[8] Tran Thi Lan Huong. (2003) Textbook on *Transportation geography,* Transport and Communication Publisher.

[9] *http://haiphongport.com.vn*

การศึกษาพฤติกรรมเสี่ยงของผู้ขับขี่รถจักรยานยนต์บนถนนมิตรภาพในเขตเมืองขอนแก่น

Study risk behavior of motorcyclists on Mittraphap Road in Khon Kaen, Thailand

หมายเลขบทความ: AYRF18-015

ณัฐวัตร ราษี[1], ชนนน ชนยุทธ[1], ณัฐวุฒิ ศรีโพนเพ็ก[1],เจษฎา คำผอง[1], ธเนศ เสถียรนาม[1]

Nattawat Rasri, Chananon Chonyuth, Nattawut Sriponpek, Jetsada Kumphong, Thaned Satiennam

[1] สาขาวิชาวิศวกรรมโยธา คณะวิศวกรรมศาสตร์

มหาวิทยาลัยขอนแก่น

โทรศัพท์. 0-4320-2846, 0-4320-2847 โทรสาร 0-4320-2847

E-mail: Nattawat_r@kkumail.com

บทคัดย่อ

บทความนี้มีวัตถุประสงค์เพื่อศึกษาพฤติกรรมเสี่ยงในการขับขี่รถจักรยานยนต์ในถนนมิตรภาพในเขตเมืองขอนแก่นการศึกษานี้สำรวจข้อมูลด้วยแบบสอบถามซึ่งสอบถามพฤติกรรมเสี่ยงในการขับขี่รถจักรยานยนต์ (52 ข้อคำถาม) จากผู้ขับขี่ในเขตเมืองขอนแก่น ที่ขับขี่รถจักรยานยนต์ (N=459) และวิเคราะห์ข้อมูลเบื้องต้นด้วยสถิติเชิงพรรณนาและโดยวิธีวิเคราะห์ปัจจัยเชิงสำรวจ (Exploratory Factor Analysis (EFA)) ผลจากการศึกษาพบว่าผู้ขับขี่รถจักยานยนต์มีพฤติกรรมเสี่ยงที่กระทำบ่อยครั้งได้แก่ จงใจที่จะขับรถเร็ว เมื่อถนนโล่ง , จงใจที่จะขับรถเร็ว เพื่อที่จะแซง , ขับรถเร่งความเร็ว เพื่อให้ทันสัญญาณไฟเหลืองหรือไฟเขียว, คุยกับเพื่อนอีกคนที่ขับไปขนานกัน หรือคุยกับคนซ้อน , ไม่ทันสังเกตเห็นหลุม/ผิวจราจรชำรุด จึงเบรกรถกะทันหันและขับรถโดยไม่สวมหมวกนิรภัย เป็นต้น นอกจากนั้นแล้วผลจากการวิเคราะห์ EFA ได้ตัวแปรใหม่ 12 ปัจจัย (ค่า KMO = 0.929 , p = 0.000) คือ การขับขี่ที่ก้าวร้าว, ความผิดพลาดในการตัดสินใจ, การหลงลืม, การใช้ความเร็ว, การฝ่าฝืนกฎจราจร , การมีสิ่งรบกวนภายในจิตใจหรือไม่มีสมาธิ, การใช้โทรศัพท์มือถือ , ความประมาท , การฝ่าฝืนความเร็ว , การสวมหมวกนิรภัย , การควบคุมที่ลำบาก , การไม่ระมัดระวังอย่างไรก็ตามพฤติกรรมเสี่ยงเหล่านี้สามารถปรับเปลี่ยนได้โดยการใช้หลักทางวิศวกรรมการจราจรและการบังคับใช้กฎหมาย ซึ่งผลที่ได้จากการศึกษานี้จะนำไปแสดงต่อหน่วยงานที่เกี่ยวข้อง เพื่อวางแผนความปลอดภัยทางถนนบนถนนในเขตเมืองขอนแก่นต่อไป

คำสำคัญ : รถจักรยานยนต์, ความปลอดภัยทางถนน, หลักทางวิศวกรรมการจราจร, พฤติกรรมเสี่ยง

Abstract

This study aims to study the risk behaviors of motorcyclist on Mittraphap Road in Khon Kaen, Thailand. The questionnaire exploring risk behaviors of motorcyclist (52 risk behaviors), was developed. The questionnaire was distributed to motorcyclists (N = 459). Data analyze by using Exploratory Factor Analysis (EFA).The results found that the most frequent risk behavior of motorcyclists are "Deliberately drive too speed on the open road, Deliberately drive too fast to overtake, Accelerate when approaching a traffic light at a green/yellow phase, Talking with friends who drive parallel or riding pillion, Not noticed the road surface is broken and Non-wearing a helmet". In addition, the results from the EFA analysis 12 new variables (KMO = 0.929 , p = 0.000) are "Aggressive Driving, Decision Errors, Lapses, Speed, Traffic Violations, Internal Distraction, Mobile Phone Usage, Inattention, Speed Violation, Helmet Usage, Control Errors, Improper Lookout". However, these risk behaviors can change by traffic engineering and law enforcement. The results of this study will be presented to relevant agencies. For road safety plan on road at Khon Kaen Urban.

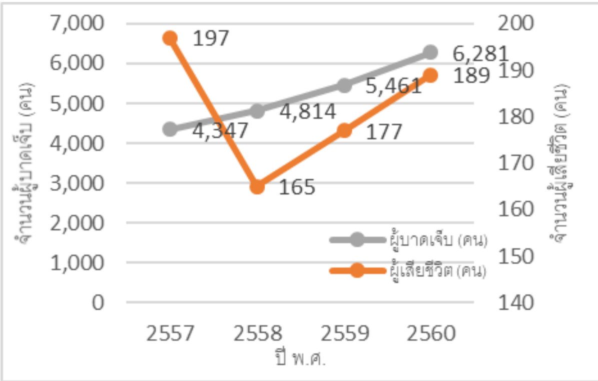
Keywords : Motorcycle, Road safety, Traffic Engineering, Risk behaviors

1. บทนำ

จากการวิเคราะห์รายงานขององค์การอนามัยโลก (World Health Organization (WHO)) ในปี ค.ศ. 2015 [1] พบว่าประเทศไทยมีสถิติอัตราการเสียชีวิตทางถนนเป็นอันดับที่ 2 จากประเทศสมาชิกทั่วโลก คิดเป็น 36.2 คนต่อประชากร 100,000 คนต่อปี ซึ่งหากพิจารณาเฉพาะผู้ที่เสียชีวิตจากรถจักรยานยนต์จะพบว่า ประเทศไทยอยู่ในลำดับที่ 1 จากประเทศสมาชิกทั่วโลก ซึ่งมีสัดส่วนเปอร์เซ็นต์การเสียชีวิตจากยานพาหนะ 2-3 ล้อเป็นร้อยละ 73 จากประเภทยานพาหนะทุกชนิด อาจเนื่องมาจากการได้รับความนิยมในการเลือกใช้รถจักรยานยนต์ที่ใช้เดินทางได้ง่าย สะดวก และราคาไม่แพง และจากการวิเคราะห์ข้อมูลของประเทศในสมาชิกประชาคมอาเซียน ซึ่งกลุ่มประเทศในภูมิภาคนี้มีความนิยมในการใช้รถจักรยานยนต์ในการเดินทาง ซึ่งพบว่าเปอร์เซ็นต์สัดส่วนการเสียชีวิตจากรถจักรยานยนต์ที่เป็นอันดับที่ 1 คือ ประเทศไทย รองลงมาคือ ประเทศกัมพูชา [1-2]

และในส่วนของจังหวัดขอนแก่น เป็นเมืองที่สำคัญแห่งหนึ่งของภาคตะวันออกเฉียงเหนือ และประเทศไทย และยังเป็นเมืองศูนย์กลางด้านการท่องเที่ยว การศึกษา การรักษาพยาบาล และอื่นๆ จึงเป็นเมืองที่มีประชากรเดินทางและอาศัยอยู่เป็นจำนวนมาก มีผู้ใช้รถใช้ถนนมาก จึงทำให้เกิดอุบัติเหตุที่บ่อยครั้ง และทำให้มีผู้บาดเจ็บและเสียชีวิตเป็นจำนวนมาก ซึ่งจากการรวบรวมข้อมูลสถิติผู้เสียชีวิต และผู้บาดเจ็บจากการเกิดอุบัติเหตุทางถนนของผู้ขับขี่รถจักรยานยนต์ในเขตจังหวัดขอนแก่น จากบริษัทกลางคุ้มครองผู้ประสบภัยจากรถ จำกัด (E-Claim) ปี 2557-2560 ดังแสดงในรูปที่ 1 จะพบว่าในแต่ละปีมีผู้บาดเจ็บและเสียชีวิตจากการเกิดอุบติเหตุทางถนนของผู้ขับขี่รถจักรยานยนต์ในเขตจังหวัดขอนแก่นมีแนวโน้มที่สูงขึ้น

จากข้อมูลอุบัติเหตุทางถนนที่ได้กล่าวมาในข้างต้นเป็นเพียงข้อมูลบางส่วนที่ได้จากการรวบรวมข้อมูลของหน่วยงานต่างๆ ซึ่งข้อมูลอุบัติเหตุทางถนนที่กล่าวมาก็เพียงพอที่จะสะท้อนให้เห็นถึงความสำคัญของอุบัติเหตุ เพราะการเกิดอุบัติเหตุขึ้นครั้งหนึ่งจะทำให้เกิดการสูญเสียทั้งด้านทรัพย์สิน การบาดเจ็บ และการเสียชีวิต ซึ่งมีแนวโน้มที่สูงขึ้นเรื่อยๆ ในแต่ละปี ถึงแม้จะไม่สามารถที่จะลดจำนวนของการเกิดอุบัติเหตุทั้งหมดได้ แต่หากสามารถทำให้อุบัติเหตุลดลงได้แม้บางส่วนก็จะช่วยลดการสูญเสียและก่อให้เกิดประโยชน์ที่ตามมาอีกมากมาย งานวิจัยนี้จึงต้องการศึกษาพฤติกรรมเสี่ยงของผู้ขับขี่รถจักรยานยนต์ บนถนนมิตรภาพในเขตเมืองขอนแก่น และ หาแนวทางในการป้องกันการเกิดอุบัติเหตุของผู้ขับขี่รถจักรยานยนต์บนถนนมิตรภาพในเขตเมืองขอนแก่น



รูปที่ 1 ข้อมูลผู้บาดเจ็บและเสียชีวิตจากการขับขี่รถจักยานยนต์ของบริษัทกลางคุ้มครองผู้ประสบภัยจากรถ จำกัด (E-Claim) ปี 2557-2560 ของจังหวัดขอนแก่น **ที่มา :** www.thairsc.com

2. วิธีการทดลอง

จากการทบทวนวรรณกรรมของงานวิจัยเกี่ยวข้องกับพฤติกรรมการขับขี่รถจักรยานยนต์ในต่างประเทศ คือ Motorcycle Rider Behavior Questionnaire (MRBQ) [3] โดยทีมวิจัยต้องการที่จะประยุกต์ใช้แบบสอบถามกับพื้นที่ศึกษา

2.1 ขนาดตัวอย่าง

ข้อมูลจาก กรมการขนส่งทางบก จังหวัดขอนแก่น ในปี พ.ศ. 2560 มีผู้จดทะเบียนรถจักรยานยนต์ จำนวน 46,582 คัน [4] (N=46,582) ระดับความเชื่อมั่น 95% สัดส่วนความคลาดเคลื่อนเท่ากับ 0.05 (e=0.05) หาขนาดตัวอย่างโดยใช้ Yamane's formula:

$n = 46{,}582 / (1+46{,}582\ (0.05)^2)$

$n = 397$

ได้ขนาดตัวอย่าง 39 7 ตัวอย่าง จา กผู้จดทะเบียนรถจักรยานยนต์ จำนวน 46,582 คัน

2.2 วิธีการสุ่มตัวอย่าง

ในการศึกษาครั้งนี้ใช้การสุ่มตัวอย่างแบบง่าย (Simple Random Sampling) โดยจะทำให้การเลือกตัวอย่างของประชากรมีโอกาสที่จะถูกเลือกเท่า ๆ กันโดยใช้หลักความน่าจะเป็น ซึ่งในแต่ละครั้งของการเลือกประชากรจะถูกแทนด้วยตัวเลขจาก 1 ถึง N จึงจะทำการสุ่มเลือกตัวอย่างอาจสุ่มโดยวิธีตารางสุ่มจับสลากหรือฟังก์ชันของโปรแกรมคอมพิวเตอร์ที่สามารถเลือกตัวเลขจากการสุ่มได้ ซึ่งเป็นการใช้หลักของความน่าจะเป็นในการสุ่ม [5]

2.3 การสร้างแบบสอบถาม

การสร้างแบบสอบถามมีการพัฒนาจากรายงานเกี่ยวกับพฤติกรรมของผู้ขับขี่รถจักรยานยนต์โดยมีคำถามทั้งหมด 40 ข้อ [6] จากนั้นผู้วิจัยได้ประยุกต์ใช้คำถามจากเครื่องมือแบบสอบถามของต่างประเทศคือ MRBQ [3] มาร่วมประยุกต์ และมีส่วนหนึ่งพัฒนาขึ้นเองจากการสำรวจความคิดเห็น

ซึ่งสุดท้ายแล้วได้คัดเลือกข้อคำถามที่เหมาะสมแก่พื้นที่ศึกษาทั้งหมด 52 ข้อคำถาม และมีการวัดความถี่ของการแสดงพฤติกรรมระดับ 1 (ไม่เคยทำ) ถึง 5 (ทำทุกครั้ง)

2.4 การวิเคราะห์ข้อมูล

ใช้หลักสถิติเบื้องต้นในการวิเคราะห์ข้อมูล เช่น ค่าเฉลี่ย ค่าเบี่ยงเบนมาตรฐาน เป็นต้น ต่อมาจึงมี วิเคราะห์ปัจจัยเชิงสำรวจ (Exploratory Factor Analysis) วิเคราะห์โดยใช้โปรแกรม SPSS การวิเคราะห์ปัจจัยเชิงสำรวจจะใช้ในการสำรวจข้อมูล เพื่อกำหนดจำนวนปัจจัยและทำการหมุนแกนปัจจัย (Factors Rotation) โดยวิธีการหมุนแกนแบบตั้งฉาก (Orthogonal Rotation) ในแบบ Varimax โดยจะพิจารณาค่า Bartlett's test of Sphericity;ค่า p-value ควรมีค่าน้อยกว่า 0.05, ค่าKaiser-Meyer-Olkin measure of sampling adequacy (KMO); ค่า KMO ควรมีค่ามากกว่า 0.8, ค่า Cronbach's alpha ฯ ล ฯ [7]

3. ผลการทดลองและอธิปรายผล

จากการวิเคราะห์ข้อมูลทั่วไป จากแบบสอบถามทั้งหมด 452 ชุด (ไม่นับรวม Missing จากเดิม 459 ชุด) พบว่า กลุ่มตัวอย่างเป็นเพศชายร้อยละ 41 เพศหญิงร้อยละ 59, อายุโดยเฉลี่ยเท่ากับ 22 ปี, ประสบการณ์ในการขับขี่โดยเฉลี่ย 7 ปี และมีใบอนุญาตขับขี่รถจักรยานยนต์ ร้อยละ 65

ในส่วนของข้อมูลที่เกี่ยวข้องกับอุบัติเหตุทางถนน พบว่า จากกลุ่มตัวอย่างเคยมีประสบการณ์ในการเกิดอุบัติเหตุทางถนน ร้อยละ 58 ซึ่งเป็นระดับความรุนแรงอุบัติเหตุที่ทรัพย์สินเสียหาย ร้อยละ 10 บาดเจ็บเล็กน้อย ร้อยละ 81 และบาดเจ็บสาหัสร้อยละ 9

3.1 ผลการวิเคราะห์ปัจจัยเชิงสำรวจ

ตารางที่ 1 แสดงผลของการวิเคราะห์ปัจจัยเชิงสำรวจ (ค่า KMO = 0.929, p = 0.000) โดยจากการวิเคราะห์ข้อคำถาม 52 ข้อคำถาม สามารถแบ่งปัจจัยได้ 12 ปัจจัย คือ 1) การขับขี่ที่ก้าวร้าว (Aggressive Driving) 2) ความผิดพลาดในการตัดสินใจ (Decision errors) 3) การหลงลืม (lapses) 4) การใช้ความเร็ว (Speed) 5) การฝ่าฝืนกฎจราจร (Traffic Violations) 6) การมีสิ่งรบกวนภายในจิตใจหรือไม่มีสมาธิ (Internal distraction) 7) การใช้โทรศัพท์มือถือ (Mobile Phone Usage) 8) ความประมาท (Inattention) 9) การฝ่าฝืนความเร็ว (Speed Violation) 10) การสวมหมวกนิรภัย (Helmet Usage) 11) การควบคุมที่ลำบาก (Control Errors) 12) การไม่ระมัดระวัง (Improper lookout) (ซึ่งแสดงค่าน้ำหนักกลุ่มปัจจัยร่วม (Factor Loading) เฉพาะที่มีค่ามากกว่า 0.3)

ตารางที่ 1 ผลของการวิเคราะห์ปัจจัยเชิงสำรวจ

พฤติกรรมเสี่ยง	ค่าน้ำหนักกลุ่มปัจจัยร่วม (Factor Loading)												Mean
	1	2	3	4	5	6	7	8	9	10	11	12	(SD)
(43) ขับรถตามรถคันอื่นด้วยอารมณ์โกรธ	0.700												1.84 (0.974)
(40) ขับรถเข้าไปใกล้รถคันที่อยู่ด้านหน้า เพื่อเป็นการส่งสัญญาณให้รีบไปหรือหลีกทาง	0.633												1.87 (0.934)
(44) จงใจขับรถเลี้ยวเข้าถนนมิตรภาพอย่างกะทันหัน ทำให้ตัดหน้ารถคันอื่น	0.617				0.314								1.58 (0.793)
(37) จงใจที่จะขับรถกระชั้นชิดกับรถคันด้านหน้า	0.568												2.02 (0.936)
(36) จงใจที่จะขับรถเร็วเพื่อให้มีความเร็วเท่ากับรถคันอื่น	0.559			0.370									2.35 (1.050)

ตารางที่ 1 ผลของการวิเคราะห์ปัจจัยเชิงสำรวจ (ต่อ)

พฤติกรรมเสี่ยง	**ค่าน้ำหนักกลุ่มปัจจัยร่วม (Factor Loading)**												**Mean**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**(SD)**
(52) ฝ่าฝืนสัญญาณไฟจราจรที่ควบคุมโดย ตำรวจ ณ ทางแยก	0.516				0.423								1.54 (0.829)
(49) จงใจขับรถเร็วบนถนนที่เปียกลื่น	0.471				0.377								2.00 (0.892)
(51) จงใจขับรถแทรกระหว่างรถคันอื่น	0.373			0.306									2.10 (0.993)
(7) กะความเร็วรถที่กำลังตามมาผิดพลาด ขณะพยายามแซงรถคันข้างหน้า		0.706											2.16 (0.868)
(6) เลี้ยวเข้าถนนมิตรภาพโดยไม่ได้ตั้งใจ ทำให้ตัดหน้ารถคันอื่น	0.308	0.655											1.73 (0.872)
(2) เมื่อกลับรถ "กะความเร็วของรถที่กำลังสวนมาผิดพลาด" จนไปตัดหน้ารถคันดังกล่าว		0.636											2.13 (0.883)
(5) เลี้ยวเข้าทางแยกด้วยความเร็ว จนรถเกือบเสียหลัก		0.580											2.20 (0.844)
(8) กะความเร็วผิดพลาดขณะเข้าสู่ทางแยกที่มีสัญญาณไฟแดง/เหลือง จนต้องเบรกกะทันหัน		0.575											2.42 (0.853)
(1) เมื่อเลี้ยวที่ทางแยก "ไม่ทันสังเกต" เห็นคนที่กำลังข้ามถนน		0.472			0.303								2.29 (0.879)
(3) คิดว่าผิวถนนสามารถเบรกได้ดี แต่พอเบรกแล้วเบรกไม่อยู่		0.468				0.396							2.52 (0.929)
(9) เบรกกะทันหัน บนพื้นถนนที่ลื่น		0.396				0.488							2.37 (0.878)
(26) ลืมรายละเอียดเส้นทางที่พึ่งขับผ่านมา			0.708										2.40 (1.061)
(27) ลืมว่าตัวเองเปิดไฟสูงในเขตพื้นที่ที่มีไฟส่องสว่าง			0.597										2.01 (0.897)
(25) ลืมสังเกตสัญญาณไฟแดงว่าเปลี่ยนเป็นไฟเขียว			0.593										1.97 (0.834)
(29) ขับรถเข้าเลนผิด ตอนเข้าสู่ทางแยก			0.578					0.301					2.09 (0.844)

ตารางที่ 1 ผลของการวิเคราะห์ปัจจัยเชิงสำรวจ (ต่อ)

พฤติกรรมเสี่ยง	**ค่าน้ำหนักกลุ่มปัจจัยร่วม (Factor Loading)**												**Mean**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**(SD)**
(28) คุณตั้งใจจะขับรถไปสถานที่ A จนคุณรู้สึกตัวว่าตัวเองอยู่ในเส้นทางที่จะไปสถานที่ B ซึ่งเป็นเส้นทางที่คุ้นเคย			0.575										2.31 (1.009)
(23) ลืมสังเกตเห็นป้าย/เครื่องหมายเตือน ว่ามีการปิดถนนชั่วคราว			0.524										1.97 (0.874)
(24) ลืมเปิดไฟหน้ารถ ในตอนกลางคืน	0.405		0.454										1.62 (0.884)
(21) กะระยะพลาด ทำให้จอดเลยเส้นหยุดบริเวณไฟแดง			0.336			0.326							2.45 (0.962)
(35) จงใจที่จะขับรถเร็ว เมื่อถนนโล่ง				0.807									3.25 (1.048)
(34) จงใจที่จะขับรถเร็วเพื่อที่จะแซง				0.799									3.12 (0.993)
(42) ขับรถเร่งความเร็วเพื่อให้ทันสัญญาณไฟเหลืองหรือไฟเขียว				0.657									3.03 (1.006)
(39) จงใจขับรถฝ่าสัญญาณไฟแดง	0.316				0.648								1.80 (0.855)
(41) จงใจขับรถย้อนศรบนถนน					0.624								1.95 (0.894)
(48) กลับรถในที่ห้ามกลับรถ					0.529								2.10 (0.916)
(38) ขับรถบนทางเท้าเพื่อที่จะหลีกเลี่ยงเส้นทางที่ไกล หรือเมื่อติดอยู่ในการจราจรที่ติดขัด หรือหลีกเลี่ยงการติดสัญญาณไฟแดง	0.325				0.398								1.73 (0.901)
(13) ไม่มีสมาธิ เหม่อลอยในการขับขี่ เช่น มองสาวมองหนุ่ม มองหาร้านอาหาร เป็นต้น						0.622							2.67 (0.997)
(14) คุยกับเพื่อนอีกคนที่ขับไปขนานกัน หรือคุยกับคนซ้อน						0.592						0.351	2.84 (1.005)
(12) ไม่ทันสังเกตเห็นหลุม/ผิวจราจรชำรุด จึงเบรกรถกะทันหัน						0.515							2.84 (0.933)

ตารางที่ 1 ผลของการวิเคราะห์ปัจจัยเชิงสำรวจ (ต่อ)

พฤติกรรมเสี่ยง	ค่าน้ำหนักกลุ่มปัจจัยร่วม (Factor Loading)												Mean
	1	2	3	4	5	6	7	8	9	10	11	12	(SD)
(17) ไม่ทันสังเกต ป้ายจำกัดความเร็ว หรือ เครื่องหมายจำกัดความเร็วในผิวทาง จึงขับผ่านด้วยความเร็วเกินกำหนด						0.376	0.311						2.47 (1.049)
(16) ใส่หูฟังฟังเพลงเสียงดัง หรืออินกับเพลง ร้องเพลง ขณะขับขี่							0.755						2.22 (1.229)
(22) ใช้โทรศัพท์มือถือในขณะขับขี่โดยไม่ได้เจตนา เช่นคุยโทรศัพท์ เล่นเกมส์ เล่นFacebook เป็นต้น							0.684						1.98 (0.959)
(50) จงใจใช้โทรศัพท์มือถือในขณะขับขี่ เช่นคุยโทรศัพท์ เล่นเกม เล่น Facebook เป็นต้น					0.321		0.625						1.87 (0.944)
(18) ขับรถมือเดียวถือสิ่งของ หรือบรรทุกสิ่งของขนาดใหญ่ ทำให้ควบคุมรถลำบาก				0.346			0.399						2.53 (0.961)
(30) ลืมเปิด/ปิดสัญญาณไฟเลี้ยว			0.352					0.601					2.39 (0.866)
(15) กะระยะเวลาเปิดไฟเลี้ยวผิดพลาด ทำให้เปิดไฟเลี้ยวกะทันหัน						0.304		0.583					2.50 (0.924)
(10) ไม่มองด้านข้าง หรือกระจกมองหลัง ก่อนออกรถหรือการแซง								0.557					2.06 (0.900)
(11) ไม่ทันสังเกตว่ารถที่จะแซงเปิดไฟเลี้ยว เพื่อที่จะเลี้ยวขวา		0.341						0.455					2.29 (0.892)
(46) ขับรถด้วยความเร็วเกิน 80 กม./ชม.									0.792				2.56 (1.123)
(47) ขับรถด้วยความเร็วเกิน 100 กม./ชม.									0.770				1.93 (1.045)
(33) ลืมสวมหมวกนิรภัย										0.834			2.58 (1.138)
(45) ขับรถโดยไม่สวมหมวกนิรภัย										0.719			2.79 (1.102)
(32) สวมหมวกนิรภัย แต่ลืมคาดสายรัดคาง							0.320			0.404			2.18 (1.125)

ตารางที่ 1 ผลของการวิเคราะห์ปัจจัยเชิงสำรวจ (ต่อ)

พฤติกรรมเสี่ยง	ค่าน้ำหนักกลุ่มปัจจัยร่วม (Factor Loading)												Mean
	1	2	3	4	5	6	7	8	9	10	11	12	(SD)
(31) ลืมเอาขาตั้งรถขึ้นในขณะขับขี่											0.684		1.86 (0.917)
(4) เข้าเกียร์รถผิด ขณะที่ขับรถด้วยความเร็ว		0.445									0.621		1.86 (0.928)
(19) ซ้อนสาม หรือมากกว่าทำให้ควบคุมรถลำบาก												0.704	2.63 (0.928)
(20) หยอกล้อกันขณะขับขี่	0.361											0.546	2.10 (0.975)
ค่า Eigenvalues	4.029	3.775	3.469	2.986	2.646	2.622	2.461	1.999	1.878	1.877	1.517	1.511	-
% Variance Explained	7.749	7.261	6.671	5.742	5.088	5.042	4.732	3.846	3.612	3.610	2.918	2.906	-
ค่า Cronbach's Alpha	0.850	0.819	0.804	0.789	0.705	0.662	0.727	0.685	0.784	0.666	0.585	0.517	-
จำนวนของข้อคำถาม	8	8	8	3	4	4	4	4	2	3	2	2	-

3.2 อภิปรายผล

ในการศึกษางานวิจัยนี้ มีวัตถุประสงค์เพื่อให้ทราบถึงพฤติกรรมเสี่ยงของผู้ขับขี่รถจักรยานยนต์ บนถนนมิตรภาพในเขตเมืองขอนแก่น ซึ่งการพัฒนาเครื่องมือหรือแบบสอบถามเพื่อวัดพฤติกรรมเสี่ยงในกลุ่มของผู้ขับขี่รถจักรยานยนต์เป็นที่นิยามในต่างประเทศ อาทิ การศึกษาแบบสอบถามพฤติกรรมการขับขี่ของรถจักรยานยนต์ (Motorcycle Rider Behavior Questionnaire (MRBQ) [3] หรือการพัฒนาแบบสอบถามการฝ่าฝืนของผู้ขับขี่รถจักรยานยนต์ของชาวจีน (Development of a Chinese Motorcycle Rider Driving Violation Questionnaire) [8] โดยที่แต่ละแบบสอบถามก็จะมีความแตกต่างกันไปขึ้นอยู่กับแต่ละพื้นที่

และจากการวิเคราะห์สามารถจำแนกพฤติกรรมเสี่ยงของรถจักรยานยนต์ ได้เป็น 12 ปัจจัย ได้แก่ การขับขี่ที่ก้าวร้าว (Aggressive Driving), ความผิดพลาดในการตัดสินใจ (Decision Errors), การหลงลืม (Lapses), การใช้ความเร็ว (Speed), การฝ่าฝืนกฎจราจร (Traffic Violations), การมีสิ่งรบกวนภายในจิตใจหรือไม่มีสมาธิ (Internal Distraction), การใช้โทรศัพท์มือถือ (Mobile Phone Usage), ความประมาท (Inattention), การฝ่าฝืนความเร็ว (Speed Violation), การสวมหมวกนิรภัย (Helmet Usage), การควบคุมที่ลำบาก (Control Errors), การไม่ระมัดระวัง (Improper lookout)

จากการศึกษาที่ผ่านโดย คุณ Ozkan และคณะ (2012) ได้มีการศึกษาโดยใช้ MRBQ ได้สามารถจำแนกปัจจัยได้ 5 ปัจจัย คือ Traffic Errors, Speed Violations, Stunts, Safety Equipment และ Control Errors และคุณ Stephens และคณะ (2016) [9] ได้มีการศึกษาโดยใช้ MRBQ ได้สามารถจำแนกปัจจัยได้ 5 ปัจจัย คือ Traffic Errors, Speed Violations, Protective Gear, Control Errors และ Stunts จากที่กล่าวมาจากผลการศึกษาเบื้องต้น พบว่างานวิจัยในต่างประเทศมีปัจจัยที่มีความสอดคล้องกับงานวิจัยนี้ คือ ปัจจัยที่เกี่ยวข้องกับการใช้ความเร็วหรือการฝ่าฝืนความเร็ว (Speed Violation), การควบคุมที่ลำบาก (Control Errors)

การใช้ความเร็ว (Speed) นับว่าเป็นสาเหตุที่สำคัญในการเกิดอุบัติเหตุทางถนน ซึ่งผลจากงานวิจัยนี้ พบว่าพฤติกรรมที่เกี่ยวกับความเร็วที่มีความถี่โดยเฉลี่ยของพฤติกรรมสูงสุดมักปฏิบัติในการขับขี่ ซึ่งเป็นพฤติกรรมที่มักจะแสดงออกที่เกี่ยวกับความเร็ว ได้แก่ จงใจที่จะขับรถเร็ว เมื่อถนนโล่ง , จงใจที่จะขับรถเร็ว เพื่อที่จะแซง และ ขับรถเร่งความเร็ว เพื่อให้ทันสัญญาณไฟเหลืองหรือไฟเขียว เป็นต้น นอกจากนี้ยังมีกลุ่ม การฝ่าฝืนความเร็ว (Speed Violation) ได้แก่ คำถามเกี่ยวกับการใช้ความเร็ว เกิน 80 km/h และ 100 km/h ซึ่งการใช้ความเร็วสูงในการขับขี่รถจักรยานยนต์ อาจก่อให้เกิดความรุนแรงที่มากขึ้นในการเกิดอุบัติเหตุทางถนน [1] นอกจากประเด็นของความเร็วแล้ว ยังมีประเด็นที่น่าสนใจ คือ ปัจจัยการสวมหมวกนิรภัย (Helmet Usage) ที่ประกอบไปด้วยการแสดงพฤติกรรมดังนี้ ขับรถโดยไม่สวมหมวกนิรภัย , การลืมสวมหมวกนิรภัยและสวมหมวกนิรภัย แต่ลืมคาดสายรัดคาง ซึ่งการสวมหมวกนิรภัยขณะเกิดอุบติเหตุหรือการชนจะสามารถลดการบาดเจ็บที่ศีรษะได้ [10-15] และจากงานวิจัยที่ผ่านมาได้ศึกษาการเกิดอุบัติเหตุของรถจักรยานยนต์ในจังหวัดขอนแก่น พบว่า ผู้ขับขี่ที่ถูกชนหรือโดนชนมักมีอาการมึนเมาและไม่สวมหมวกนิรภัย [16]

จากที่กล่าวมาในเบื้องต้นเมื่อเปรียบเทียบกับงานวิจัยในต่างประเทศที่ผ่านมาจะพบว่างานวิจัยนี้มีความหลากหลายที่สามารถจำแนกได้หลายปัจจัย อาจมาจากสาเหตุว่า งานวิจัยนี้มีพฤติกรรมเสี่ยงถึง 52 พฤติกรรม เมื่อวิเคราะห์โดยวิธี EFA จึงจำแนกออกมาได้พฤติกรรมได้หลายปัจจัย

4. สรุปผลการดำเนินการและข้อเสนอแนะ

4.1 สรุปผล

จากศึกษาพฤติกรรมเสี่ยงของผู้ขับขี่รถจักรยานยนต์ บนถนนมิตรภาพในเขตเมืองขอนแก่น พบว่ามีพฤติกรรมที่ควรเฝ้าระวังอุบัติเหตุทางถนน ได้แก่ จงใจที่จะขับรถเร็ว เมื่อถนนโล่ง , จงใจที่จะขับรถเร็วเพื่อที่จะแซง , ขับรถเร่งความเร็ว เพื่อให้ทันสัญญาณไฟเหลืองหรือไฟเขียว, คุยกับเพื่อนอีกคนที่ขับไปขนานกัน หรือคุยกับคนซ้อน , ไม่ทันสังเกตเห็นหลุม/ผิวจราจรชำรุด จึงเบรกรถกะทันหัน , ขับรถโดยไม่สวมหมวกนิรภัย, ไม่มีสมาธิ เหม่อลอย ในการขับขี่ เช่น มองสาว มองหนุ่ม มองหาร้านอาหาร ฯลฯ , ซ้อนสาม หรือมากกว่า ทำให้ควบคุมรถลำบาก และลืมสวมหมวกนิรภัย เป็นต้น จากคำถาม 52 ข้อคำถาม สามารถจำแนกพฤติกรรมเสี่ยงของรถจักรยานยนต์ ได้เป็น 12 ปัจจัย ได้แก่ การขับขี่ที่ก้าวร้าว (Aggressive Driving), ความผิดพลาดในการตัดสินใจ (Decision errors), การหลงลืม (Lapses), การใช้ความเร็ว (Speed), การฝ่าฝืนกฎจราจร (Traffic Violations), การมีสิ่งรบกวนภายในจิตใจหรือไม่มีสมาธิ (Internal Distraction), การใช้โทรศัพท์มือถือ (Mobile Phone Usage), ความประมาท (Inattention), การฝ่าฝืนความเร็ว (Speed Violation), การสวมหมวกนิรภัย (Helmet Usage), การควบคุมที่ลำบาก (Control Errors), การไม่ระมัดระวัง (Improper Lookout)

4.2 ข้อเสนอแนะความปลอดภัยทางถนน

การแสดงพฤติกรรมเสี่ยงขณะขับขี่รถจักรยานยนต์ที่กล่าวมาในข้างต้นนี้ สามารถป้องกันได้โดยตัวผู้ขับขี่เองในเบื้องต้น หากผู้ขับขี่ทุกท่านมีระเบียบหรือวินัยจราจรในการขับขี่รถและมีน้ำใจในการใช้รถใช้ถนนร่วมกับผู้อื่น ทีมวิจัยมีความเชื่อมั่นว่า อุบัติเหตุทางถนนบนถนนมิตรภาพในเขตเมืองขอนแก่น จะไม่สามารถเกิดขึ้นได้แน่นอน นอกจากการปฏิบัติตนของผู้ขับขี่แล้ว ปัจจัยอื่นที่สามารถลดการเกิดอุบัติเหตุ ได้แก่ การปรับปรุงเส้นทางหรือซ่อมบำรุงถนนที่ชำรุดให้ถูกต้องตามหลักทางวิศวกรรมทางถนน และตรวจสอบสภาพรถหรือยานพาหนะของผู้ขับขี่ อย่างน้อยปีละ 1 ครั้ง เป็นต้น หากปฏิบัติตามคำแนะนำหรือเหตุผลที่กล่าวมานั้น ทีมวิจัยเชื่อว่าการขับขี่บนถนนมิตรภาพในเขตเมืองขอนแก่น จะเป็นการขับขี่ที่ปลอดภัยอย่างแน่นอน จากผลการศึกษาสามารถนำผลการศึกษาไปแก้ปัญหา โดยสามารถทำได้ตามข้อเสนอแนะต่อไปนี้

1. ด้านการขับขี่ที่ก้าวร้าว ควรใช้มาตรการในการปลูกฝังจิตสำนึกของผู้ขับขี่ ซึ่งจะช่วยให้ผู้ขับขี่ตระหนักถึงเพื่อนร่วมทางมากขึ้น
2. ด้านความผิดพลาดในการตัดสินใจ ควรใช้มาตรการในการตรวจสอบตนเอง ถึงความพร้อมทางร่างกายและอารมณ์ ความเหนื่อยล้าอาจทำให้ความคิดไม่แจ่มใสและตอบสนองช้า อาจส่งผลให้ตัดสินใจในการขับขี่ที่ผิดพลาด
3. ด้านหลงลืม ควรใช้มาตรการในการตรวจสอบตนเอง ถึงความพร้อมในการขับขี่
4. ด้านการใช้ความเร็ว ควรใช้มาตรการปลูกฝังจิตสำนึกของผู้ขับขี่ เพื่อให้ใช้ความเร็วอย่างเหมาะสมในการขับขี่ เพื่อความปลอดภัย
5. ด้านการฝ่าฝืนก ฎหมายจราจร ใช้มาตรการด้านการบังคับใช้กฎหมาย เพื่อควบคุมผู้ขับขี่ที่จงใจฝ่าฝืน
6. การมีสิ่งรบกวนภายในจิตใจหรือไม่มีสมาธิ ควรใช้มาตรการในการตรวจสอบตนเอง ก่อนที่จะขับขี่ ซึ่งความโกรธ,ความวิตกกังวลและความตื่นเต้น เป็นอารมณ์ที่ส่งผลต่อจิตใจหรือสมาธิของผู้ขับขี่
7. ด้านการใช้โทรศัพท์มือถือ ควรใช้มาตรการควบคุมการใช้โทรศัพท์ขณะขับรถ โดยในระหว่างขับขี่ หากจำเป็นควรใช้ head phone หรือ speaker phone หรืออาจใช้ระบบตอบกลับอัตโนมัติ เพื่อลดความเสี่ยงในการเกิดอุบัติเหตุ
8. ด้านความประมาท ควรใช้มาตรการปลูกฝังจิตสำนึกของผู้ขับขี่ ให้มีความระมัดระวังในการขับขี่
9. ด้านการฝ่าฝืนความเร็ว มาตรการในการจัดการด้านการฝ่าฝืนความเร็วควรใช้มาตรการด้านวิศวกรรม เช่นการใช้ speed camera เป็นต้น และด้านการบังคับใช้กฎหมาย
10. ด้านการสวมหมวกนิรภัย ควรใช้มาตรการสวมหมวกนิรภัย 100 % โดยมีการรณรงค์และแจกสื่อประชาสัมพันธ์ ถึงความปลอดภัยในการสวมหมวกนิรภัย และด้านการบังคับใช้กฎหมายอีกด้วย
11. ด้านการควบคุมที่ลำบาก ควรใช้มาตรการปลูกฝังจิตสำนึกของผู้ขับขี่ ให้มีความตระหนักถึงอันตรายที่จะเกิดขึ้น
12. ด้านการไม่ระมัดระวัง ควรใช้มาตรการในการปลูกฝังจิตสำนึกของผู้ขับขี่ ให้ตระหนักถึงความปลอดภัยอยู่เสมอ

5. กิตติกรรมประกาศ

ขอขอบพระคุณทุน อุดหนุนการทำโครงงานวิจัย (Project) สำหรับนักศึกษาระดับปริญญาตรี คณะวิศวกรรมศาสตร์ มหาวิทยาลัยขอนแก่น และขอขอบพระคุณทุนวิจัยสำหรับคณาจารย์บัณฑิตศึกษา เพื่อให้สามารถรับนักศึกษาที่มีความสามารถและศักยภาพสูง เข้าศึกษาในหลักสูตรและทำวิจัยในสาขาที่อาจารย์มีความเชี่ยวชาญ ประจำปีการศึกษา 2559 บัณฑิตวิทยาลัย มหาวิทยาลัยขอนแก่น

เอกสารอ้างอิง

[1] World Health Organization. (2015) Global Status Report on Road Safety 2015. Geneva, Switzerland.

[2] Kumphong J., Satiennam T., Satiennam W. A Study of Social Norms and Motorcycle Helmet Use Intentions among Student Riders in University: A comparison of the Theory of Reasoned Action and the Theory of Planned Behavior. Conference proceedings, in Proc. 12th Int. Conf. on the Eastern Asia Society for Transportation Studies. 2017; 11. (In Thai).

[3] Ozkan, T., et al.. Motorcycle accidents, rider behaviour, and psychological models. Accident Analysis and Prevention. 2012; 49: 124-132.

[4] Transport Statistics Group. Number of vehicles registered. [serial online][cited 2018 July 26];1(1):[1 screens]. Available from: URL: http://apps.dlt.go.th/statistics_web/newcar.html

[5] Security Division. Study of black spot and risk behavior of student drivers at Khon Kaen University Report; 2017; Khon Kaen,Thailand. (In Thai).

[6] Tiyabutr T. Application of the theory of planned behavior to study factors affected red-light running intention and behavior. Khon Kaen: Khon Kaen University; 2016. (In Thai).

[7] Vanichbuncha k. SPSS For Windows. 3rd ed. Bankok: Thammasarn; 2006. (In Thai).

[8] Cheng, A.S.-K. and Ng, T.C.-K. Development of a Chinese Motorcycle Rider Driving Violation Questionnaire. Accident Analysis and Prevention. 2010; 42: 1250–1256.

[9] Stephens, A.N., et al. The relationship between Motorcycle Rider Behaviour Questionnaire scores and crashes for riders in Australia. Accident Analysis and Prevention. 2017; 102: 202–212.

[10] Branas, C.C., Knudson, M.M. Helmet laws and motorcycle rider death rates. Accident Analysis and Prevention. 2001;33, 641-648.

[11] Keng, S.H. Helmet laws and motorcycle fatalities in Taiwan. Accident Analysis and Prevention. 2008;37, 349-355.

[12] Hill, P.S., Nnh, A.D., Khuong, T.A., Dao, H.L., Hoang, H.T.M., Trinh, H.T., Nguyen, L.T.N., Nguyen, P.H. Mandatory helmet legislation and the print media in Viet Nam. Accident Analysis and Prevention. 2009; 41, 789-797.

[13] DeMarco, A.L., Chimich, D.D., Gardiner, J.C., Nightingale R.W., Siegmund, G.P. The impact response of motorcycle helmets at different impact severities. Accident Analysis and Prevention, 2010; 42, 1778-1784.

[14] Erhardt, T., Rice, T., Troszak, L., Zhu M. Motorcycle helmet type and risk of head injury and neck injury during motorcycle collisions in California. Accident Analysis and Prevention. 2016; 86, 23-28.

[15] Ramli, R., Oxley, J. Motorcycle helmet fixation status is more crucial than helmet type in providing protection to the head. Injury. 2016; 47, 2442-2449.

[16] Nakahara, S., Chadbunchachai, W., Ichikawa, M., Tipsuntornsak, N., Wakai, S. Temporal distribution of motorcyclist injuries and risk of fatalities in relation to age, helmet use, and riding while intoxicated in Khon Kaen, Thailand. Accident Analysis and Prevention. 2005; 37, 833-842. (In Thai).

A Survey on Motorcycle Drivers' Phone Use While Driving in Vietnam

Topic number: 5 Paper Identification number: AYRF18-016

HA HUY NGUYEN NAM

Monitoring and Evaluation Assistant - AIP Foundation
18Bis/19 Nguyen Thi Minh Khai, District 1, Ho Chi Minh City, Vietnam
Email: nam.ha@aipf-vietnam.org – namhhn90@gmail.com

Abstract

While speeding is also revealed to be the biggest cause of road crashes in Vietnam, it is observed that there is an increasing number of motorcycle drivers using mobile phones while driving, potentially causing accidents. However, in Vietnam, there is a lack of studies on distracted driving behaviors causing by cell phone use, especially for motorcycle which is widely accepted as the dominate vehicle. In this paper, the patterns and rates of using mobile phone while driving of motorcyclist will be presenting, providing an overview of the characteristics of the status quo as well as the trends of use base on different factors. Besides, reviewing on the definitions of distraction driving and related elements is also given. These gain results will support for suggesting effective measures to address the situation as well as raising citizen awareness about distracted driving by using mobile phone.

Key words*: Mobile phone using, motorcycle driving, distracted driving, road safety*

1. Introduction

Traffic accident is one of the most serious problems not only in Viet Nam but also in all countries all over the world, causing a huge impact on the health of the community. There are many causes of traffic accidents including those related to the distracted driving, requiring policymakers and regulators to pay sufficient attention to address this problem.

In Vietnam, according to the Traffic Police Agency (2016), there were more than 21,000 traffic accidents in the country, killing nearly 9,000 people in 2016. While speeding is also revealed to be the biggest cause of road crashes in Vietnam, it is observed that there is an increasing number of motorcycle drivers using mobile phones while driving, potentially causing accidents. Unfortunately, there is a lack of studies on distracted driving behaviors causing by cell phone use in Vietnam, especially for motorcycle which is widely accepted as the dominate vehicle.

The main goal of this paper is presenting the patterns and rates of using mobile phone while driving of motorcyclist, providing an overview of the characteristics of the status quo as well as the trends of use base on different factors. Besides, the definitions of distraction driving and related elements are also given. These gain results will support for suggesting effective measures to address the situation as well as raising citizen awareness about distracted driving.

2. What is distracted driving?

The definition of driver distraction was developed by the Canadian Council of Motor Transport Administrators (CCMTA, 2006), Strategy to Reduce Impaired Driving (STRID), Sub-Group on distraction, which is:

Distracted driving is the diversion of attention from driving, as a result of the driver focusing on a non-driving object, activity, event or person. This diversion reduces awareness, decision-making or performance leading to increased risk of driver error, near-crashes or crashes. The diversion of attention is not attributable to a Medical condition, alcohol/drug use and/or fatigue.

It is obviously that distraction is when looking at a competing activity instead of attention to vital activities for safety driving (Ranney, 2008). When drivers are distracted, their attention is temporarily divided between what is often referred to as the "primary task" of driving and "secondary tasks" not related to driving (Klauer et al., 2006). Typical examples of secondary tasks are talking or texting on the phone, eating and drinking, talking to people on the vehicle as well as fiddling with the stereo, entertainment or navigation system - anything that takes the driver's attention away from the task of safe (NHTSA, 2017).

In other words, distraction on driving occurs when some kind of external events affect to the driver, leading to shifting attention of the driver away from safety driving (e.g. a ringing mobile phone). Thus, it can be said that, diversion of attention appears due to the driver is either performing an additional task or temporarily focusing on an object, event or person not related to primary driving task (Klauer et al., 2006).

3. What can distract vehicle drivers?

There are many things that can distract vehicle drivers. The US National Highway and Traffic Safety Administration has identified several main sources of driver distraction (Stutts, Reinfurt, & Rodgman, 2001).

These include those deriving from inside and outside the vehicle, those deriving from vehicle technologies and those deriving from everyday activities that people perform in the cockpit. Although these terms are used for cars driving, it also could be applied to research on motorcycles driving.

Internal distraction: Reserved for crashes in which the driver fails to recognize a situation requiring a response because his/her attention is directed to some event, object, person, or activity inside the vehicle (M. A. Regan, Hallett, & Gordon, 2011). Ex: tuning the radio, adjusting the heat/cooling system, engaging in a conversation with a passenger, using a cell phone, retrieving fallen objects, reading books / magazines / maps / invoices, etc.

External distraction: Crashes in which the driver fails to recognize a situation requiring a response because his/her attention is directed to some event, object, person, or activity outside a street address, construction activity, looking at a building or scenery, looking at a sign, looking at a previous vehicle (M. A. Regan et al., 2011). Ex: searching for a street address, construction activity, looking at a building or scenery, looking at a sign, looking at a previous crash site, etc.

In conclusion, to defining distraction of motorcyclists, some key elements should be taken into consideration (Stutts, Reinfurt, Staplin, & Rodgman, 2001):

- Diversion of attention away from driving, or safe driving
- Attention is diverted toward a competing activity, inside or outside of the vehicle, which may or may not be driving-related factors
- The competing activity may make the motorcyclists diverting attention toward it.
- There is an implicit, or explicit, assumption that safe driving is adversely affected
- Eating/drinking
- Other vehicle occupants
- Relating to smoking
- Talking/listening on mobile phone
- Dialing mobile phone
- Using device/object integral to vehicle
- Outside person/object or event
- Other distraction
- Unknown distracts.

It is easy to find that using mobile phone while driving is one of the important factors affecting to safety driving performance. Moreover, it is classified as an internal factor of distracted driving.

4. What are types of distracted driving?

Based on research from various sources, the researcher synthesizes four types of distracted driving as show below:

Visual (Eyes off the road): Looking away from the road for a non-driving-related task. Distraction caused by moving drivers' eyes from the road and looking to the mobile phone to use it, especially, when starting and completing calls or when seeing visual information (e.g. Reading SMS). Further, even if drivers' eyes are focusing on the road, they 'look but do not see'. Visually: mobile phones could visually distract drivers in two ways ("Use of mobile phones while driving–effects on road safety," 2010): Firstly, drivers have to move their eyes from the road and focus on the mobile phone in order to be able to use it. Secondly, while talking on a mobile phone, even if drivers' eyes are focused on the road, they 'look but do not see'.

Cognitive (Minds off the road): Reflecting on a subject of conversation as a result of talking on the phone – rather than analyzing the road situation). That happens when two mental tasks are happening at the same time. Instead of focusing on driving, drivers focus on the topic of the phone conversation (Dragutinovic & Twisk, 2005). Listening, alone, can reduce activity in the part of the brain associated with driving by more than a third.

Physical (Hands off the steering wheel): When the driver holds or operates a device rather than steering with both hands, or dialing on a mobile phone or leaning over to tune a radio that may lead to rotating the steering wheel)(Brace, Young, & Regan, 2007). Drivers have to use one or both of their hands to hold the phone, dial a number, answer or end a call instead of focusing on the tasks required by driving (e.g. steering, gear changing).

Auditory: Responding to a ringing mobile phone, or if advice is turned up so loud that it masks other sounds, such as ambulance sirens) (M. Regan, 2007). Drivers move their attention to the sound of the mobile phone or conversation instead of sounds from the road environment.

5. Effects of distracted driving

Distraction when driving has a great influence on controlling the driver's vision. In a study by Transport Canada's Ergonomic Division, it has been shown that the visibility of the driver is significantly reduced when using a mobile phone while driving compared to when not in use. (See Figure 2). In addition, in the study of the effects of distracted driving on the human brain by 2013, Smith demonstrated that using the phone while driving causes the brain to receive less images of obstacles on the road than that of when drivers completely focused on safe driving. This notice is clearly shown in Figure 3.

Figure 1: Visible range while driving when not in use and using the phone

Source: Transport Canada's Ergonomics Division

Figure 2: The difference between reality and image is processed in the brain

Source: Du et al., 2013, Smith, 2013

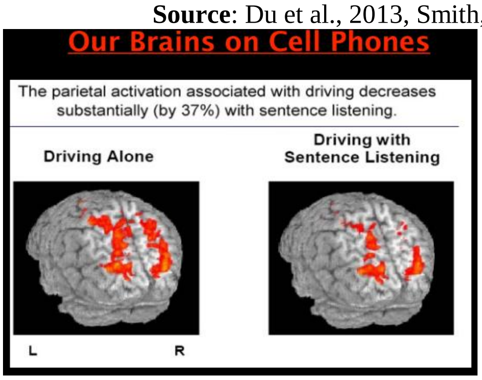


Figure 3: Functional areas of the brain while driving normally and when using the phone while driving

Source: Carnegie Mellon University

Similarly, image 4 shows a clearer illustration of the brain in the processing of information for those two case studies. Whereby, the driving alone shows the data processing area larger than of the driver using the phone. This study was conducted by Carnegie Mellon University.

From the above studies, effects of using mobile phone while driving are undeniable. However, when analyzed from the perspective of driving performance, these effects are shown under the four basic groups presented in Table 3.

Table 1: Effects of distraction on driving causing by mobile phone use

Groups	Effects
Velocity	• Impaired ability to maintain an appropriate speed (i.e. usually driving slower)
Reaction time	• Longer reaction times to detect and respond to unexpected driving-related events (Burns, Parkes, Burton, Smith, & Burch, 2002). • Slower braking reactions with more intensive braking and shorter stopping distances • Slower reactions to traffic signals/missed signals
Safety distance	• Impaired ability to maintain correct lane position • Reduced field of view (i.e. drivers more likely to look straight ahead and not at periphery or in mirrors) • Accepting gaps in traffic streams that do not give sufficient time for the driver to safely maneuver the vehicle into the traffic flow • Shorter following distances
Other errors	• Increased mental workload, resulting in higher levels of stress and frustration • Reduced driver-awareness of what is happening around them.

Source: (M. Regan, 2007)

6. Surveying and evaluating the current use of mobile phones while driving

6.1 Survey locations

To assess the actual using mobile phone while driving a motorcycle, conducting video-based observation and direct observation at 9 locations divided into three areas: urban roads, rural roads and highways in Ho Chi Minh City and Thu Dau Mot city (Binh Duong) are implemented. Traffic flow at Each location was recorded in 120 minutes in 3-time frames: morning (6h30 - 8h30), noon (11h00 - 13h00), afternoon (16h00 - 18h00).

The main purpose of the video recording is to count the total volume of vehicles passing through the survey sections and direct observation is to detect drivers using mobile phone while driving.

Specifically, there are three sub-purposes of the direct observation drivers using the phone while driving:

- Used form: hands-held, hands-free and texting of cell phone.
- Reaction process: vehicle moves normally, vehicle moves to the right lane and slow down, vehicle moves to the right lane and stop.
- Demographic factors: gender, age.

6.2 Characteristics of observation locations

The characteristics of the observation locations are shown in the table below:

Table 2: Characteristics of observation locations

Classification	Locations								
	1	2	3	4	5	6	7	8	9

Road types									
Urban road	•	•	•						
National highway				•	•	•			
Rural road							•	•	•
Location									
Intersection		•				•		•	
Straight road	•		•	•	•		•		•
Types of road									
Mixture	•		•		•		•	•	•
Separate lanes		•		•		•			

Source: Author

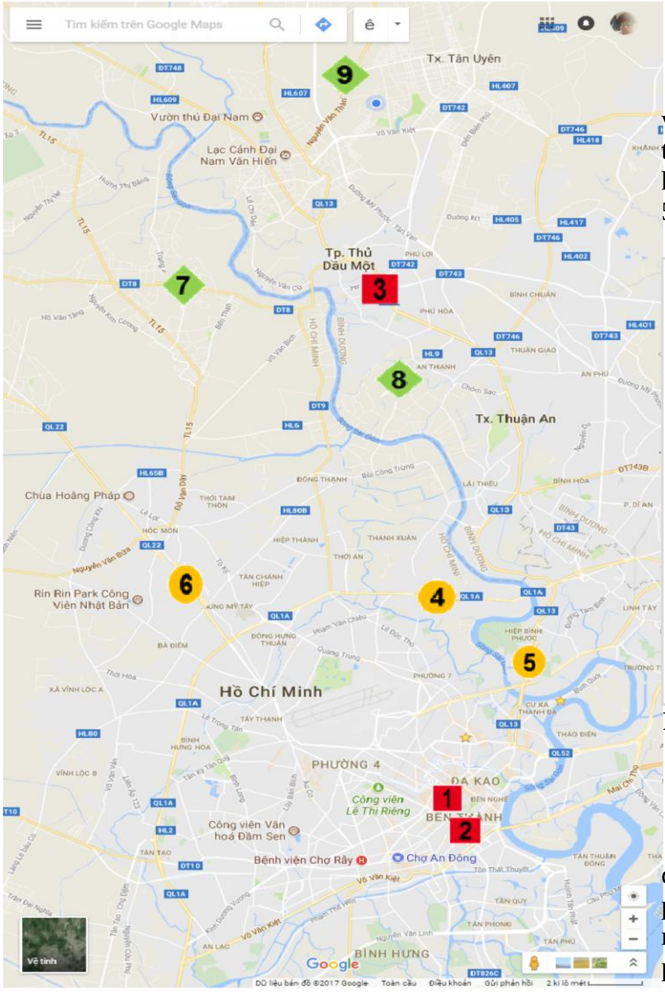


Figure 4: Observation locations

7. Observation results for motorcycle

7.1 Rates of driver using mobile phone while driving

❖ **By region**

The total number of vehicles observed at the survey sites was 210,191 vehicles, of which 50% vehicles (104,700 vehicles) accounted in urban road, 36% in national highways (75,208 vehicles) and 14% in rural roads (30,283 vehicles).

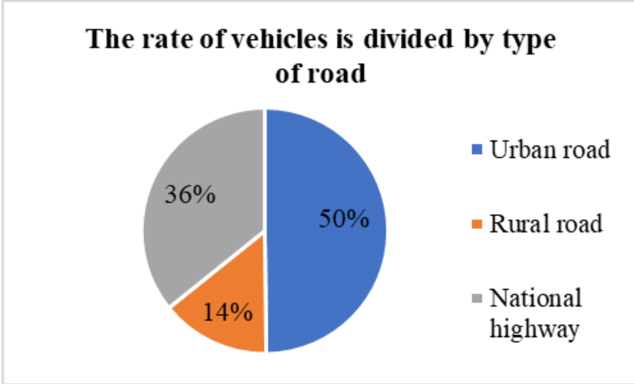


Figure 5: The rate of vehicles is divided by type of road (region)

On average, there are 6.2 people use mobile phone while driving for 1,000 observation vehicles. Of which, the highest number belongs to rural roads with 10.9, highway and urban road with relatively equal numbers of 5.6 and 5.4 respectively.

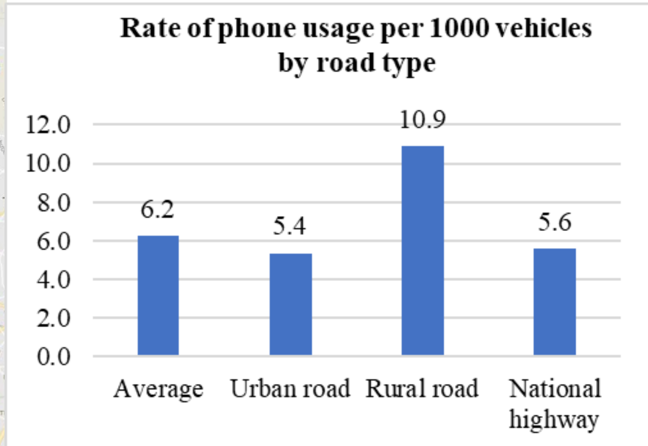


Figure 6: Rate of phone usage per 1000 vehicles by road type

❖ By time frame

The proportions of driver using mobile phone while driving divided by time frame are quite equal. Night peak hour has the highest rate of 39%, followed by morning peak hour with 32%, the lowest rate is noon peak hour at 29%.

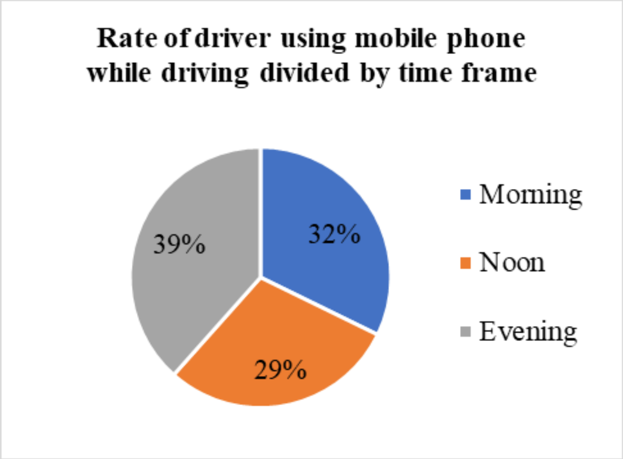


Figure 7: Rate of driver using mobile phone while driving divided by time frame

❖ **By type of vehicle**

In general, motorcycle drivers had the highest using rate of 88.8% (1165 motorbikes), more than 10.6% (139 electric bicycles) are the rate of e-bike using, bicyclists (0.6%, 8 bicycles) rarely use the phone while driving.

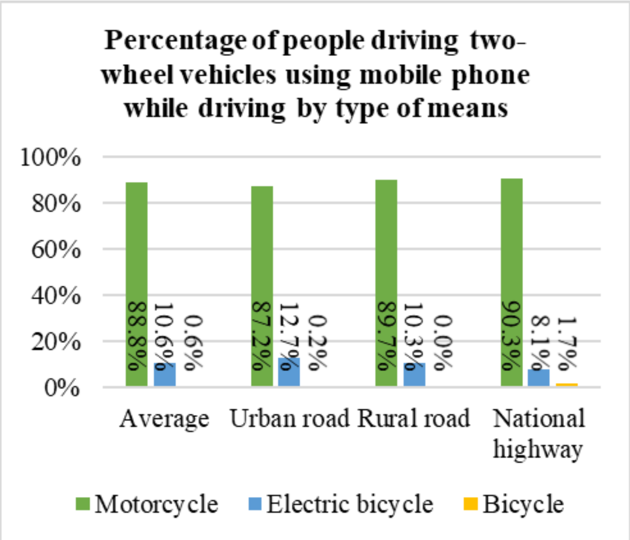


Figure 8: Percentage of people driving two-wheel vehicles using mobile phone while driving by type of means

However, regarding to the relative proportions, electric bicycles have the highest rate of using mobile phones while driving (more than 192 drivers use phones per 1,000 observation vehicles), next is motorbike (5.6) and finally is bicycle (4.8).

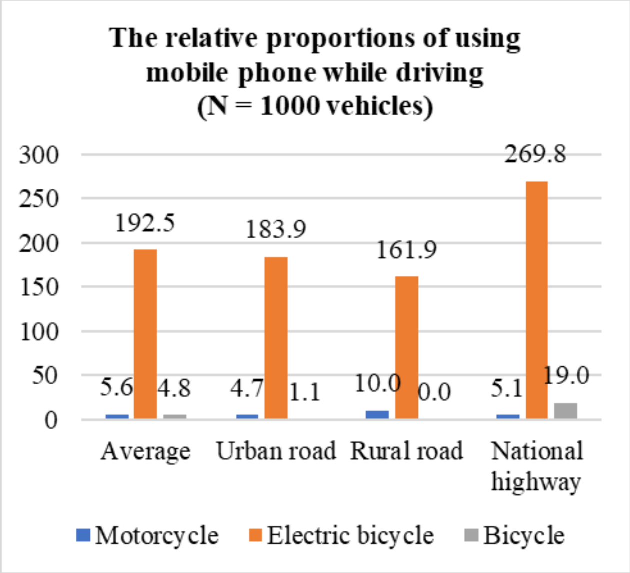


Figure 9: The relative proportions of using mobile phone while driving (per 1000 vehicles)

❖ **By gender**

It was found on the survey that, men use phones 3 times more than women. According to observable data, percentage of men using the phone while driving was more than 76% (995 men) while that of women was only one third, at 24% (317 women).

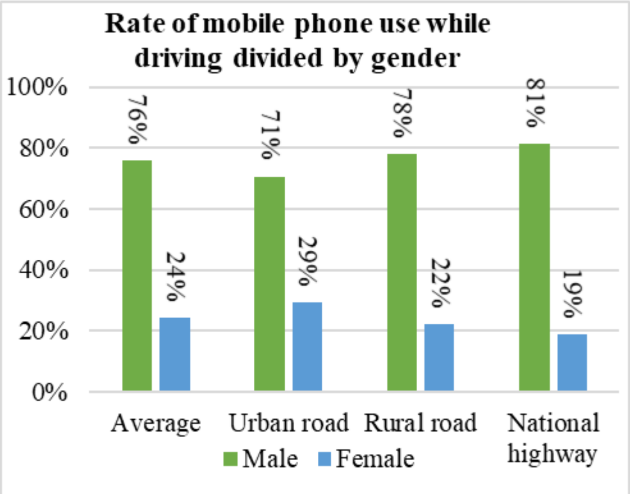


Figure 10: Rate of mobile phone use while driving divided by gender

❖ **By age**

The middle-age driver group (from 25 to 60 years old) has the highest number of mobile phone users, accounting for nearly 84%, while group of less than 24-year-old uses less than one-sixth of that (about 14%), finally, group of older than 60 years old have the smallest rate of phone use while driving (less than 3%).

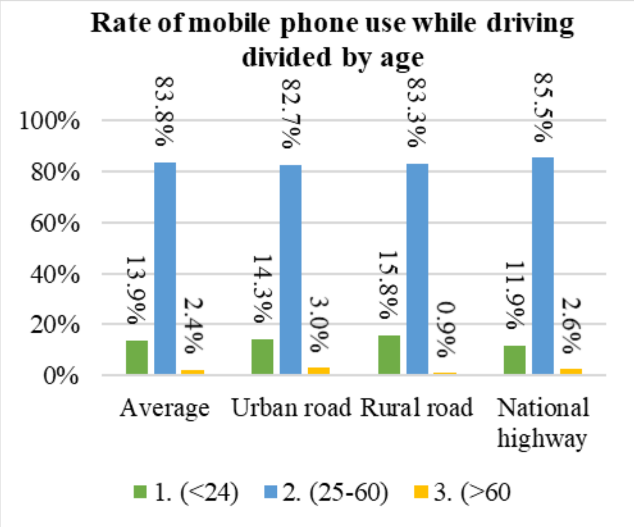


Figure 11: Rate of mobile phone use while driving divided by age

7.2 Forms of using mobile phone while driving

There are 1312 vehicles observed using cell phone while driving, in which the driver with hands-held using while driving was 611 people (46.6%), hands-free was 48 people (3.7%), and texting was 653 people (49.8%).

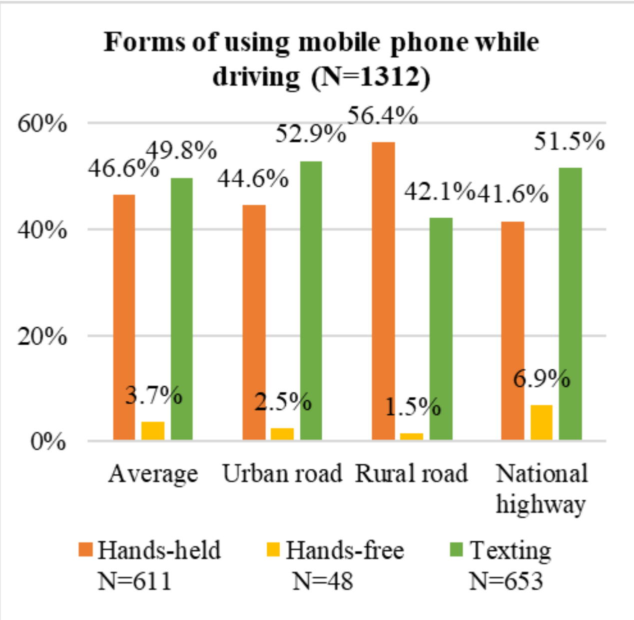


Figure 12: Forms of using mobile phone while driving

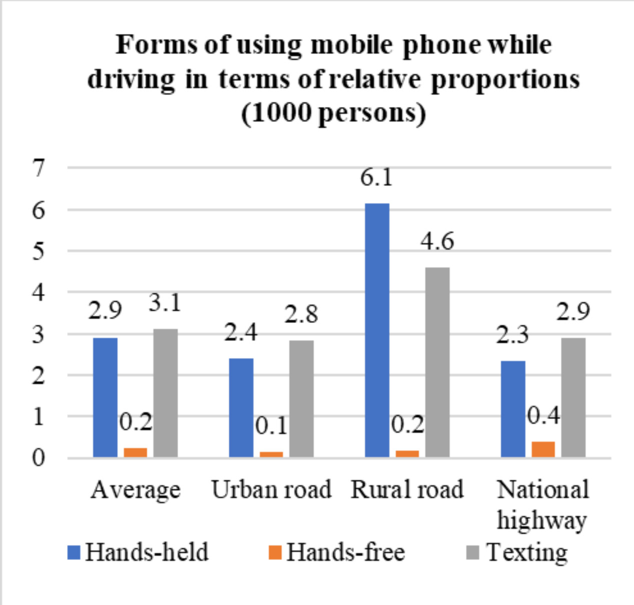


Figure 13: Forms of using mobile phone while driving in terms of relative proportions (1000 persons)

Notably, the forms of using mobile phone while driving in terms of relative proportions (for 1000 people) shows that on average, each of every 1000 people has 3.1 persons texting, 2.9 persons hands-held using and 0,2 persons hands-free using. Particularly, the high rates are found in rural roads in the form of hands-held with 6.1 persons and texting with 4.6 persons.

7.3 Vehicle status while driver using mobile phone

General description of vehicle status while the driver uses mobile phone is presented by 3 behavior groups, which are:

- The vehicle moves normally (the vehicle remains speed, the position of the car is unchanged compare with other vehicles).
- The vehicle moves to right side and slows down (vehicles slow down, change lane, vehicles slower than nearby vehicles).
- The vehicle moves to the right side and stops completely (the vehicle slows down, change lane, pulls the motorcycle to the side and stops).

❖ **Analyze vehicle status while driver using mobile phone regarding to road types**

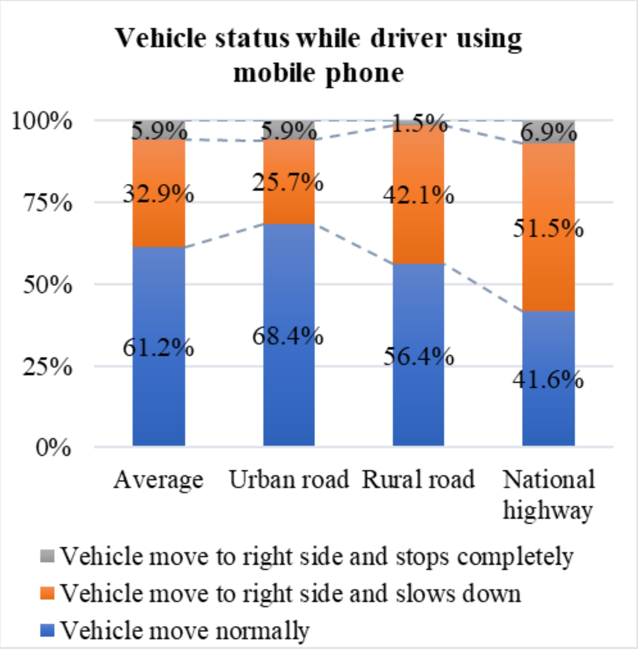


Figure 14: Vehicle status while driver using mobile phone

On average, the highest proportion was accounted for 61% of drivers who still keep the same speed during time they use their phones. Besides, there are more than 32% of drivers shifted to the right side and slowed down while only just approximately 6% of drivers shifted to the right side and stop, which is acclaimed as the most safety method.

Specifically, in urban roads, the majority of vehicles are moving normally while using mobile phones (68.4%), at the highway, most people slow down (51.5%). as well as normal moving (41.6%), however, notably in rural roads, it is rare for people to move to right side and stop completely to use the phone (1.5%).

❖ **Vehicle status regarding to form of phone use**

Hands-held: in 611 cases of drivers use hands-held while driving, the vehicles are mostly either keeping speed or moving to the right side and slowdown, which are nearly equal rates (43% and 49%).

Hands-free: in 48 cases of drivers use hands-free while driving. The number of vehicles moving to the right side and stopping increases compared to 8% of the hand-held but remains low (19%), while the highest rate belongs to keeping the normal speed at 48%.

Texting: 653 cases of drivers texting while driving, surprisingly, 78% of the vehicles were still moving when using phone, meanwhile only 18% moved slowly to the right and 3% stopped to texting.

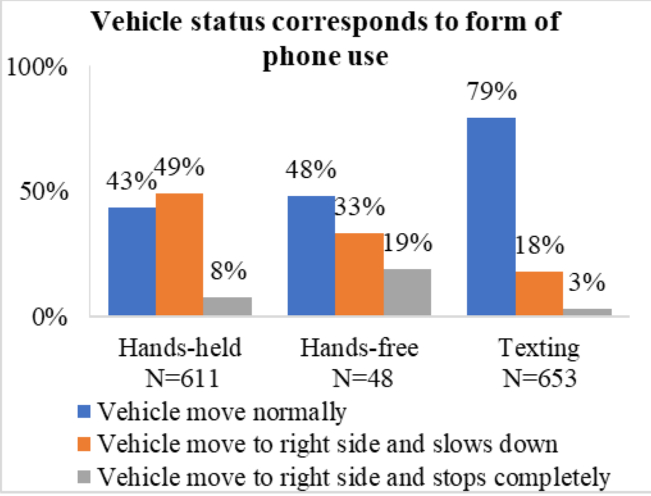


Figure 15: Vehicle status corresponds to form of phone use

8. Conclusion

The current situation in using a mobile phone while driving of motorcycles in the two cities in Vietnam have been summary as follows.

- The number of men using mobile phone while driving is bigger than that of women.
- The age group of using mobile phone is mainly from 25 to 60 years old.
- E-bike is the most common vehicle that driver using mobile phone while driving,
- Rural roads have the most drivers using the phone while driving.
- The most common form of phone use is calling and messaging.
- While using the phone, most drivers stay at normal speed (same speed as high as other vehicles) and only a few stops to call or text.

9. Proposing solutions and policies.

Based on the results of the study and experience of countries in the world, the researcher proposed seven measures to limit the use of mobile phones while driving vehicles in traffic, including:

1. Continuing to maintain the law prohibiting all acts of using the phone in any form while driving.
2. Raising fines for behavior of either phone texting or phone calling enough to deter motorists. In parallel with the administrative penalty, the driver's license must be deprived (according to Decree 46 of the Government on administrative penalties in the field of road and railway traffic from 1 January 2017).
3. Strengthening the patrol and punishment: Traffic police combined with agencies have installed surveillance cameras on the road to extract the image of using the phone while driving for the work of punishment after the driver in violation.

4. Allowing insurance companies to have the right to cancel a driver's insurance policy if the accident is due to use the phone while driving.
5. Raise awareness among people about the harmful effects of phone use while driving through the implementation of educational campaigns and communications. Presenting the analysis results about the possibility of increasing the frequency of traffic accidents by using the telephone while driving, it could be the messages of great power in changing the attitude and behavior of citizens.
6. Improved driving training and driver licensing tests: Provide information to participants about the dangers of using a cell phone while driving, as well as how to drive safely when they intend to use the phone.
7. Encourage the development and use of software tools to limit the use of mobile phones when driving.

10. Acknowledgements

The author is grateful to Professor Dr.-Ing. Manfred Boltze from the TU Darmstadt, Dr. Eng. Vu Anh Tuan, from Vietnamese-German University for reading and commenting on earlier drafts of this manuscript. I also thank MSc. Nguyen Minh Thong for the pleasant discussions during the entirety of my research work. Finally, I would like say thank to five anonymous reviewers for their helps and excellent feedback.

References

[1] Brace, C. ., Young, K. ., & Regan, M. a. (2007). Analysis of The Literature: The use of mobile phone while driving. Analysis, 37, 48. Retrieved from https://www.nsc.org/news_ resources/Resources/Documents/Analysis of the Literature, The Use of Mobile Phones While Driving.pdf

[2] Burns, P. C., Parkes, A., Burton, S., Smith, R. K., & Burch, D. (2002). How dangerous is driving with a mobile phone. Benchmarking the Impairment to Alcohol, 56.

[3] Dragutinovic, N., & Twisk, D. (2005). Use of mobile phones while driving – effects on road safety, 52.

[4] Du, W., Yang, J., Powis, B., Zheng, X., Ozanne-Smith, J., Bilston, L., & Wu, M. (2013). Understanding on-road practices of electric bike riders: An observational study in a developed city of China. Accident Analysis and Prevention, 59, 319–326. https://doi.org/10.1016/j.aap.2013.06.011

[5] Klauer, S. G., Klauer, S. G., Dingus, T. a., Dingus, T. a., Neale, V. L., Neale, V. L., … Ramsey, D. J. (2006). The Impact of Driver Inattention On Near Crash/Crash Risk: An Analysis Using the 100-Car Naturalistic Driving Study Data. Analysis, (April), 226. https://doi.org/DOT HS 810 594

[6] Ranney, T. a. (2008). Driver Distraction: A Review of the Current State-of-Knowledge. National Highway Traffic Safety Administration, (April), 1–32. https://doi.org/ DOT HS 810 787

[7] Regan, M. (2007). Driver distraction: Reflections on the past, present and future. Distracted Driving, 29–73.

[8] Regan, M. A., Hallett, C., & Gordon, C. P. (2011). Driver distraction and driver inattention: Definition, relationship and taxonomy. Accident Analysis and Prevention, 43(5), 1771–1781. https://doi.org/10.1016/j.aap.2011.04.008

[9] Stutts, J. C., Reinfurt, D. W., & Rodgman, E. a. (2001). The role of driver distraction in crashes: an analysis of 1995-1999 Crashworthiness Data System Data. Annual Proceedings. Association for the Advancement of Automotive Medicine., 45(May), 287–301. Retrieved from www.aaafoundation.org

[10] Stutts, J. C., Reinfurt, D. W., Staplin, L., & Rodgman, E. A. (2001). The role of driver distraction in Traffic crashes. AAA Foundation for Traffic Safety, (May), 70.

[11] Use of mobile phones while driving–effects on road safety. (2010). SWOV Institute for Road Safety Research, Retrieved from www.rsa.ie /.../Mobile Phone/RSA_Research_Mobile_ Phones.pdf?%5Cn

A GPS-Based Application For On-Road Emergency Needs Of Drivers

Topic Number: 9 Paper Identification Number: AYRF18-017

Maria Cristine TAN[1], Kathleen Ann DACULLO[2], Max DEL ROSARIO[3], Lance KOA[4], Alexis FILLONE[5], Maria Cecilia PARINIGT[6]

[1]College of Civil Engineering, Undergraduate
De La Salle University - Manila
Telephone (632) 524 4611, Fax. (632) 521 9094
E-mail: maria_cristine_tan@dlsu.edu.ph

[2]College of Civil Engineering, Undergraduate
De La Salle University - Manila
Telephone (632) 524 4611, Fax. (632) 521 9094
E-mail: kathleen_dacullo@dlsu.edu.ph

[3]College of Civil Engineering, Undergraduate
De La Salle University - Manila
Telephone (632) 524 4611, Fax. (632) 521 9094
E-mail: max_delrosario@dlsu.edu.ph

[4]College of Civil Engineering, Undergraduate
De La Salle University - Manila
Telephone (632) 524 4611, Fax. (632) 521 9094
E-mail: lance_koa@dlsu.edu.ph

[5]Department of Civil Engineering, Associate Professor
De La Salle University - Manila
Telephone (632) 524 4611, Fax. (632) 521 9094
E-mail: maria.cecilia.paringit@dlsu.edu.ph

[6]Department of Civil Engineering, Full Professorr
De La Salle University - Manila
Telephone (632) 524 4611, Fax. (632) 521 9094
E-mail: alexis.fillone@dlsu.edu.ph

Abstract

As modernization rapidly grows in the Philippines, the transport sector continuously produces innovations to keep up with this trend. One is the inclusion of the Global Positioning System (GPS) on mobile phones to track the vehicle's current location. Even so, the occurrence of emergencies on road which may vary depending on the situation is still possible. However, due to such technology, the development of an application that can provide help in case of any on-road emergencies is made easier. This study aims to propose a design for a GPS-based emergency mobile application that can locate the nearest establishment that will cater to drivers' on-road emergency needs, and to be able to provide access to information regarding the establishment including its location details. The users will be Filipino citizens. To accomplish the application, preliminary surveys were done to determine the need of the said application; furthermore, the survey also led to the determination of the type of establishments to be inventoried, as well the as preferred features that users deemed to be significant in the usage of the proposed application.

Keywords: Geographic Information System, Mobile application, Emergency application, On-road emergencies

1. General Introduction

Providing the needs of commuters has always been the main goal of the transportation sector. Similarly, for private car users, safety and comfort of the passenger are the top priorities. Most published and even on-going researches are focused on the development of a possible solution to help with the daily needs of people riding private or public vehicles. Meanwhile, on the position of drivers, only a few problems are identified and little efforts are made to solve them since most often than not, conflicting standpoints arise from both of a commuter and/or a passenger, and of a driver. There are countless problematic occurrences that people can encounter while driving such as car malfunctions, car accidents and it could also something as simple as the driver's own needs.

Almost all of the driving population have experienced an on-road emergency; whether this may come as driver-related emergency or vehicle-related issues, the occurrence such emergencies may cause accidents and fatalities. Here in the Philippines, A television shows=, entitled "Ang Pinaka", the top 10 most common causes of road accidents, wherein mechanical malfunction and driver errors, including distracted, drowsy and hurried drivers, fall into 7th and 1st place, respectively[1]. With this in mind, on-road emergencies should be prevented immediately to minimize accidents and fatalities.

On-road emergencies, whether almost always or seldom occurring, the researchers believe that there is a need to provide a feasible solution that will cater to the needs of the drivers during such situations. With the emergence of different mobile applications that uses GPS in order to locate places, as well as people, it would be a good option to consider and to apply in the development of a design of a GPS-based application that would help in situations wherein drivers who are experiencing an on-road emergency, and are not familiar with the location of a certain area, would easily locate the establishments that would cater to their needs.

With this, the researchers aim to design a mobile application that would provide immediate assistance to drivers in the event that they encounter these emergencies. The application can serve as a bridge to connect drivers to all nearby establishments that can cater to their needs by directing them on where to go or who to call in a short amount of time. Traffic caused by car accidents and car malfunctions can be also minimized with immediate and adaptive responses of establishments that can provide assistance to the driver's needs due to the application's functions. In addition, this innovation can be widely used by many application developer due to the rise of smartphone usage. The GPS-based application can also help boost business establishments in the city especially small businesses that are private and secluded provided that they contribute to the application. Meanwhile, this study can be beneficial to both the government as well as businessmen as the results of this study can be used to assess the availability and accessibility of the different establishments that cater to the on-road emergencies of drivers. Moreover, this study can be of use to other researchers in such a way that they can utilize the data and results of this study should they pursue a related study which can also help the public.

2. Literature Review

2.1 Application Development

One of the most crucial portion in the development of an application is its design stage. The reason behind this is due to the fact the actual design of the application would encompass the user interface, which is the space where interactions between human and machines occur. A study[2] was conducted related to designing mobile applications for emergency response. With the aim to propose several findings about how to design effective and efficient mobile emergency notification applications, the said paper presented a study on similar applications for identifying both limitations and common features. According to the study[2], considering that modern mobile devices embed several sensors such as GPS receivers, Wi-Fi, accelerometers or cameras, the main findings on the two main aspects of emergency applications which are the content and interaction were: (1) the possibility to automatically retrieve the user position with the use of embedded GPS, and (2) the usability as the focus of the interface considering situations where other factors as fear or panic come into play.

2.2 Similar Emergency Applications

Similar to what the researchers visualize on how the GPS-based tracker would work, a study[3] on a location-based emergency medical assistance system using OpenStreetMap (OSM) where the health care centers are mapped by taking the waypoints of them is considered as a possible reference. Additional information on the proposed location-based emergency medical assistance system is that it is comprised of a database as a central server of the detail information of the health care centers and that in order to access the said information, android devices must have the application installed[3]. The application would show markers of health care centers, as well as the distance between the current location of the user and location of the nearest health center which are all calculated using haversine formula[3].

Google maps is there to help locate any particular location, landmarks and more; however, there is an application for smartphones which can help users find the nearest hospitals, clinics, and health service centers at and around any particular location which is called the Hospital Finder[4]. Hospital Finder is a lot helpful users wouldn't have to deal with other listings such as restaurants, banks, stations, etc. aside from hospitals and other health centers. Similar to Hospital Finder, the researchers would like to narrow down the scope of their proposed application to locations of establishments that will cater to the most common on-road emergencies encountered by drivers here in the Philippines. One of the advantages of Hospital Finder, apart from giving the users all the locations of hospitals, clinics and healthcare centers around his or her location, the users get the option to call the phone number given in the listing directly on the application. Furthermore, the application has the feature that allows the users to minimize and maximize the radius of where it would look for the necessary establishments[4].

2.3 Quantum Geographic Information System (QGIS)

Considering the purpose of the application which is to provide the users the nearest establishment that would cater to their on-road emergency needs, obtaining geographical information on the different establishments, as well as the roads within the study area to which users would pass. Along the studies of the OpenStreetMap (OSM), a study[5] ascertained that frameworks for data evaluation are inaccessible. Taking that into account, their study introduces an extension to the Quantum GIS (QGIS) processing toolbox and utilizing it to create different scripts to manage geographical data. QGIS is an accessible source of the GIS software that applies an object-oriented Python foundation named the processing toolbox. The processing toolbox can enhance the effectiveness and efficiency of present algorithms[5].This would help analysts and researchers determine the integrity of the geographical data using inherent parameters that can give the most convenient workflow designs.

3. Methodology

3.1. On-Road Emergencies

To be able to proceed with the study, an assumption that on-road emergencies exist was first made by the researchers. In order to validate the said assumption, a preliminary survey was conducted. The respondents of the survey were asked to rate the emergencies based on how often they experience them. Included in the choices were some of the assumed on-road emergencies involving the driver such as sleepiness, urge to go to the restroom, and hunger. Also included were the emergencies involving the vehicle such as flat tires, empty gas tank, dead battery, and overheating engine. The emergencies mentioned in this survey were obtained from a reviewed literature and thorough discussion among the researchers as to what are the possible emergencies encountered by the drivers. The result of the survey is shown in Fig. 1.

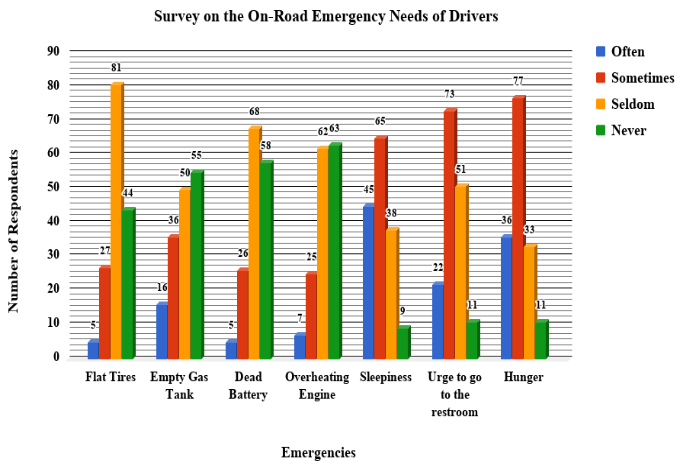


Fig 1. Results of preliminary survey related to on-road emergency needs of drivers

3.2. Application Features

The main objective of this study is to develop a GPS-based smartphone application design that can cater to the on-road emergency needs of drivers. First, the on-road emergencies and establishments related to the emergencies to be tackled in this study came from related literatures as presented in Table 1. In choosing the type of establishments to include in the application, the researchers looked into the services offered by the establishments to determine whether that particular type of establishment would be of help to the users in there emergency. On the other hand, the features and information that the application possessed and displayed were determined through a sample survey, wherein the respondents ranked the proposed features of the application, which were obtained from reviewing applications related to the study.

Table 1. List of on-road emergencies tackled in the study

	On-road Emergencies	Type of Establishments
Involving drivers	Hunger	Restaurant, Fast Food, Coffee Shop, Convenience Store, Bakery, Eatery
	Urge to go to the restroom	Restaurant, Fast Food, Coffee Shop, Gas Station, Motel/Hotel
	Sleepiness/Fatigue	Coffee Shop, Motel/Hotel, Convenience Store
Involving vehicles	Flat tires	Gas Station
	Transmission breakdown	Auto Repair Shop
	Overheating engine	Gas Station
	Empty gas tank	Gas Station
	Brake malfunction	Auto Repair Shop
	Broken air conditioner	Auto Repair Shop

3.3. Establishment Mapping

The establishments were located on QGIS using an OSM layer within the area of study - a particular portion of Malate and Ermita, as shown in Fig. 2. The researchers focused on the said area of study to map out the establishments to have a more manageable data in developing this initial study. The area considered is bounded by Roxas Boulevard, President Quirino Avenue, Singalong and Pablo Ocampo Street; however, when the researchers did a preliminary inspection of the area, it was discovered that some types of establishments were not in the study area. Therefore, the study area was extended to Apacible and General Luna Street.

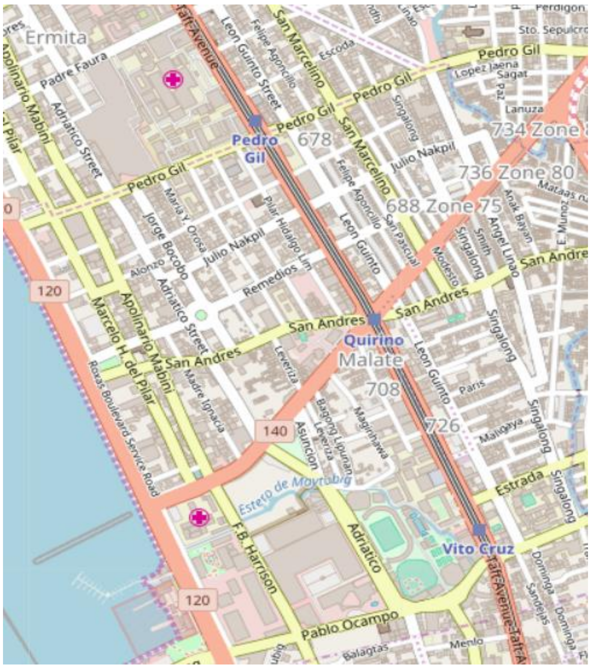


Fig. 2. Area of study
Source: www.OpenStreetMap.org

On the other hand, a detailed process of how establishments were mapped in QGIS were summarized in Fig. 3. First, the OSM layer was overlaid in QGIS using the OpenLayers plugin. This map layer was also used for the application itself. A new Shapefile layer was created, wherein a point vector was established and named. The required fields or attributes were the information that the respondents wanted to be appear in the application, including the x and y coordinates of the establishments. With this, the establishments were located on QGIS with the aid of Google Maps, Google Street View and OpenStreetMap.

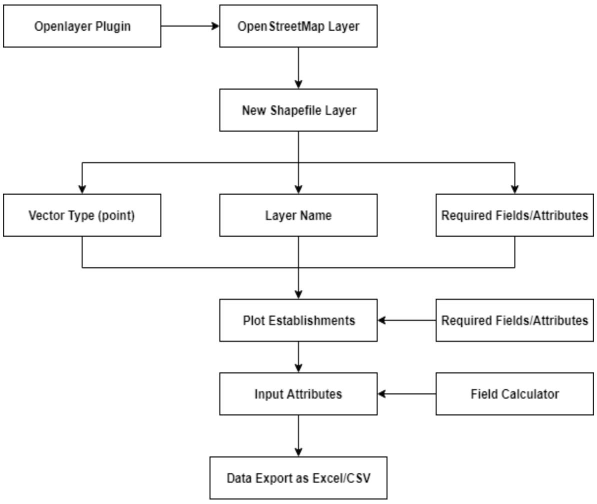


Fig. 3. Establishment mapping in QGIS

3.4. Travel Time Data Collection

3.4.1 Road Network Mapping

Prior to travel time data collection, the road network of the study area was mapped using Equilibre Multimodal, Multimodal Equilibrium (Emme4) to introduce turns on each intersection with corresponding penalties. Moreover, the roads were according to their function and lanes to group the segments and collect travel time data based on the classification

3.4.2. Travel Time Data

The travel time data was supplied for each road classification was collected using the floating car method. Additionally, the said method was proceeded with during the morning, off and evening peak of weekdays (excluding Monday morning and Friday evening), and weekends. Afterwards, the travel time was all converted to speed and translated to a speed distribution curve, wherein the standard deviation for each sample data set were checked using the following equation:

$$N = \left(\frac{t_{\alpha} x \sigma}{d}\right)^2 \quad (1)$$

and the Kolmogorov-Smirnov (K-S) test was done, wherein the maximum difference between the empirical cumulative distribution function (cdf) and the theoretical cumulative distribution function was compared to the critical value obtained from the K-S table, which depends on the number of samples, to determine whether the empirical speed distribution curve follows a normal distribution.

$$D = sup|F(x) - S_n(x)| \quad (2)$$

3.5. Application Development

3.5.1 Requirement Modeling

The purpose of the study is to help users find an establishment that will cater to their on-road emergency needs. The functional requirements are to locate nearest establishments offering the necessary service/s and help users. In a requirements modeling, the Input-Process-Output (IPO) model is needed to illustrate the inputs and the processes it will take to come up with outputs.

IPO for Mobile Application

1. INPUT: User coordinate
2. PROCESS: The application will detect the nearest establishment
3. EXPECTED OUTPUT: View the nearest establishment and its information

If the application process is successful, it will show the nearest location of the establishment and provide the fastest route to it.

4. Results

4.1 Application Features

To provide a functional and user-friendly application to the user, various applications related to the proposed application were explored to provide the possible features that were asked in the survey. Google Forms was the platform utilized to collect survey responses to ascertain the possible application features and information to be displayed in the mobile application and from this survey, there were a total of 165 respondents.

In the survey form, wherein the respondents were asked about the possible features and information to be displayed on the application, the respondents have the liberty to check all the options that they think are suitable. For the possible application features, Fig 2. provides the summary of features and the number of respondents that chose a particular option. The percentage of responses with respect to the total were also presented and 80% was the set cut-off percentage for the researchers to integrate a feature to the application.

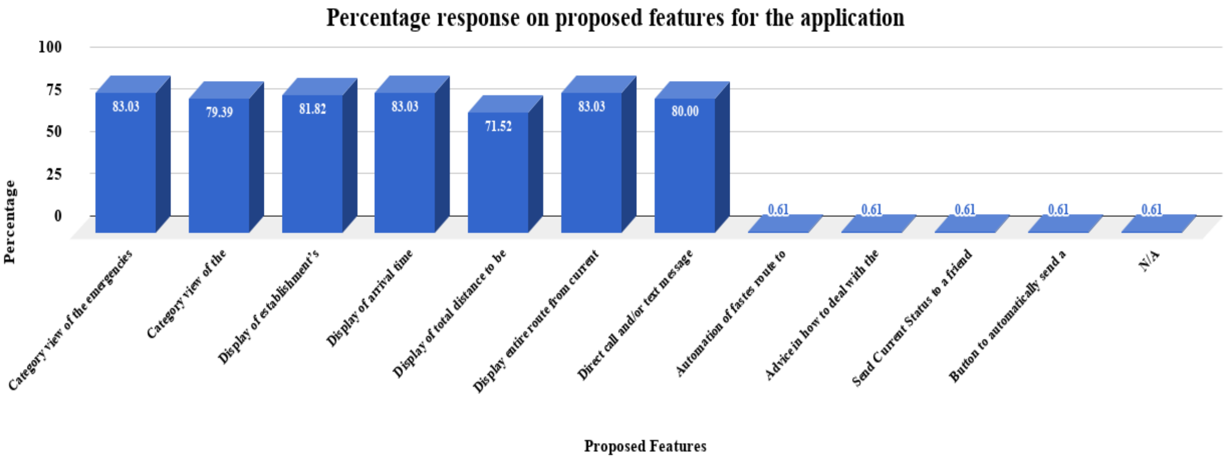


Fig. 4. Results of the proposed features survey of the mobile application

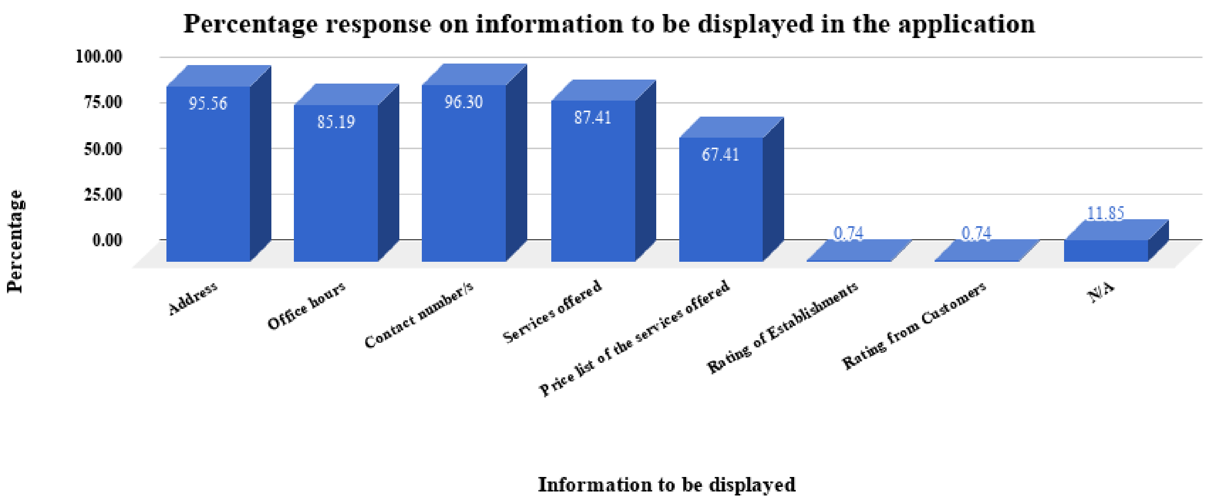


Fig. 5. Results of the information to be displayed on the mobile application

Meanwhile, if the people chose the feature that displays the establishment's information upon choosing an establishment, the next question was required to be answered by them. Since there were only 135 respondents that chose the said feature, it is only sensible that the total number of respondents choosing the options under this question must not exceed 135 also. However, upon collating the results, the tally of some options for this question exceed 135 respondents. With this, the researchers double checked the results, retallied, and presented the final results in Fig. 4 and 5.

With this, the application features would include category view of the emergencies, display of establishment's information, display of arrival time, display entire route from current location to the chosen establishment, and direct call and/or text message while the information to be displayed are the address, open hours, contact numbers, and services offered.

4.2. Establishment

Given the classifications of establishments based on the emergencies tackled in this study, all the establishments were mapped in QGIS with all the information included as attributes for the establishments, which were based on the information that the users want to see in the application. One of the information required to be displayed is the services offered of the establishments and this information are based on the typical services that the researchers assumed.

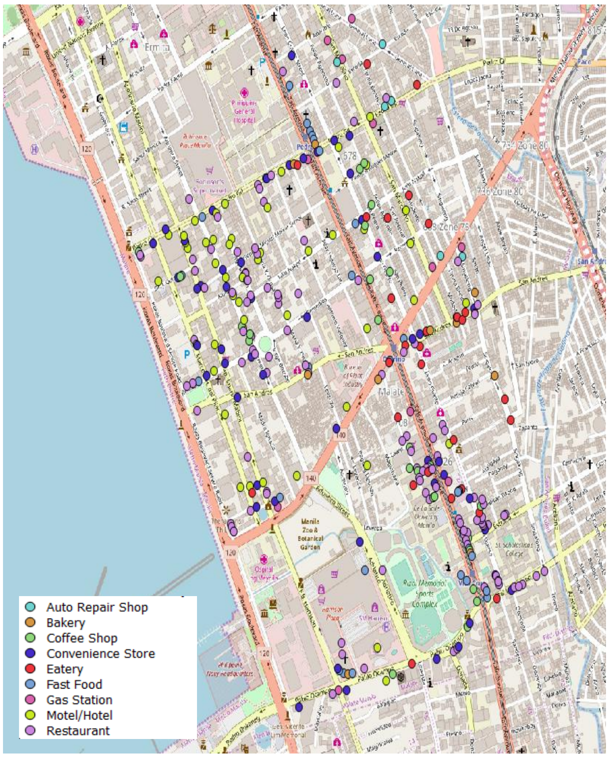


Fig. 6. Mapped establishments in QGIS

The count for the total number of establishments within the study area that were plotted was 327. Considering the type of establishment, there were 6 auto repair shops, 4 bakeries, 6 bakeshops, 27 coffee shops, 51 convenience stores, 30 eateries, 27 fast foods, 11 gas stations, 49 motels/hotels, and 116 restaurants.

4.3. Road Network and Travel Time Data

When the roads were mapped using Emme4, the study area had a total of 277 nodes and 521 links. The road segments were also classified into 7 classifications.

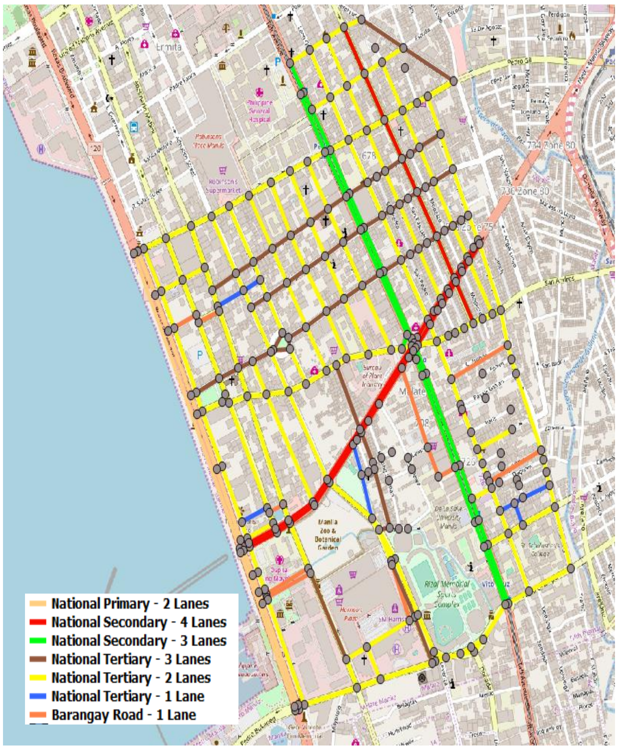


Fig. 7. Road classification

Subsequently, the travel time data collected for morning peak (MP), off peak (OP) and evening peak (EP) for weekdays and weekends were converted to speed for the speed distribution curve to be generated by constructing a frequency table.

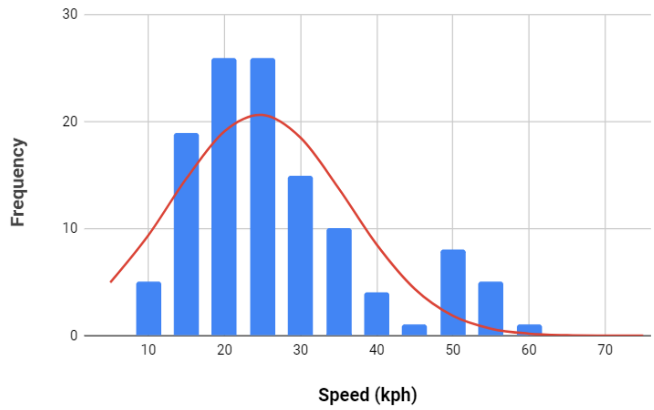


Fig. 8. Speed distribution curve for national primary roads with four lanes during the weekday morning peak

It is to be noted that the roads with only 1 lane have a sample size of 60 while the others have 120. The standard deviation for each classification and time period was compared with the accepted value computed using Equation 1. For a sample size of 60, the accepted value for the standard deviation is 19.355 and for a sample size of 120, the accepted value is 27.607.

Simultaneously, the empirical and theoretical cumulative distribution function for each frequency table was calculated and compared with the critical K-S value from the table. All the results were summarized in Table 2.

Table 2. Summary of values for travel time data

Road Classification	Number of Lanes	Time Period	No. of Sample	Accepted Standard Deviation	Kscritical	Weekday			Saturday		
						Mean	Standard Deviation	KSmax	Mean	Standard Deviation	Ksmax
National Primary	4	MP	120	27.607	0.124	24.553	11.592	0.118	21.167	8.009	0.1
		OP	120	27.607	0.124	21.536	10.069	0.04	22.208	7.866	0.086
		EP	120	27.607	0.124	17	10.175	0.112	7.643	1.339	0.069
National Secondary	4	MP	120	27.607	0.124	22.381	12.716	0.058	15.527	4.212	0.117
		OP	120	27.607	0.124	20.324	12.92	0.078	19.261	6.808	0.091
		EP	120	27.607	0.124	11.137	8.268	0.121	12.947	5.291	0.075
	3	MP	120	27.607	0.124	19.236	8.225	0.072	10.604	5.939	0.066
		OP	120	27.607	0.124	12.316	4.989	0.071	20.765	7.018	0.069
		EP	120	27.607	0.124	13.637	7.812	0.106	13.062	5.381	0.067
National Tertiary	1	MP	60	19.355	0.175	41.41	17.213	0.159	19.153	9.77	0.125
		OP	60	19.355	0.175	20.224	11.493	0.075	10.637	5.625	0.163
		EP	60	19.355	0.175	12.386	4.453	0.045	13.767	4.836	0.067
	2	MP	120	27.607	0.124	22.584	15.609	0.109	14.034	4.182	0.11
		OP	120	27.607	0.124	32.33	18.045	0.048	18.218	6.339	0.035
		EP	120	27.607	0.124	18.622	13.71	0.105	17.442	5.553	0.038
	3	MP	120	27.607	0.124	11.48	8.399	0.081	18.743	7.405	0.036
		OP	120	27.607	0.124	18.097	9.554	0.121	20.268	9.578	0.062
		EP	120	27.607	0.124	13.913	10.461	0.11	16.639	6.978	0.031
Barangay Roads	1	MP	60	19.355	0.175	13.996	5.497	0.062	10.452	5.78	0.115
		OP	60	19.355	0.175	20.939	11.74	0.048	13.923	4.089	0.081
		EP	60	19.355	0.175	22.476	15.677	0.136	10.251	3.567	0.063

4.4. Application

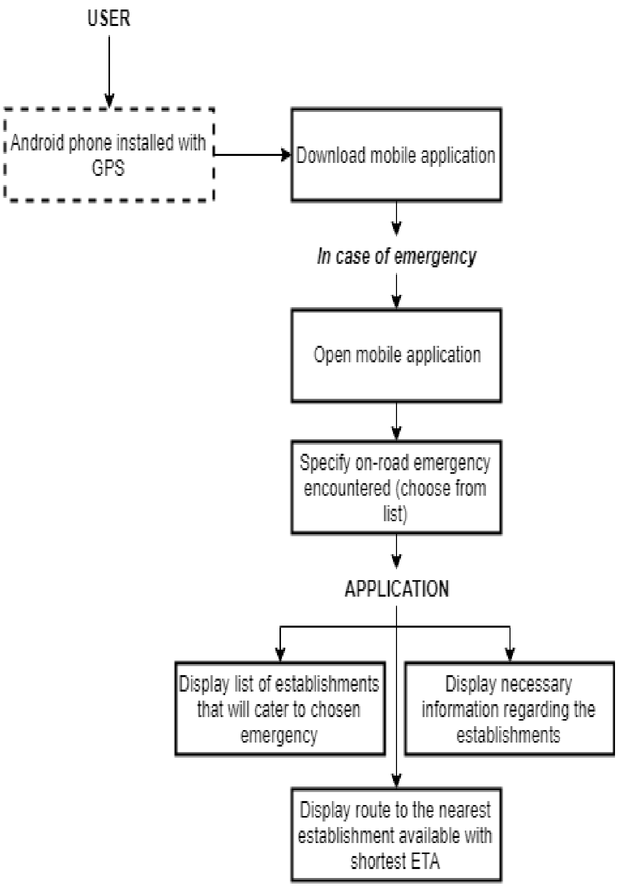


Fig. 9. Application flow diagram for users

5. Conclusion/Discussion

5.1. Application Features

From the results presented, the features to be included on the application are a category view of the emergencies, display of establishment's information, display of arrival time, display entire route from current location to the chosen establishment, and direct call and/or text message while the information to be displayed are the address, open hours, contact numbers, and services offered. On the other hand, 97% of the respondents think that the application would be of help to the community, which supports further the significance of the study.

5.2 Establishments

Based from the count of the establishments according to its type, it was observed that almost 50% of the establishments situated within the area were restaurants alone; thus, problems of drivers with regards to hunger and their urge to go to the restroom can easily be catered by the said establishment type. It was also observed that there is an abundance of other establishments that would cater the drivers' needs of sleepiness through convenience stores, coffee shops, and motels/hotels. However, establishments that offer services for autos which includes gas stations, vulcanizing shops, and auto repair shops, only constitutes 5% of the entire establishment count.

5.3 Speed and Travel Time Data

As seen on Table 2, the values of the standard deviation and the $KS_{critical}$ were accepted for all classifications and time periods, which means that the distribution curves all follow a normal distribution. With this, the application will get a random speed value for a particular road classification within a time period, $\pm 3\sigma$ from the mean.

References

[1] GMA News Network (2012). "Ang Pinaka" top 10 most common causes of road accidents. Retrieved October 8, 2017 from http://www.gmanetwork.com/news/newstv/angpinaka/267871/ang-pinaka-top-10-most-common-causes-of-road-accidents/story/.

[2] Romano, M., Onorati, T., Aedo, I. & Diaz, P. (2016). Designing mobile applications for emergency response: Citizens acting as human sensors. Retrieved December 3, 2017 from https://pdfs.semanticscholar.org/5ad0/bbf2f9a34bde7002e40086e99eb21c7ffd55.pdf

[3] Das, R., & Alam, T. (2014). Location based emergency medical assistance system using OpenStreetMap. Retrieved October 9, 2017, from http://users.cis.fiu.edu/~talam005/ICIEV14.pdf

[4] Bhawani, C. (2012). Hospital finder app for Android – Helps find hospital based on location. Retrieved December 3, 2017 from http://androidadvices.com/hospital-finder-app-android-helps-find-hospital-based-location

[5] Sehra, S., Singh, J. & Singh Rai, H. (2017, April 21). Assessing OpenStreetMap Data Using Intrinsic Quality Indicators: An Extension to the QGIS Processing Toolbox. Retrieved October 20, 2017,from http://www.mdpi.com/1999-5903/9/2/15/html

Perspectives of the use of GPS in travel survey: Research on identification of missing trips in a GPS pilot survey in Hanoi

Topic number: 2. Paper Identification number: AYRF2018-018

Thanh Tu NGUYEN

Faculty of Transport Economics,
University of Transport and Communications, Hanoi, Vietnam
Telephone +84 989-194-794, Fax. +84 243-766-4053
E-mail: thanhtunguyen.utc@gmail.com

Abstract

GPS-based data collection methods have become particularly popular in travel behavior research, mainly because of the worldwide coverage and the accuracy of the GPS system. This paper identifies the missing trip data obtained by two methods survey reported and GPS recorded in the same days. This study shows that the GPS survey can be used successfully to complete the conventional transport surveys, but it is still too early to predict the complete substitution of conventional survey by the GPS mobility survey.

Keywords: Missing trips, GPS, travel diary, logit model, comparison

1. Introduction

Travel survey methods based on new technologies have evolved in the past few decades, shifting from limited experiments to large-scale travel surveys. GPS-based data collection methods have become particularly popular in travel behavior research, mainly because of the worldwide coverage and the accuracy of the GPS system.

A challenge in the GPS data post-processing is the development of methods to fill GPS missing data and to reconstitute automatically continuous sequence, both in space and time. The results obtained from the post-processing software are calibrated by comparison with conventional methods, particular a few questions when getting back the GPS device, providing for a few trips, taken at random, additional information on the reliability of the device and on more detailed characteristics (mode, purpose and accompanying persons).

The primary objective of this paper is to compare survey-reported trips and GPS-recorded trips for the same individuals to identify the reasons for differences between two sources of data. It could be from the household, individual or travel reasons. Based on these results, we could evaluate the contributions and challenges of travel data collected by GPS in travel survey. Besides, if we could identify the influencing factors on missing trips, the quality of travel survey data will be improved.

To give full information, first, this paper introduces some statistics about both data sources. In which, the percentage of the missing trips by different characteristics are investigated. It means that all the trips recorded by GPS but not reported by respondents and the reported trips with no GPS trace are concerned in this step. Further, these missing trips are modeled using a logit model to estimate the variables that affect the difference between the survey-reported and GPS-recorded trips, without making any a priori assumptions about the accuracy of the data from each source. This finding could be useful in further researches in order to the quality of travel data collected by GPS or by travel diary. The data of this study was collected in Hanoi.

This study has two limitations. First, this paper accepts the self-selection bias and the representativeness of the sample caused by the limited acceptability by some group of respondents. Second, the GPS-recorded trips were derived by algorithms that were developed by IFFSTTAR/DEST (Yuan, 2010) and we don't know whether similar studies using different algorithms would find similar results.

The remainder of this paper is structured in 4 parts. The next one provides a summary of using GPS in travel survey. Section 3 introduces an overview of the GPS pilot surveys in Hanoi city. Section 4 presents the factors influencing missing trips from two survey methods. The final section summarizes the important findings and some recommendations for the travel survey methods by both travel diary and GPS.

2. GPS technology in household travel surveys

In recent years, GPS technology has been increasingly used in travel survey research in order to evaluate and to improve the travel data reported by diary. All modes of transport, particularly walking and transit have been provided the opportunity to begin collecting GPS data. In fact, two large-scale travel survey by GPS have been conducted in Cincinnati and Jerusalem.

As a main tool to collect the travel data, the comparison between GPS-recorded trips in comparison with the respondent-reported trips is very important. The travel survey by GPS was conducted for the first time in 1997 in Austin - Texas (Casas and Arce 1999) and since then there are several studies on the use of this technology in travel survey. GPS data show firstly the rate of missing trips obtained from conventional methods (by CATI, CAPI, face-to-face or self-administrated). This is a significant shortfall considering that household travel surveys are used for transport modeling and planning. From data of six surveys using CATI and GPS in the US from 2001 to 2004, Wolf (2006) has shown that the rate of missing trips can be from 11% to 35%. However, the first experiment was only on car trips, which facilitated the performance of GPS at a time when the capacity of batteries was very limited. In the research of Forrest and Pearson (2005), they showed that in a CATI household travel survey in Laredo, Texas only 44 percent of trips recorded by a GPS were able to be successfully matched with a trip reported by CATI. By combining GPS and a prompted recall survey, Stopher et al. (2007) found that the rate of non-reported trips was only 7.4% but they ignored all the trips non-recorded in the GPS for some reasons (forgetting to wear, no satellite signal, etc.).

Besides the comparison between travel data by GPS and diaries, many studies try to identify the key factors characterizing the under-reported trips. Zmud and Wolf (2003) identified key demographic factors that may contribute to misreporting of trips. It is particularly the case for individuals younger than 25 years old with low income. Household size and household income are also significant factors of trip reporting accuracy. They noted that the highest reporting accuracy at 63% for single-member household and lowest reporting accuracy at 31% for two-member family. Generally, higher income groups tend to have higher reporting accuracy. Bricka and Bhat (2006) have found that young adults (less than 30 years of age), men, individuals with less than high school education, unemployed individuals, individuals working in clerical and manufacturing professions, workers employed at residential, industrial, and medical land-uses, and individuals in nuclear families are all more likely to under-report trips than other respondents. Houston et al. (2014) have similar findings in their research. They have found that participants who were older, had a lower education, lower household income, or were employed, were associated with the trip under reporting. In another research, Bricka et al. (2012) divided the trips into work and non-work for identifying the factors influencing the difference in survey-reported and GPS recorded. Education levels, employment characteristics (full time or part-time) and household income are the main significant variables of their model.

In addition to demographics, travel behavior characteristics have influenced on reported missing trips. Wolf (2000) claims that short duration trips are often forgotten or omitted. The travel purpose and the number of trips undertaken on the survey day also have impacts on reported missing trips, Forrest and Pearson (2005) found that home-based non-work and non-home-based trips are more significant for missing trips in Laredo, Texas. Bricka and Bhat (2006) and Stopher et al. (2007) found that individuals with high mobility level tend to under-report their travel. The factors influencing survey trip under-reporting were also examined by the travel data from the St. Louis household travel survey and the same findings from 2001 Los Angeles travel survey (Nustats, 2003,2004). By comparing the average vehicle and person trip rates, Pierce et al. (2003) also estimated trip under-reporting and found that trip under-reporting was more related to low-income households. In addition, discretionary trips were found to be more likely to be under-reported than non-discretionary trips. With the introduction of lighter-weight wearable GPS devices, a lot of household travel survey used this devices for recording trips, not only in the US (Giaimo et al., 2009) but also in other countries (Bohte and Maat 2009) ; (Ohmori et al. 2006); (Bellemans et al. 2008); (Kochan et al. 2006). In the household travel study conducted in Western Cape, South Africa, Krygsman and Nel (2009) found that significant under-reporting of trips and tours originate from home and work. Besides, trips with shorter time duration and trip distance for visits and picking up or dropping off a passenger were more likely to be under-reported.

Besides trip under-reporting, the situation where the GPS unit recorded fewer trips than that reported by respondent, has been studied by some researchers. Wolf et al. (2003) looked for the reasons why the GPS trips were missed in comparison with the trip diaries. Forrest and Pearson (2005) found some level of higher reporting from survey diaries than recorded through GPS units. The lack of power for GPS, cold-start, mis-recording due to the loss of signal are the main reasons of this situation. Stopher and Shen (2011) also found that another reasons for the trip not being recorded in the GPS but being reported in the survey data, are the forgetfulness of respondents and the GPS device problems. Besides, the trips undertaken at early morning or late evening, are easier to be under-recording by GPS units. More details, (S. G. Bricka et al. 2012) have examined the differences in measures of intensity of travel between survey and GPS trips for two trip purposes (work and non-work purposes). They found that the GPS survey should be considered as the data collection method for the younger, more technology experiences and have high travel propensities but for the elderly and more leisurely travelers, the traditional survey method is recommended.

In summary, GPS devices are increasingly being used to collect travel data in many countries. Among them, in the US, the resulting GPS-recorded trips seems to provide a better picture of true trip-making patterns than do survey-reported trips. This study does not evaluate better survey method between GPS recorded and travel diary reported, but to examine the factors influencing the number trip collected by two methods.

3. Data information and descriptive

The travel surveys were conducted in Hanoi city using two main tools at the same time: a wearable GPS devices and a travel diary self-reported. The methodology is mentioned as follows: all participants - who are author's relatives, friends, neighborhoods, and colleagues - were asked to wear the GPS on all their trips during one week. They were also asked to report their trips in the diary at the end of the day. 95 respondents accepted for the pilot survey. The data collected includes start time, end time, mode of transport, travel purposes and travel distance. The household information and personal socioeconomic characteristics were self-reported. The personal information was: age, gender, educational level, occupation, income, motorcycle/car driving license, the taste and frequency for driving. In order to remind the participants to always wear the GPS during their trips, text messages have been sent to them every early morning and late evening.

The data recorded by the GPS includes GPS ID, latitude, longitude, date, time and speed. At the first step, a rule-based algorithm developed by IFSTTAR/DEST was used for identifying trip (Yuan, 2010). The trip identification procedure as follows: a program was run to remove all burden points and create trip ends where the GPS device was stationary for 120 seconds or more. The dwell time is 120s suggested by (J Wolf 2000) based on the traffic signal cycle at an intersection is always less than 120s according to the US Highway Capacity Manual. The second program was run that created trip information, including origin, destination, distance, starting time, end time, and trip duration. All identified trips were exported to one data table saved as .csv format.

In the travel survey test in Hanoi, we collected data from 95 participants with 1150 matched trips among 1872 reported-trips and 1680 GPS-recorded trips.

Table 1 Number of matched and un-matched trip in France and Vietnam

Number of trip	Matched	Un-matched	Total	Missing (%)
By Diary	1150	722	1872	39%
By GPS	1150	530	1680	32%

Source: GPS survey in Hanoi

The missing percentage of a survey reported and GPS recorded trips is 39% and 32%. Table 2 shows the distribution of missing trip by the different group of respondents, in which, we divided the missing trips into 2 groups: (1) missing trips in travel diary i.e. the trip recorded in GPS but did not report in travel diary; (2) missing trips in GPS, i.e. the trips reported in diary but no trace in GPS.

The socio-economic variables of respondents were divided into 2 groups:

- Demographic factors: sex, age, job characteristics (full time or part-time), motorization (0-1-2 and 2+), health conditions (good, medium, bad);
- Travel characteristics: number of trip, trip distance, departure time, travel purpose, mode of transport, travel day - the day of the week that travel was recorded.

Table 2 Personal characteristics and travel behavior in 2 surveys

	GPS	Travel diary
Total trips	1680	1872
Nb. of missing trips	530	722
% missing trips	32%	39%
Gender		
Male	33%	33%
Female	31%	45%
Age		
<30 years	27%	36%
30-50 years	35%	48%
>50 years	50%	36%
Employment status		
Full time	33%	38%
Part-time	24%	40%
Not employed	33%	40%
Motorization		
0	21%	46%
1	33%	40%
2	21%	22%
2+	NA*	NA
Health conditions		
Good	28%	40%
Medium	32%	30%
Bad	71%	47%
Nb. of trip/day		
1-2	14%	39%
3-4	24%	43%
5-6	34%	39%
6+	43%	26%
Starting time		
Before 9h	18%	41%
9h-11h30	30%	40%
11h30-14h00	40%	47%
14h -17h	42%	38%
17-21h	33%	33%
21-24h	39%	26%
Trip purpose	NA	
Home	#	40%
Shopping	#	61%
Entertainment	#	28%
Professional	#	26%
Others	#	53%
Trip modes	NA	
Bus	#	23%
Bike	#	60%
Walk	#	42%
Moto/Car	#	40%
Others	#	49%
Trip distance		
< 2 km	50%	59%
2- 5 km	21%	36%
5-10 km	26%	33%
> 10 km	17%	24%
Day of trip		
Weekday	30%	38%
Weekend	39%	40%

Source: GPS survey in Hanoi

In terms of demographic, younger people tend to record more trip by GPS than the elderly. This finding was confirmed by (Bricka et al., 2012) in their research of factors influencing differences in survey-reported and GPS-recorded trips.

In term of mobility, the person with high travel frequency tends to miss more trips by GPS than those who travel less (e.g. 43% missing GPS trips for people making more than 6 trips per day, compared to 14% for those making 1-2 trip per day). The trip distance seems also to have an influence with 50% missing trips under 2km while this percentage is only 17% over 10km in the survey.

The elders are more likely to have diary missing trips, people who is more mobile (from 30 – 50 years old), has more missing trips. When people are more mobile and make longer trips, rather for work or education than for shopping or personal purpose, the number of the missing trips is lower. In this paper, we forgot the factor of speed when studying the GPS trips, but the study of (Thao, 2015) found that this unmatched rate is the greatest (77%) for speeds below 7km/h which correspond to "Walk". The reasons would be the omission of important events by the respondent or a wrong imputation of the mode of transport by GPS post-processing. This is the same result when we compare with diary missing trip, the respondent would forget the non-motorized trips (the missing rate is 60% by bike and more 40% on foot in both surveys).

4. Factor influencing missing trips

To identify the factors influencing missing trip, a logit binary model was used, in which the dependent variable is the possibility of missing trip (i.e. Yes - No), include: (i) the GPS missing trips and (ii) diary missing trips. The independent variables are demographic and travel behavior of the respondents. By using a logit binary regression (logistic regression), the dependent variable could be estimated. The independent variables could be one or more nominal, interval or ratio level measurement.

By comparing the survey reported trips and survey recorded trips, 3 trip types were identified:

- Diary missing trips: trips recorded by GPS but not reported in the travel diary
- GPS missing trips: trips reported in the travel diary but no recorded by GPS
- Matched trips: trips recorded by GPS and also reported in the travel diary.

4.1 Identification of GPS missing trips

The GPS missing trips are trips reported in the travel diary but have not been detected by GPS devices. We previously counted 1872 trips in the travel diary, in which 722 trips missing data in GPS. To better understanding the factors influencing GPS missing trips, we use a binary logistic regression with the dependent variable is GPS missing trip (yes/no). The independent variables are characteristics of households, personal information and travel behavior.

Table 3 shows the factors influencing GPS missing trips. Trip distance, number of trips per day, mode of transport and starting time were significant variables.

Table 4 shows the odds ratio when matching survey trips and GPS trips, it is the percentage of the GPS missing trips of each groups compared with the reference group.

Table 3. Factors influencing GPS missing trips

Variables	DF	Wald Khi-2	Pr > Chi -2
Trip purpose	4	.	.
Trip distance	3	107.60	<.0001
Nb. of trips per day	3	11.26	0.0104
Respondent occupation	7	.	NS
Household types	4	.	NS
Gender	1	.	NS
Healthy situation	3	.	NS
Motorization level	3	.	NS
Mode of transport	6	39.62	<.0001
Starting time		29.19	<.0001

Source: GPS survey in Hanoi

NS: Non - significant

Table 4: Odds ratios for matching survey trips and GPS trips

Variables	Odds ratio	95% Confidence	
Starting time			
Before 9h	0.35	0.20	0.64
9h-11h30	0.81	0.46	1.44
11h30-14h00	0.79	0.44	1.41
14h -17h	1.03	0.60	1.77
17-21h	0.81	0.49	1.36
21-24h	Reference		
Trip distance			
< 2km	4.32	2.91	6.55
2- 5km	2.13	1.53	2.96
6-10km	1.62	1.17	2.24
>10km	Reference		
Number of trips per day.			
1-2	1.49	1.09	2.02
3-4	1.55	1.18	2.03
5-6	1.25	0.93	1.68
>7	Reference		
Modes of transport			
Bus	0.62	0.04	10.87
Walk	0.32	0.02	5.36
Car	0.26	0.01	4.68
Taxi	0.29	0.01	5.32
Bike	0.21	0.01	3.55
Motorcycle	0.13	0.01	2.50
Other	Reference		

Source: GPS survey in Hanoi

Trip distance has an important impact on GPS missing trips: the percentage of missing trips under 2km is 4.372 times higher than for trips over 10km. The second factor is the trip frequency: the more trips are undertaken per day, the higher the GPS missing trips is. The mode of transport is the third factors. In table 4, for "Trip Mode", we choose factor "Others" like Reference. We find that the odds rate is the highest for bus trips and the lowest for the motorcycles. It means that the respondents would remember well the motorcycle trips. They tend to forget the trips by bus or walk.

4.2 Identification of reported missing trips

The reported missing trips are those detected by GPS but were not reported in the travel diary. As shown in table, 530 trips omitted among 1680 GPS recorded trips. For a better understanding the reason for these trips, we estimate a binary logistic regression on each survey.

Table 5: Factors influencing reported missing trips

Variables	DF	Wald Khi-2	Pr > Chi -2
Number of GPS trips	3	41.69	<.0001
Duration of GPS trips	1	7.83	0.0051
Distance of GPS trips	3	33.38	<.0001
Starting time	5	20.92	0.0008

Source: GPS survey in Hanoi

Table 6 provides the detail of significant variables of reported missing trips. Among the influencing factors of missing trips in the diary, the number of trip is the most important factor. Individuals who make frequent trips tend to have more reported missing trips: the ratio of reported missing trips is 10 times lower for a day with 1-2 trips than for a day with 7 trips or more. Travel duration is also one of the factors: the rate of reported missing for trips under 5 minutes is 11.918 times higher than for trips over than 60 minutes. The personal occupation has only a light impact: employees and retired persons have more reported missing trips. Besides, the start time could have a light influence: trips started early in the morning (from 5h00 to 9h00) are more usually reported.

Table 6: Odds ratio for matching GPS trip and survey trips in Vietnam

Variable/Item	Odds-ratio	Pr > Khi-2
Departure time		
Before 5:00	NS	0.2831
5:00 - 9:59	0.621	<.0001
9:00 - 11:59	1.274	0.3497
2:00 - 16:59	2.078	0.2656
17:00 - 20:59	1.334	0.9145
After 21:00	Reference	
Travel distance		
< 2km	2.643	1.885
2- 5km	0.948	0.0031
6-10km	1.434	0.7295
>10km	Reference	
Number of trip per day		
1-2	0.301	<.0001
4-3	0.52	0.3638
5-6	0.686	0.0933
>= 7	Reference	
Trip duration		
< 5 min.	11.918	<.0001
5 to 15 min.	6.221	<.0001
15 to 30 min.	3.733	0.5999
30 to 60 min.	1.911	0.0003
> = 60 min.	Reference	

Source: GPS survey in Hanoi

4.3 Comparison between GPS recorded trip and survey reported trips

After identifying factors influencing the missing trips, we compare the matched-trips i.e. those were recorded by GPS and also reported in the travel diary.

Table 7: Comparison GPS trips and reported trips

Absolute difference	%
Departure time	
From 0 to 2 minutes	19%
From 2 to 5 minutes	23%
From 5 to 10 minutes	21%
More than 10 minutes	37%
Arrival time	
From 0 to 2 minutes	35%
From 2 to 5 minutes	21%
From 5 to 10 minutes	16%
More than 10 minutes	28%
Travel duration	
From 0 to 2 minutes	20%
From 2 to 5 minutes	22%
From 5 to 10 minutes	22%
From 10 to15 minutes	14%
More than 15 minutes	20%
Travel distance	
From 0 to 0.5km	28%
From 0.5 to 1.0km	16%
From 1-2km	20%
From 2-5km	23%
More than 5km	13%
Total	100%

Source: GPS survey in Hanoi

The results in table 7 shows the absolute difference of trips collected by 2 methods. The result shows that:

- The departure time reported in the diary is earlier than that recorded by GPS for about 70% of trips. In which, the difference exceeds 10 minutes is for 37%.

- The difference for ending time is lower than for departure time, in which 28% of the difference in ending time between these surveys is more than 10 minutes. The smaller difference for ending time than for departure time may be due to the *Time necessary to first fixe* (TTFF) that is a measure of the time required for a GPS receiver to acquire the satellite.
- People tend to over-estimate the travel duration (Noble, 2001; Hubert, 2003), i.e. the reported duration is longer than GPS recorded. This research presents similar results: the reported travel duration is over-estimated for about 80% of trips.
- The travel distance reported in the diary is usually greater than travel distance recorded by GPS but the difference is usually less than 5 km (87% of trips).

5. Conclusion

The paper aimed at two main objectives. First, it examined the influencing factors for the missing trips by using a logistic regression. Secondly, it analyzed the differences in the characteristics of travel for matched trips. The findings from this research can inform both survey-reported as well as GPS-recorded travel data collection approaches.

In terms of missing trips (non-recorded as well as non-reported), trip distance and the frequency of trip making are the main influencing factors: there are more unmatched for short trips and for days with a high number of trips. Male, those are an employee or retired are the more likely unmatched trip.

For matched trips, departure time, arrival time, trip duration and trip distance were compared between diary and GPS. Because of cold start, the departure time recorded by GPS is generally later than that reported in the diary, while there is less difference between the two measurements for arrival time. Trip duration and trip distance are over-estimated in the diary for about 80% of trips, but the difference is usually less than 15 minutes or 5km.

Overall, there is a large difference in the measurement of daily mobility between GPS recorded and survey reported trips. These results suggest that improvements are needed in both methods to yield more accurate and un-biased data. So we recommend that the GPS-only survey should be conducted with caution. Future research could involve the development of more complex choice models to explain other margins of transport choice (e.g. the decision to own a car). Furthermore, the travel survey by GPS only should strongly consider to develop the algorithms to impute trip purpose. In addition, the GPS seems to be a method dealing the younger, more technology savvy individuals as well as those that have high travel propensities or characteristics associated with trip chaining, in order to ensure that all trip details are recorded. However, for the elderly and more leisurely travelers, the traditional survey method is recommended.

6. Acknowledgment

The author would like to thank the support of the French Institute of science and technology for transport, spatial planning, development and networks (IFSTTAR) and the colleagues at the Laboratory "Economic and Social Dynamics of Transport" for their precious contributions and comments.

References

[1] Bellemans, Tom, Bruno Kochan, Davy Janssens, Geert Wets, and Harry Timmermans. 2008. "Field Evaluation of Personal Digital Assistant Enabled by Global Positioning System: Impact on Quality of Activity and Diary Data." *Transportation Research Record*: Journal of the Transportation Research Board 2049 (1): 136–43. https://doi.org/10.3141/2049-16.

[2] Bohte, W., and K. Maat. 2009. "Deriving and Validating Trip Purposes and Travel Modes for Multi-Day GPS-Based Travel Surveys: A Large-Scale Application in the Netherlands." *Transportation Research Part C*: Emerging Technologies 17 (3): 285–97.

[3] Bricka, Stacey, and Chandra Bhat. 2006. "Comparative Analysis of Global Positioning System-Based and Travel Survey-Based Data." *Transportation Research Record*: Journal of the Transportation Research Board 1972 (1): 9–20. https://doi.org/10.3141/1972-04.

[4] Bricka, Stacey G., Sudeshna Sen, Rajesh Paleti, and Chandra R. Bhat. 2012. "An Analysis of the Factors Influencing Differences in Survey-Reported and GPS-Recorded Trips." *Transportation Research Part C*: Emerging Technologies 21 (1): 67–88.

[5] Casas, J., and C. Arce. 1999. "Trip Reporting in Household Travel Diaries." presented at the Presented at the 78th *Annual Meeting of the*

Transportation Research Board, Washington D.C, January.

[6] Forrest, T., and D. Pearson. 2005. "Comparison of Trip Determination Methods in Household Travel Surveys Enhanced by a Global Positioning System." *Transportation Research Record 1917* (1): 63–71.

[7] Houston, Douglas, Thuy T. Luong, and Marlon G. Boarnet. 2014. "Tracking Daily Travel; Assessing Discrepancies between GPS-Derived and Self-Reported Travel Patterns." *Transportation Research Part C*: Emerging Technologies 48 (November): 97–108. https://doi.org/10.1016/j.trc.2014.08.013.

[8] Kochan, B., T. Bellemans, D. Janssens, and G. Wets. 2006. "Dynamic Activity-Travel Diary Data Collection Using a GPS-Enabled Personal Digital Assistant." *In AATT.* Chicago, Illinois, USA.

[9] Krygsman, S., Nel, J.H., 2009. The use of global positioning devices in travel surveys – a developing country application. In*: Proceedings of the 28th Southern African Transport Conference*, Pretoria, South Africa.

[10] Ohmori, N., M. Nakazato, K. Sasaki, K. Nishii, and N. Harata. 2006. "Activity Diary Surveys Using GPS Mobile Phones and PDA." *TRB 85th Annual Meeting* Compendium of Papers CD-ROM, 2006.

[11] NuStats, 2003. Household Travel Survey Final *Report of Survey Results*. East-West Coordinating Council, St. Louis.

[12] NuStats, 2004. Year 2000 Post-census Regional Travel Study, GPS Study Final Report. *Southern California Association of Governments,* Los Angeles.

[13] Nakazato, M., Harata, N., 2005. GPS mobile phone-based activity diary survey. *Proceedings of the Eastern Asia Society for Transportation Studies.*

[14] Pierce, B., Casas, J., Giaimo, G., 2003. Estimating trip rate under-reporting: preliminary results from the Ohio household travel survey. In: Presented at the 82nd *Annual Meeting of the Transportation Research Board*, National Research Council, Washington, DC.

[15] Stopher, P., and L. Shen. 2011. "An In-Depth Comparison of GPS and Diary Records." In *https://trid.trb.org/view/1148676.*

[16] Stopher, Peter, Camden FitzGerald, and Min Xu. 2007. "Assessing the Accuracy of the Sydney Household Travel Survey with GPS." Transportation 34 (6): 723–41. https://doi.org/10.1007/s11116-007-9126-8.

[17] Wolf, J. 2000. "Using GPS Data Loggers to Replace Travel Diaries in the Collection of Travel Data." *Dissertation,* Georgia Institute of Technology, School of Civil and Environmental, 58--65.

[18] Wolf, J., M. Loechl, M. Thompson, and C. Arce. 2003. "Trip Rate Analysis in GPS-Enhanced Personal Travel Surveys." In *Transport Survey Quality and Innovation*, 28:483–98. Amsterdam : Oxford : Elsevier.

[19] Wolf, Jean. 2006. "Applications of New Technologies in Travel Surveys." *In Travel Survey Methods*, 531–44. Emerald Group Publishing Limited. https://doi.org/10.1108/9780080464015-029.

[20] Yuan, S. 2010. "Méthodes d'analyse de Données GPS Dans Les Enquêtes Sur La Mobilité Des Personnes - Les Données Manquantes et Leur Estimation." Paris: Université Paris 1 Panthéon-Sorbonne.

[21] Zmud, J., and J. Wolf. 2003. "Identifying the Correlates of Trip Misreporting – Results from the California Statewide Household Travel Survey GPS Study.", Lucerne.

[22] Wolf, J. (2006) Applications of New Technologies in Travel Surveys, in: *Travel Survey Methods.* Emerald Group Publishing Limited, pp. 531–544.

Practical Approach for Improving Safety of School Transport in Thailand

Paper Identification number: AYRF 2018 - 019

Thanachart PALIYAWATE

Part-time Lecturer, Faculty of Humanities and Social Sciences
Phranakhon Rajabhat University, Bangkok, Thailand
Telephone 0-81480-0186, Fax. 0-2391-7984
E-mail: poppy_mom@yahoo.com

Abstract

This paper aims at studying problems and obstacles of provision of safe school transport in Thailand and finding practical means to improve safety of school transport in Thailand based on automotive engineering, legal and management approach. This paper is made as a result of qualitative research, mainly from documentary analysis, in-depth interview and a quasi-focus group discussion. The research tackles situation that passengers/pupils are taking risk of being in fatal traffic accidents at all times, as those unlicensed and modified PHVs in various types used for school transport are hazardous by their unsafe physical condition, nature of utilization and drivers' qualification despite existing safety requirements by law. Based on the safe system approach and international pillars of action for road safety i.e. safe vehicle, road user behavior and road safety management, the research finds unsupportive and impractical mechanism for compliance with all specification and safety standard, effective management of school transport i.e. insufficient technical and financial support, less public attention and lack of appropriate management point. The writer suggests technical support and funding for provision of safe PHVs, stricter enforcement of the DLT regulation on PHVs against substandard structure, component and equipment, overloading, misuse of vehicles and disqualified drivers, setting up a joint committee to assign management point/focal point, to provide financial support from local administrative organizations and to support and expand setting up multi-lateral school transport network.

Keywords: School bus, school transport, safety, private hire vehicles, provision of education

1. Introduction

Children and parents do struggle for access not only into formal education and extensive education but also opportunity of routine safe transport to and from school. In general, nationwide provision of school bus is limited and standardized school bus that ensures safe transport is scarcely available as well as public bus services are poor in respect of area coverage and sufficiency.

A number of parents, commonly, do not have alternative means of safe transport for their children, particularly those who are in shortage households and remote areas. The children have to travel by challenging modes of transport between home in distance and school located in downtown/city. They take school transport by the private hire vehicles ("PHVs") which are personal car/private-owned or local people-owned vehicles (between 8-12 seats) including van, pickup truck, six-wheeled truck/Songthaew with cushion seats, roof and standard safety equipment.

The Road Safety Group Thailand's report unveiled the statistics* that, in 2017 at least 30

accidents occurred in relation to school transport by all type of vehicles, the unlicensed PHVs that mostly resulted 7 pupils dead and 386 pupils injured or in average at least one pupil got injury by school transport in each day (Jardbandista, 2018, p.2),

According to Land Transport Department, number of PHVs applied for registration of the vehicle of school transport is very less in comparison to all PHVs being in actual service all over the country. A number of PHVs' bodies are modified to supply space or load passengers (pupils) as many as possible and are also not improved to comply with safety standard. Those PHVs' structure and component do not meet safety standard or legal requirement (Jardbandista, 2018, p.2) such as being obsolete, incomplete and unsecured, aside from misuse.

In addition, their drivers sometimes cause nervousness and danger, as they may be unhealthy, ineligible for driving or may leave and lock children in PHVs unknowingly or negligently for long time. The drivers hold different type of motor vehicle license, or otherwise do not hold any driving license.

Besides, nowadays those children/pupils have to ride routinely motorcycle allowed by their parents, although they do not qualify to ride it by age of below 15 and to apply for the motorcycle rider license. They also take a private hire motorcycle for transporting them to and from school under the fact that riding motorcycles is a common mode of transport for Thais everywhere.

The main question is how to improve safety of school transport in Thailand by means of automotive engineering, legal and management, as those unlicensed and modified PHVs in various types and motorcycles used for school transport are hazardous by their unsafe physical condition, nature of utilization and drivers' factor despite existing safety requirements by law. The passengers/pupils are taking risk of being in fatal traffic accidents at all times.

This paper aims at 1) studying problems and obstacles of provision of safe school transport in Thailand; 2) studying principles, guideline and best practices of Thailand and foreign countries by safety engineering, legal and management approaches; and 3) suggesting practical improvement of the safety of school transport in Thailand.

2. Literature review

Gibson (2015) stated students who get to school in their own vehicles or ride with others. This is considered the most dangerous form of transportation to or from school. In fact, students are 50 times more likely to arrive to school alive if they take the bus than if they drive themselves or ride with friends, according to the American School Bus Council. European Commission (2004) indicated also in a final report on road safety in school transport that travelling by bus or coach appears to be by far the safest mode. Statistics suggest that a child travelling by car is seven times more likely to take part of being involved in a road traffic casualty than a child travelling by bus.

Deng, F. and Kurgan, G. (2012) pointed out many countries establish a regulatory framework to govern bus design, driver qualifications, and motorist behavior around schools and school buses.

Regulations in Australia, Belgium and Germany require school buses to use warning signals to alert traffic when a school bus is about to load or offload school children and traffic must reduce speeds. New Zealand has set a maximum speed limit of 20km/h around school buses, in Japan and the United Kingdom vehicles are required to drive slowly when passing a school bus. Vigorous enforcement of regulations is essential. In the United States, local, state, and school officials work with law enforcement entities to enforce traffic safety laws around buses, bus routes, and in school zones.

Jardbandista, (2018) indicated that public buses provide service only along the route of concession and may not pass the pupils' home. In addition, the buses take more time with any passengers hop in and get off the buses, being not able to control the time. The situation of public buses has become worse because the operators cannot improve the service quality since they encounter negative result of operation such as less passengers, discontinued transportation, more competitors, more payment for concession fee, loss, etc. The public buses are unlikely to be the main choice of the pupils' travel to and from the school in many areas and many provinces as well as the number of public buses in provincial tend to diminish.

Wongtienthana (2018) indicated that existing regulations do not facilitate management of safe school bus and bring about loss. Related regulations include:

1) A Ministry of Interior's ordinance (2004) on finance and audit of local administrative organization ("LAO") that does not clearly provide an authority of LAO to disburse or commit binding financial obligation in relation to provision of school bus;

2) A Ministry of Education's ordinance (1993) on supervision of the use of school bus that merely provides a duty of school operators to ensure safety of picking-up and dropping-off pupils but does not determine a duty of management of the travel or school transport;

3) A guideline of Department of Land Transport ("DLT')'s registrar (2016) on permission to make use of the vehicle utilized for school transport that such vehicle's specification, equipment and nature of utilization must meet safety requirements for transporting passengers and the school's certification is required. For obtaining DLT's permission, the owners' expenditure is high and not worthy in calculation with income obtained from engaging the school transport.

3. Methodology

This paper is developed by qualitative research, mainly from documentary analysis of secondary data i.e. news, statistics, report, research paper. The research also includes in-depth interview and discussion with primary data i.e. informants who are teachers, students in secondary level and transport operators participating in a seminar namely "Policy on Management of Standard and Safety for School bus" which is equivalent to a focus group discussion together with other participants from concerned government agencies, delegates of international organization, road safety network, civil society and foundation.

The writer collects such information to synthesize and analyze pursuant to 3 objectives especially in order to answer the research's main question on how is practical ways of improving safety of school transport based on 3 approaches i.e. safety engineering, legal and management. To suggest practical improvement of the safety of school transport in Thailand, the writer considers basic elements of road traffic or transport system which relates to automotive and safety engineering principle i.e. vehicle, driver, road and environment. The safe system approach and international five pillars under Decade of Action for Road Safety 2011-2020 are kept in mind as a main principle and methodology in the study. The study focuses on three of such five pillars are in connection with actions for safe school transport i.e. (1) Road safety management (lead agency strategy, target and funding); (2) Safe vehicles (safety engineering and standard and roadworthiness) and (3) Road user behavior (speed management and qualified/licensed). The research also focuses on domestic and foreign best practices of safety engineering, legal and management approaches.

4. Results

The writer finds nature of school transport, problem and obstacle as well as good practice of foreign countries in provision of safe school transport in Thailand as detailed in these following findings: 1) Tackling unsafe PHVs and school transport and regulatory framework; 2) School transport in connection with provision of education and government support and 3) Good practices of the provision of safe school transport in Thailand

4.1 Tackling unsafe PHVs and school transport and regulatory framework

Modes of school transport by road in Thailand mainly comprise with the following 4 groups of vehicles.

The first group, **school bus** which are a vehicle having yellow/black color, entrance and exit at its body's side, safety belts in every seats (optional), categorized in registration no. 40 under the Land Transport Act B.E. 2522 ("LTA"), so called **"school bus"**, owned or managed by the school to transport pupils to and from the school, fulfill safety standard of both vehicle and driver in pursuance with legal requirements.

Although the registered school bus can assure safety of the school transport in equivalent to safety standard of school bus in developed countries, huge amount of money must be spent by the school for its procurement, management, maintenance and qualified driver. The utilization of school bus for other business is limited. As a result, registration of school bus is minimal.

Fig. 1 The public bus registered under LTA

The second group, **public buses**, as for current public transportation system, are categorized in registration no. 10 or 30 under the Land Transport Act B.E. 2522 ("LTA"). Service of public buses is usually provided along the route or limited to implement concession contractual obligations made with the state agency. It is widely known their service may not cover all areas, not pass or address into sub-soi/alley and where are location of a number of pupils' home. In addition, the buses take more time with any passengers hop in and get off the buses, being not able to control the time. Thus, pupils may not reach the school on time and their parents may not trust or have reliance on travel by public bus. The situation of public buses in many routes has become worse since they encounter negative result of operation such as less passengers, discontinued transportation, more competitors, more payment for concession fee, loss, etc. Public buses are unlikely to be main choice of the pupils' travel to and from the school and the number of public buses in provincial tend to diminish (Jardbandista, 2018, p.1).

The third group, **private hire vehicles (PHVs)** which are personal car/private-owned or local people-owned vehicle (between 8-12 seats) such as pickup truck (as appeared in Fig. 3 herein), six-wheeled truck/Songthaew with cushion seats, roof, various component and equipment, and van complied with safety standard for transporting passengers subject to specification, nature of utilization and driver's qualification, acquiring the school's certification and the DLT inspection for registration and specific license to make use of the vehicle utilized for school transport (short-term, by semester) issued under the Motor Vehicle Act B.E. 2522.

The DLT issued a new regulation to ensure PHVs and the drivers meeting safety standard for specific PHVs (for school transport) license and then issued a revised guideline of Department of Land Transport ("DLT')'s registrar (2016) on permission of making use of the vehicle utilized for school transport for better implementation of safety requirements. *(Remark: group of PHVs for non-school transport are connection with taxi services of Uber and Grab)*

Such DLT's new regulation issued in response to the PHVs' misuse and unsafe physical conditions impair security and safety of cars and passengers i.e. obsoleteness, substandard structure, component and equipment such as fastening loosely passenger seats on vehicle floor, installing many extra seats to supply space or loaded pupils as many as possible, sticking opaque mirror film, none of locked door or blockage-metal bar at the door-end (pickup truck), none of extinguisher and hammer to break mirror etc.

In an effective management, the schools prefer to contract with the vehicles operators (private sector) to provide school transport by PHVs, as its cost and expenditure are cheaper and risk is slighter. However, this school arrangement of school transport service, parents have to pay for it for instance international schools providing air-conditioned buses between home and school independently checked at regular intervals, trained bus drivers and monitors.

However, for obtaining DLT's permission or license, the PHVs owners/operators' cost and expenditure is high and not worthy in calculation with income obtained from engaging the school transport. As for the fare is increased higher, parents might not able to pay in long term.

Accordingly, a part of parents themselves have to transport their children by personal car and motorcycle. But such transport also brings about increasing expenditure and loss of time and resources of transport. Meanwhile, a lot of parents turn to find somebody like neighbor or people in community or transport operator who is able to drive personal car and motorcycle to transport their children and the amount of fare, route and time is flexible; therefore, the fourth group of vehicle takes place to be another mode of the school transport.

Fig. 2 Many unlicensed and modified private hire vehicles (PHVs) are overloaded by pupils during school transport.

The fourth group, **unlicensed PHVs** which are personal car/private-owned or local people-owned vehicle utilized for transporting pupils to and from the school, include several types of agricultural motor vehicle, truck, van, motorcycle, six-wheeled truck, but neither meets safety standard for transporting passengers in terms of specification, equipment and nature of utilization.

The vehicle owners/operators normally undertake a school transport and directly charges fare individuals from parents on voluntary basis without the school's involvement. Its drivers hold different type of motor vehicle license (Pu-ar-ree, 2017).

The DLT information unveiled that as of July 2016 total 22,861 registered PHVs for school transport, breakdown into 15,781 vans, 3,175 six-wheeled truck, 2,667 pickup truck and 2,755 misused vehicles (the unlicensed PHVs) (SMBUYER Magazine, n.d. [Online]). In fact, huge number of the unlicensed PHVs are out of record due to they have not yet been unfounded and not arrested.

A part of all modified PHVs having substandard structure, component and equipment deny and neglect improvement and application for license of school transport under such DLT's new regulation.

The DLT's regulations set specifications for the vehicles in which school bus (PHVs) operators have to invest more. This is not practical for those providing informal bus services in rural areas. As a result, the regulations cannot bring about quality services and the operators prefer not to register their vehicles. Meanwhile, general road safety standards have also not been properly enforced. As such, the operation of informal buses (unregistered and unlicensed PHVs) has become a popular but dangerous choice for students (Thongphat, 2018).

Moreover, unlicensed PHVs may cause danger and fatal risk due to misbehaviors of the PHVs' drivers and misbehaviors of the other party passengers such as hi-speed driving, impetuous driving, aside from loading excessive passengers/pupils and disqualified.

With reference to the statistics* reported by Road Safety Group Thailand in 2017, at least 30 accidents occurred in relation to school transport by all type of vehicles, the unlicensed PHVs that mostly resulted 7 pupils dead and 386 pupils injured or in average at least one pupil got injury by school transport in each day (Jardbandista, 2018, p.2), as appeared in statistics during 2015-2017 in table 1 and table 2 below. *(*derived from mere collection of news and report through media and networking organizations, as the official statistics was not available and found)*

Table 1 Number of Accidents of School Transport (by year and type of private hire vehicle/PHVs)

	2015	2016	2017
Van	6	14	6
Pickup truck	8	6	15
6 wheeled-truck	3	8	4
Bus/coach	-	-	5
Total	**17**	**28**	**30**

Table 2 Number of Deceased and Injured by School Transport

	2015		2016		2017	
	D	I	D	I	D	I
Van	11	52	2	90	1	88
Pickup truck	11	101	4	59	5	165
6 wheeled-truck	2	59	1	105	0	78
Bus/coach	-	-	-	-	1	55
Total	**24**	**212**	7	**254**	**7**	**386**

(D =Deceased people and I = Injured people)

Source: Road Safety Group Thailand by Jardbandista, T., 2018

Among the aforesaid 4 groups of vehicles for school transport, big number of accident and loss having occurred in relation to the unlicensed PHVs are the most (Jinwong, 2015 and Jardbandista, 2018, p.2). From the statistics by year and type of private hire vehicle/PHVs appeared in Table 1 and Table 2, the pickup truck seems to be the most dangerous vehicle of school transport.

According to the American School Bus Council the most dangerous form of transportation to and from school is students getting in their own vehicles or ride with others which are 50 times more likely to arrive to school alive if they take the bus than if they drive themselves or ride with friends (Gibson, 2015 [Online]) and the school transport that travelling by bus or coach appears to be by far the safest mode, with reference to final report on road safety (European Commission, 2004, p.2).

In another mode of school transport, nationwide, as mentioned above, a number of parents allow their children to ride motorcycle to and from school, although they do not qualify to ride it by age of below 15 and immaturity and to apply for the motorcycle rider license. According to Ramathibodi Hospital's Child Safety Promotion and Injury Prevention Centre (CSIP), approximate

15,800 children annually get into motorcycle-related accidents that result around 700 deceased and most of them getting injury. This is another issue of grave safety concern.

The unlicensed PHVs are advantageous due to their lower cost, affordable fare/payment, flexible route and time, its utilization for other income-earning activities or businesses out of time of school transport, more convenient from and to individuals' home than public buses and school bus for school transport. Safety of such PHVs is not prioritized or concerned by many parents. With reference to a survey of PHVs users/pupils in 6 regions of Thailand made by the road safety network strengthening for safe public vehicles project in 2016, major reason of selecting PHVs for school transport is convenience and rapidness (56%), safety (19%), none of other choice (14%).

A number of accident and loss having occurred in relation to the unlicensed PHVs seems to be the most since drivers' disqualification, substandard structure, component and equipment with reference to automotive engineering specifications and safety standard, as stipulated in the DLT regulation. Likewise, many countries establish a regulatory framework to govern bus design, driver qualifications, and motorist behavior around schools and school buses (Deng, F. and Kurgan, G., 2012 [Online]). However, for obtaining DLT's license for school transport and compliance with all safety standard, this is not practical since the PHVs owners/operators' cost and expenditure is high and not worthy in engaging the school transport as well as those PHVs are improperly utilized for other income-earning or businesses at the same time. As a result, the regulations cannot bring about quality services and the operators prefer not to register their vehicles. Meanwhile, general road safety standards have also not been properly enforced. As such, the unlicensed PHVs) has become a popular but dangerous choice for students (Thongphat, 2018).

It is also noted that insurance system may not fully help protection and remedy pupils/passengers (in case of death, loss of organs or permanent disability) because a number of unlicensed PHVs are old, modified and misused vehicles holding only mandatory insurance policy, not voluntary insurance policy that provides additional passenger coverage.

4.2 School transport in connection with provision of education and government support

In consideration of problem and obstacle of provision of safe school transport in Thailand, education system of Thailand is a main issue. The mandatory education to children from pre-school/kindergarten to secondary level 3 (grade 9) is provided all over the country. Local administrative organizations and private sector are allowed to participate in provision of education by decentralization. In virtue of law and policy, access into education and educational extensive opportunity are definitely set out to create an educational equality. However, provision of education and its access usually cover free study, public service and welfare in educational place/institution such as lunch, uniform, educational materials etc. but it generally excludes provision of school transport.

Provision of safe school transport in general to pupils/students which is, actually, a support for regular travel for class attendance or a facilitation of addressing education is interpreted by concerned government agencies that it is out of mission or extent of the provision of education. Wongtienthana (2018) indicated that the local administrative organization's duty of provision of education covers curriculum, educational personnel, surroundings in school compound, academic excellence, various equipment but excludes provision of school transport. Nevertheless, such school transport may be provided for particular groups i.e. the small children development center, disadvantaged or disabled children on social services basis (State Audit Office of the Kingdom of Thailand, 2017).

In Thailand, such travel needs safe school transport supported by government sector in particular a number of schools located in rural or remote area where the government budget has allocated fewer and limited manner due to less and decreasing number of pupils, less potential and attention by any way. These schools face difficulties to provide standard and safe school bus or safe school transport by their own.

On the other hand, the government budget and subsidy are allocated more to large-sized schools located in urban or central city where a number of pupils choose to enroll since they are attractive among pupils who can get easier access into sources of knowledge, information technology, intensive tuition, educational resources etc. This regard can be questioned whether it is inequality or not, in respect of educational access and opportunity (Jardbandista, 2018, p.2). For international schools and schools having bi-lingual or other special programs, parents afford tuition fee, materials, expenses and extra services including contracting standard school.

In principle, the regular travel to the school compound for attending class is still noteworthy for children's education and development, although nowadays access into learning and education has expanded to education via online, open source, distance education, informal education. In respect of Convention on the Rights of the Child, to recognize the right of the child to education, measures to encourage regular attendance at schools and the reduction of drop-out rates shall be taken (Article 28e). In mind of the best interests of the child services and facilities responsible for the care or protection of children shall conform to the standards..…particularly in the areas of safety (Article 3) (Thanachart, 2018).

In UK, such facilitation of addressing education and support for regular travel to and from school are some objectives of the provision of school transport and as a part of the provision of education. As a result of decentralization, with annual budget and other financial support, the local administrative authorities implement education missions as the local education authorities/LEAs for instance under Education Act 1996 the Council as an education authority has a duty to promote high standards of education and fair access to education and another duty on school transport i.e. to make provision for suitable home to school travel arrangements for eligible children of compulsory school age (5-16) to facilitate attendance at a relevant educational establishment at free of charge (s508B), to promote sustainable modes of travel to assess general school travel needs (s508A) (Surrey County Council, 2017, pp.1-3). The LEAs provide free transport for all pupils of compulsory school age (5-16) if their nearest suitable school is beyond 2 miles (below the age of 8) and beyond 3 miles (between 8-16), making transport arrangements for all children who cannot reasonably be expected to walk to school because of their mobility problems or because of associated health and safety issues related to their special educational needs (SEN) or disability (Department for Education of UK. (2014).

4.3 Good practices of the provision of safe school transport in Thailand

Good practices of provision and improvement of safe school transport can be highlighted, based on the safe system approach, as follows:

<u>Safe vehicles</u>

1) Technical support to develop safe vehicle for school transport: In June 2018 MTEC, Road Safety Group Thailand and Thai Health Promotion Foundation collectively handed over "a prototype of school pickup truck" to Baan Ta Reung School, Chantaburi province, as appeared in Fig.2. The pickup truck is equipped with strong and safe-structured metal roof, seats, floor and various safety component and equipment i.e. double locked- rear door with alarm at the time of opening, staircase, vivid amber color light signal that clamped with car body by strong device in order to prevent removal and protect passenger in the event of accident. Such prototype will be expectedly used for testing and further manufacturing standard and economical roof truss, component and equipment from domestic raw materials. The output would be installed on the pickup truck by entrepreneurs of car modification shop for transporting the pupils in line with Thai local people's lifestyle.

Fig. 3 The prototype of school pickup truck, as a modified private hire vehicle (PHVs), not exceeding 12 seats)

<u>Road user behavior and road safety management</u>

2) Bang Pla Mar model: an initiation of an administrative teacher Bussakorn of Bang Pla Mar school, Supanburi province in 2008 becoming a school bus model by "provision of safe private hire vehicle/PHVs. The initiation came from circumstances of pupils' assembly for improper activities after school

and pupils' unsafe transport to and from school as well as conflict between concessionary route buses and modified private hire vehicle of local people. An agreement on sharing-school transport among them was reached, encouraging formation of a school transport club, an issuance of internal regulation and sanction in place and recruitment of owners/drivers to be members and the club's committee member. The school coordinated with Provincial Transport Office to issue a certificate for the club's members and with the club to develop equipment and accessories ensuring pupil's safety and to set up a fund for maintenance of vehicles. However, this Bang Pla Mar management was changed by teacher Bussakorn official transfer to new position in the other school in 2014 and lasted in long term due to its merely ad hoc and informal setting in local area with less involvement of all concerned government agencies and senior management level of Ministry of Education, etc.

3) Development of the school bus/PHVs network and effective management in various districts in Chantaburi province: such network includes (1) school and teacher facilitating school transport; (2) school bus/PHVs club; (3) pupils taking service of school transport and their parents; (4) capacity building on road user/drivers' behavior; (5) awareness raising on road safety and (6) land transport official and police official. Thus, safety measures and management process of school bus/PHVs has been set up, in connection with the club's management rules and recommended management point/focal point e.g. school.

4) The Association of Confederation of Consumer Organization of Thailand and the Foundation for Consumers organize several activities such as "Prototype and Cooperation for Safe School Bus" seminar held in March 2018, a survey of PHVs users/pupils in 6 regions of Thailand made by the road safety network strengthening for safe public vehicles project in 2016 in order to improve safety of school transport.

5. Conclusion and suggestions

Safety of the PHVs for school transport is not prioritized by a number of parents and pupils, according to survey's result in 2016. Safer modes of school transport i.e. school bus, public buses personal/private car, licensed PHVs, as a whole, are not available or otherwise not favorite. In taking consideration of number of road accidents and loss, unsafe school transport in particular the unlicensed PHVs (esp. pickup truck) which is obsolete, modified, misused and substandard is very concern of their unsafe physical condition (structure, component and equipment), nature of utilization and drivers' qualification under the DLT regulation on PHVs covering safety engineering specification (vehicle), qualification (drivers) and management that linked to the safe system approach. The research finds unsupportive and impractical mechanism for compliance with all specification and safety standard, effective management of school transport i.e. insufficient technical and financial support, less public attention and lack of appropriate management point. The safety concern extends to pupils routinely riding motorcycle as a mode of school transport.

With regard to management issue, provision of school transport to pupils/students is actually a support for regular travel for class attendance or a facilitation of addressing education in pursuance with protecting a right of the child to education, as nowadays attending class at school compound is still noteworthy for children's education and development. But it is interpreted by concerned government agencies of Thailand that it is out of mission of provision of education. As a result, Standardized school bus/PHVs that ensures safe transport is scarcely available and government financial support or funding has been provided fewer and limited manner for safe school transport or even for provision of school buses especially schools located in rural and remote areas.

This writer realizes that the aforesaid local good practices, principles and lessons learnt from global experiences are useful to be guidance and practical ways to provide and improve safety of the school transport in Thailand. To increase compliance with engineering specification and safety standard and to have effective management, suggestions are as follows:

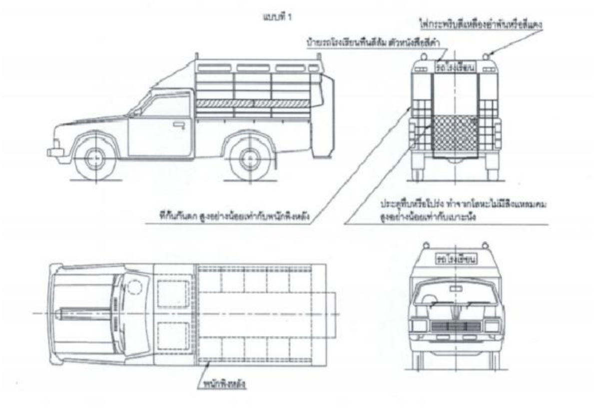


Fig. 4 model of each type of PHVs for school transport in the DLT regulation on PHVs

<u>Safe vehicles and road user behavior</u>

1) To find technical support and funding so as to develop safe PHVs for school transport in compliance with engineering specifications, safety

standard and model of each type of vehicle (pickup truck, van and 6 wheeled-truck) in the DLT regulation on PHVs (as appeared in Fig.4 herein) in cooperation with the DLT, technical agencies, engineering academic institutions and funders;

2) The DLT as a lead agency, to take actions against substandard structure, component and equipment, overloading, misuse of vehicles and disqualified drivers by stricter enforcement of the DLT regulation on PHVs;

Road safety management

3) To set up a joint committee among ministries and concerned agencies such as Ministry of Education, Department of Local Administration, Department of Land Transport and/or Ministry of Industry to assign management point/focal point to find practical measure for improving safety of school transport i.e. technical support, budget or funding;
4) To have various local administrative organizations supported budget or financial contribution to provide more safe and standardized vehicles transport pupils to and from school;
5) To support and expand setting up multi-lateral school transport network among (1) school and teacher facilitate school transport; (2) school bus/PHVs club; (3) pupils taking service of school transport and their parents and (4) land transport official and police official in local area for developing safe and standardized PHVs and for better management

6. Acknowledgement

The writer is hereby very thankful to Legal Development Program (LDP) under Asia Injury Prevention Foundation supported by WHO and the Bloomberg Initiative for Global Road Safety (BIGRS), AIP country manager, LDP team members and staff, Road Safety Group Thailand's members participating in the safety of school bus research and activities, participants in the forum on "Policy on Management of Standard and Safety for School bus held on 21 May 2018 at Sukosol Hotel, Bangkok.

References

[1] Deng, F. and Kurgan, G. (2012). On the Road to Safe School Transport in China. *World Bank paper*. Retrieved from http://www.worldbank.org/en/topic/transport/publication/on-the-road-to-safe-school-transport-in-china

[2] Department for Education of UK. (2014). *Home to school travel and transport: Statutory guidance for local authorities*. Reference: DFE-00501-2014, Department for Education, p. 10.

[3] European Commission (2004). Road safety in school transport study – Final report, Brussels: TIS, p. 2.

[4] Gibson. (2015, March 4). School transportation: how to keep students safe. *Blog*. [Online]. Retrieved from https://www.gibsonins.com/blog/school-transportation-how-to-keep-students-safe

[5] Jardbandist, T. (2018). Regulating School Buses - Are we heading in the right direction?. *LDP Thailand*, pp.1-3. Retrieved from https://bit.ly/2IgIarI

[6] Jinwong, T. (2015, 13 August). Accidents of unlicensed private hire vehicles causing persistent loss has still had none of solution. *Isranews*. Retrieved from https://www.isranews.org/isranews/40559-aa_405599870.html

[7] Paliyawate, T. (2018). A Study on the Provision of Safe School Transport in Foreign Countries. *LDP Thailand*. Retrieved from https://bit.ly/2JDoQ48

[8] Pu-ar-ree, C. (2017). Safety Standard of School Bus in Pilot area of Chantaburi Province, *Research Paper*. Road Safety Group Thailand

[9] SMBUYER Magazine. (n.d.). How do pupils think about school bus?, Vol.198, Accessed on 30 May 2018. Retrieved from https://www.chaladsue.com/article/2642

[10] State Audit Office of the Kingdom of Thailand. (2017, 20 April). Report on verifying the operation of contract for school bus service for schools under Pathumthani Provincial Administrative Organization, p. Kor and Kor and Official Letter of Department of Local Administration No. Mor.Tor. 080.2/1736 dated 8 February 2016 on seeking for consultation of entering into an agreement on financial support for management of school buses

[11] Surrey County Council. (2017). *Surrey Education in Partnership: Local authority education duties 2017*. Version 2. Surrey: Surrey County Council, pp. 1-3.

[12] Thongphat, N. (2018, 10 May). Safer school buses need not be pricey.*Bangkok Post*. Retrieved from https://search.bangkokpost.com/search/result?category=all&q=Safer+school+buses+need+not+be+pricey

[13] Wongtienthana, T. (2018). Safe and standardized school buses are an educational necessity. *LDP Thailand*. Retrieved from https://bit.ly/2IZ6NIZ

Policy Impacts to Traffic Safety: Experience of Seoul (Korea) and Hanoi (Vietnam)

Topic number: 05 Paper Identification number: AYRF 2018-020

An Minh NGOC[1]

[1]University of Transport and Communications, Section of Transport Planning and Management
Telephone +84-024-3766 40 53, Fax. +84-024-3766 64 96
E-mail: anminhngoc@utc.edu.vn

Abstract

The rapid growth of automobile ownership and use in developing countries resulted in an exponential growth in road traffic related fatalities and injuries. It is estimated that 1.25 million road traffic deaths occur in the world every year (WHO, 2015), most of them in developing countries in which more than 51% are vulnerable road users. The complexity and unexpected nature of the traffic accidents put the decision makers confronted with the quandary of forming a particular combination of measures to reduce traffic accidents. Many countries have various traffic safety policies in place to address this issue. The aim of the present study was to assess the traffic safety policy impacts in reduction of traffic acidents in Hanoi (Vietnam) and Seoul (Korea), two cities are facing with serious transport problems related to road safety. By state of traffic safety in these two cities was determined by analyzing the characteristics of the traffic environments of the respective cities, their traffic accident figures, and the causes of such accidents. Also, by comparing the various traffic safety policies currently in the works for the two cities, as well as detailed strategies for implementation, solutions to the traffic issues facing cities were examined. The results of this study deduced that, despite the substantially different traffic environments, that is, differences in the modal shares of transportation, traffic safety policies have a definite directionality. It is judged that the present study will be helpful in establishing sustainable traffic safety policies to create convenient and comfortable urban traffic environments in many large cities throughout Asia.

Keywords: Traffic accident, Fatality, Road safety, Policy

1. Introduction

In Hanoi, about 7,739 traffic accidents have occurred over the past 5 years (2011 – 2015), resulting in approximately 3,199 fatalities and 5,015 injuries. The number of traffic accidents that caused causalities varied from 1,027 in 2012 to 962 in 2015, sustaining a predominantly sideways trend. However, the statistics also showed an approximate 24% reduction effect in fatalities over this period, from 794 in 2011 to 603 in 2015. During that time, the number of automobiles increased from 4.8 million at the end of 2012 to 6.2 million in 2015—an increase of 28% in five year. This increase is expected to continue over some time in the future, making traffic safety a major for concern and interest going forward.

With the same situation, traffic accident is a growing concern in Seoul, with more than 2,000 killed and over 280,000-recorded injuries for the past 5 years. However, fatalities have shown a stable decrease of 13.5%, dropped from 435 in 2011 to 376 in 2015.

Comparing Hanoi accident statistics to Seoul, it can be seen that there was around one dead for 100 accidents in the Seoul statistics, while there was one dead per 3 accidents according to Hanoi statistics. This situation showed that Hanoi has had the much higher fatality risk.

The facts from Hanoi and Seoul show that the number of traffic fatalities has decreased over the past five years despite a significant increase in the number of automobiles suggest that traffic safety situation has been improved. This achievement comes from applying various policies, combine education, engineering and enforcement. In which, traffic safety education is kept continuously and considered as the long-term effects.

Table 4. Traffic Accident in Hanoi and Seoul

		Unit	2011	2012	2013	2014	2015
Seoul							
	No. of accidents	Cases	40,451	40,829	39,439	40,792	41,665
	No. of fatalities	Cases	435	424	378	400	376
	No. of injuries	Cases	57,625	58,583	56,761	57,345	58,656
	Fatalities per 100 accidents		1.1	1.0	1.0	1.0	0.9
Hanoi							
	No. of accidents	Cases	1,027*	777*	2,252	1,986	1,697
	No. of fatalities	Cases	794	588	605	609	603
	No. of injuries	Cases	443	1043	235	1863	1431
	Fatalities per 100 accidents		77	75	26	30	35

Source: Hanoi Traffic Police Bureau (2016), Seoul Statistics (2016)

The aim of this paper is to consider the effects of traffic safety policies on reducing traffic accident fatalities. Firstly, this paper describes the overall picture of traffic safety situation in two cities, Hanoi and Seoul. Secondly, history of major traffic safety policies in both cities is reviewed to examine the efforts of city governments on ensuring traffic safety. Finally, this paper evaluate and assess the policy impacts to traffic safety for both cities.

2. Current Situation of Traffic Safety in Hanoi and Seoul

Until the end of 2016, Hanoi has total of 6.2 million registered vehicles, 60% increase over seven years from the 3.9 million registered vehicles in 2010. Motorcycles comprise about 90% of this figure, and increased 7.8% on average annually. Therefore, it is not surprised to know that the majority of casualties in Hanoi involve motorcyclists, constituting more than 58% of the total number of casualties. Motorcycle casualties in Hanoi are 2 times higher than car casualties, 28 times higher than pedestrian casualties and above 80 times higher than urban buses casualties. In the same time, motorcycle-related traffic accidents accounted for only 9% of traffic accidents in Seoul, and commercial vehicles contributed the highest proportion of traffic accidents with more than 60%.

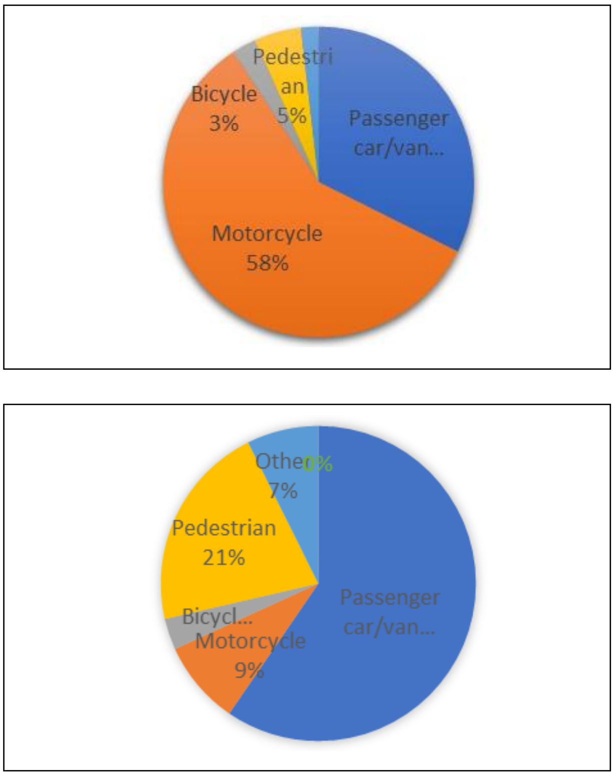
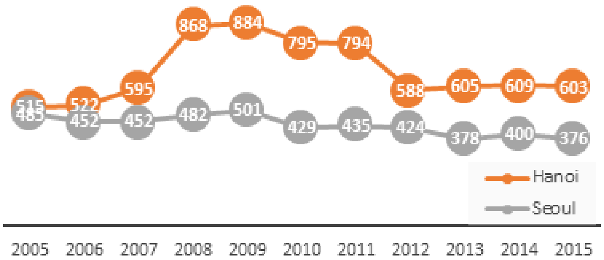


Fig.1. Casualty distribution by transport mode in Hanoi (upper) and Seoul (lower)

Considering that the number of fatalities caused by traffic accidents has continuously decreased in both cities even the 28% increase in the number of registered vehicles over the past five years (2005-2015) in Hanoi and 3.7% in Seoul, one could see even the subsequent relative increase in traffic, traffic accidents have been restrained to some degree.



Source: Hanoi Traffic Police Bureau (2016), Seoul Statistics (2016)

Fig.2. Number of fatalities caused by traffic accidents

The result is a decrease in the number of fatalities per 10,000 vehicles by almost half in Hanoi, dropping from 1.82 in 2011 to 1.08 in 2015. In the same time, this rate in Seoul felt from 1.3 to 1.1. Fatalities per 100,000 citizens also decrease from 11.7 and 4.2 in 2011 to 8.2 and 3.8 in 2015 in Hanoi and Seoul, respectively.

Table 2. Rate of fatalities by 10,000 vehicles and 100,000 persons

Year	Hanoi		Seoul	
	Fatal. per 10,000 veh.	Fatal. per 100,000 pop.	Fatal. per 10,000 veh.	Fatal. per 100,000 pop.
2011	1.82	11.7	1.30	4.2
2012	1.20	8.6	1.20	4.2
2013	1.18	8.5	1.10	3.7
2014	1.14	8.4	1.20	4.0
2015	1.08	8.2	1.10	3.8

Source: GSO (2016), vehicle register (2016), Hanoi Traffic Police Bureau (2016), Seoul Statistics (2016

Traffic accidents are caused by a multitude of factors, the most notable of which - driver behavior, incidents of traffic violations, and awareness, among others—directly threaten traffic safety in big ways.

Table 3. Traffic accidents by traffic violation (in 2015. Units: %)

Causes	Seoul	Hanoi
	100%	**100%**
Unsafe driving (incl. lane shifting and turning)	55%	40.8%
Lack of observation	-	29.9%
Over speed	12%	9%%
Falling to keep safe distance	-	9.6%
One-way violation	-	2.4%
Careless crossing of pedestrian	2%	0.5%
Light violation	24%	-
Others	8%	7.8%

Source: Hanoi Traffic Police Bureau (2016), Seoul Statistics (2016)

Table 3 shows the composition of traffic accidents by causes in Hanoi and Seoul in 2015. Most traffic accidents are caused by road users' errors, among which "unsafe driving" is the primary causes, accounting for 40.8% in Hanoi, following by "lack of observation" with 29.9%. The significant improvement of road infrastructure during the last decade seems to make the drivers became more subjective while travelling. As a result, road users tend to not paying attention on roads with relatively little traffic. Unsafe lane shifting by trucks, buses and passenger cars expose low-speed vehicles, such as motorcycles and bicycles, to great risk in a mixed traffic situation.

Meanwhile, analyzing 65 per 139 deads caused by commercial vehicles in Seoul in 2015, it could be seen that law violation accounted for the highest proportion, 50% of which were categorized as unsafe driving, followed by traffic light violation (24%) and 12% over speed.

The cited results in both cities indicated that driver awareness is the biggest issue. 41-55% of mortalities from traffic accidents were caused by unsafe driving. Under these circumstances, strict enforcement of traffic rules and effective traffic education of road users are crucial in reducing traffic accidents. In addition, physical measures such as improvement of surface conditions, paving of shoulders, re-designing of roads, and installation of traffic signs and signals are also necessary.

Details of traffic accidents occurring in Hanoi 2015 show that the highest percentage of accidents involved multiple vehicles (96.2%), followed by involvement with pedestrians (3.8%). However, 13.2% of fatalities involved pedestrians. More seriously, the number of fatalities caused by pedestrian traffic accidents in Seoul is roughly four times higher, accounted for 56% of the total number of fatalities (211 out of 376 persons in 2015), indicating that it is critical to protect safety for pedestrians in Seoul.

Further analysis of accidents involving pedestrians reveals a significant rate of accidents involving pedestrians take place during the crossing (54%). This situation means what is often considered the safest location was actually associated with higher risk. This also indicates that countermeasures such as education about safe walking or installing safe equipment for pedestrian are necessary.

Determining risk levels derived from data not only illustrates the current situation of traffic safety but also is also useful for evaluating policies that have been implemented and determining what policies should be going forward.

3. Review on Traffic Safety Policies in Hanoi and Seoul

With the raise of traffic accidents issues, national government and city governments in both large cities have pursued a series of polies in the effort toward improving traffic safety and preventing accidental death and injury.

In Vietnam, traffic safety issues were first mentioned in 1995 with the Government decree 49/1995/ND-CP, providing for administrative sanctions against violations of traffic safety. This decree was set as the first milestone that marked the government's concern about traffic safety. Two year later, the National Traffic Safety Committee (NTSC) and local traffic safety committees at 63 provinces were established, traffic safety was recognized as one of the critical social issues facing the country. During the period of 1995-2014, regulations for penalties on traffic violations continuously adjusted to increase the fine for traffic violations in order to deter road users and prevent traffic accidents.

At national level, one important policy was applied that significant contributed on the reduction of fatalities, that is helmet wearing. This policy was promulgated in 2003 and officially applied in 2007, obligated motorcyclists to wear safety helmets when driving motorcycles on all types of roads.

At city level, the policy of lane separations for different types of vehicles was applied in 2009 to several roads in Hanoi. However, this policy was failed due to applying at under standard roads and meeting the protest of road users.

Hanoi had a first five-year traffic safety plan in 2010 within the project framework funded by JICA (Japan). One of the objectives of this plan is a reduction of 7% in traffic accidents per year against previous year in period of 2011-2015. This project has basically success and has a positive effects in general efforts in ensuring traffic safety.

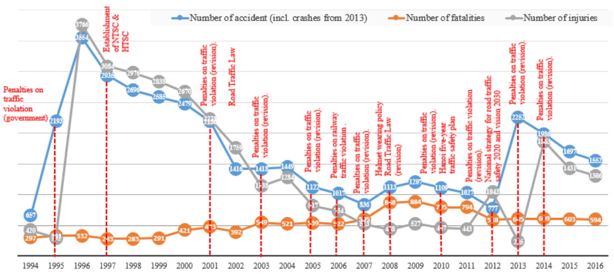


Fig.3. Some milestones and traffic safety policies in Vietnam and Hanoi

In Korea, the earlier efforts were implemented by government in 1983, when the fundamental law regarding traffic safety – the Traffic Safety Act – established the first basic traffic safety plan. From this perspective, 1983 could be construed as the initial phase of building various systematic advances relative to traffic safety.

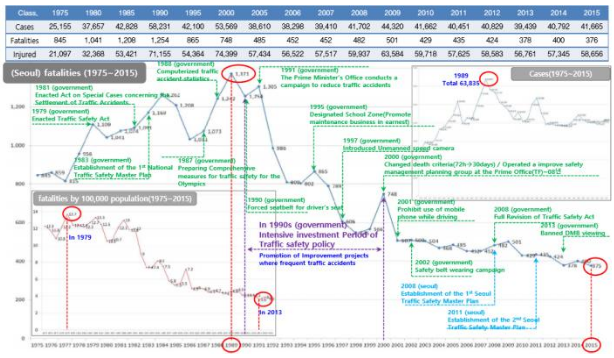


Fig.4. Time-series of accidents and traffic safety policies in Korea and Seoul

In 1991, a campaign to reduce traffic accidents was launched by the Prime Minister's Office while the greatest number of fatalities was seen two years earlier, 1989, with 1,371 fatalities. One year earlier, government forced seatbelt for driver's seat. Since 1990, one could witness a series of traffic safety policies such as designated school zone (1995), changed death criteria from 72h to 30 days (2000) and operated a improve safety management planning group at the Prime Office, prohibit use of mobile phone while driving (2001), safety belt wearing campaign (2002), Establishment of the 1st Seoul traffic safety master plan (2008), full revision of traffic safety Act. (2008), establishment of the 2nd Seoul traffic safety master plan (2011).

There is a similarity between the 1st Seoul traffic master plan (2008) and Hanoi Five-year traffic safety plan (2010). Both plans focused on improvement at black spot, concerned with passenger/cargo safety management, strengthening traffic safety measures for walking and cycling and emphasizing the cooperation system related agencies by segmenting traffic policies such as public transport as well as strengthening the safety of transportation vulnerable.

4. Assessment of Policy Impacts to Traffic Safety in Hanoi and Seoul

Due to the fact that almost traffic accidents caused by human errors (~ 98%), the policies from Hanoi aim at enhancing driver awareness of traffic safety and their behaviors of obeying traffic safety regulations. Policies have been in effect for many years with different types of measures (such as promotion bands, education at schools, exhibitions of traffic safety, etc.). Enforcement does not directly influence driver behavior, but only influences their attitudes of safe and unsafe behavior. Combining enforcement with education and training will have long-term effects on driver attitudes towards legislation. Belong with this, driver attitudes toward legislation are also influenced by other elements of traffic environments such as infrastructure, traffic operation and management, and congestion in traffic flow.

The national strategy for road traffic safety 2020 and vision 2030 focuses on a reduction of traffic accidents by 5-10% annual in all 3 criteria of number of accidents, number of fatalities, number of injuries as one of the national policy targets managed by the Prime Minister. The National Traffic Safety Committee was strengthened to decide on a five-year plan and annual action program for reducing the number of fatalities and injuries caused by traffic accidents, chaired by the Vice Prime Minister with involvement by the Ministry of Transport, the Ministry of Public Security, the Ministry of Justice, the Ministry of Information and Communications, the Ministry of Education and Training, the Ministry of Health, Voice of Vietnam, etc.

Similar to national level, at city level, Hanoi traffic safety committee set a target values for each year, and establish the promotion strategies to achieve the targets in order to reduce accidents. Detail of the target and strategies in period of 2011-2015 are outlined as in Table 4.

While the initial results of these related actions have not achieved initial target values, they have produced a certain effect by helping reduce the number of fatalities by 24% over the past five years. The number of fatalities per 10,000 vehicles is still high compared to Asian countries, but there has been a decrease from 1.82 in 2011 to 1.08 in 2012, and a decrease in fatalities per 100,000 people from 11.7 in 2011 to 8.2 in 2015.

In 2017, Hanoi government issues a traffic safety improvement plan, one of the main targets of this plan is continuing decrease from 5% to 10% the number of road and railway traffic accidents (in all three criteria: number of cases, fatalities and injuries), at least 5% serious accident related to inland waterway transport and commercial vehicles. In order to achieve this target, strategies focuses on propaganda of regulation on traffic safety, encouraging people to use public transport, planning and developing traffic infrastructure, inspection and handling traffic violation.

Table 4. Target and strategies for ensuring traffic safety in Hanoi

Target	▪ Majority of road users have formed the inherent habit of respecting all traffic rules. ▪ A reduction of 7% in traffic accidents per year against previous year, in terms of the absolute number of fatalities. ▪ To strengthen basically the capability and functions of the organizations involved in road traffic safety and to develop completely most of new organizations and rules/regulations necessary to ensure sustainability of traffic safety measures.
Strategies	▪ Development of Safe Road Traffic Environment ▪ Enhancement of Safe Driving ▪ Ensuring Safety in Vehicles ▪ Effective and Efficient Traffic Control and Enforcement ▪ Enhancement of Traffic Safety Education and Propaganda

Source: TRAHUD (2010)

Compare to Hanoi, traffic safety policies in Seoul are much more diverse. Before 2010, Seoul established policy direction based on national traffic safety master plan, therefore it was lack of interest in traffic safety in urban transport matters and poor cooperation of institutions related transport safety. In 2008, Seoul established regional traffic safety policy that focused on countermeasures against changes in traffic conditions, it was so-called the 1st Seoul Traffic Safety Master Plan. The 2nd Seoul Traffic Master Plan was established in 2011 that focused on advanced traffic safety measures. Considering the specific conditions, Seoul traffic safety policies toward promotion of school zone improvement, designation of senior protective zones, countermeasures for pedestrians, improvement of black spots, and establishment of traffic safety information management system in connection with new technology and big data, as well as promotion of traffic safety education.

Details of the related traffic safety plans are outlined in the Table 5 and Table 6

that everyone agrees
- Construction of traffic safety system.

Source: The 2nd Seoul traffic safety basic plan, p. 261, http://opengov.seoul.go.kr

Table 5. Main details of 1st Seoul traffic safety master plan

Target (2009-2011)	▪ A reduction of fatalities from 477 (2008) to 375 (2011) ▪ Number of fatalities per 10,000 vehicles falling from 1.4 (2008) to 1.1 (2011) ▪ A reduction of pedestrian fatalities from 255 (2008) to 150 (2011) ▪ A reduction of elderly fatalities from 121 (2008) to 105 (2011)
Strategies	▪ Implementation of special improvement measures at black spots ▪ Special reduction measure for pedestrian accidents ▪ Improvement of mobility for the transportation vulnerable: school zone, silver zone ▪ Introduction of advanced traffic system ▪ Concentration of management of transport business ▪ Improvement of the safety of transportation companies ▪ Establishment of linkage system with related organizations ▪ Expansion and improvement of Metro traffic safety facilities ▪ Strengthening education and promotion to improve Metro utilization culture ▪ Strengthening bicycle culture education ▪ Establishment of traffic safety orientated transport policy promotion system ▪ Raising awareness of traffic safety and disseminating traffic safety knowledge.

Source: Jongmin KIM (2009)

One could see that this policy was insufficient because it did not achieve initial target values. In 2011, the number of fatalities remained at 435 (expected figure was 375), fatality rate per 10,000 vehicles kept at 1.3 (expected figure was 1.1).

Table 6. Main details of 2nd Seoul traffic safety master plan

Target (2012-2016)	▪ The number of traffic accident fatalities is less than 298 in 2016
Strategies	▪ Creating safe and pleasant traffic safety environment ▪ Promotion of traffic safety awareness by citizens ▪ Improvement of traffic safety system

Although the number of traffic accident and fatalities decreased annually, but the achievement of the number of pedestrian fatalities and the number of the elderly fatalities was not as expected. In addition, the rate of decrease in the number of fatalities of commercial vehicles is sufficient, the figures falling from 142 persons (2012) to 139 persons (2015).

A "3rd Seoul traffic safety basic plan" spanning five years (2017-2021), recently began. The countermeasure formulates four central strategies to create a city that respects life and guarantee safe transport in order to reduce the number of fatalities is less than 180 in 2021.

The first of these strategies is a reduction of 70% in pedestrian fatal accidents. It includes measures of limitation of the urban road speed 5030, installation of omni-directional crosswalk and crosswalk considering walkway, installation and inspection of school zone, silver zone, etc.,

The second strategy is to reduce the taxi/bus accidents in half by providing incentives to transport safety companies, activation of operation record analysis system of commercial vehicles, and strengthening the control of getting on and off at bus stop, pedestrian crossing, intersection

The third strategy is to reduce the bicycle/motorcycle accidents in half by controlling illegal parking on bicycle priority road and safety education for delivery, quick service company.

The final strategy is safety system management that focuses on installation and expansion of emergency response support facilities for emergency vehicles.

Deeply consideration of the practice of the traffic safety policies in Hanoi and Seoul, one could see that besides the similarities between these policies, the typical differences are also recognized. While Hanoi always tied traffic safety and congestion in one policy, even "the reduction of traffic congestion" is considered as a main strategy, Seoul plan separated clearly between traffic safety and congestion and did not include congestion as a target.

Take a look on the Seoul policy, the traffic accident reduction of both pedestrian and elderly people are strongly emphasized in Seoul policy, but they are not considered as main targets in Hanoi.

Similarly, Seoul sets up a main target to reduce the traffic accidents of commercial vehicles, while Hanoi plan do not consider them. Whilst it can be explained that the number of pedestrian fatalities in Hanoi (13.2%) is very low in comparison with Seoul (56%), it is no reason to explain why Hanoi skip setting the target to reduce traffic accidents of commercial vehicles.

As bicycles are emerging a sustainable transport mode in Korea, the Seoul plan consider this mode as a main strategy to reduce the number of bike accidents. Hanoi is also currently facing an increase in bike accidents, it could be learned from Seoul experience for this issue.

Motorcycle is the main transport mode in Hanoi and motorcycle-related accidents accounted a highest proportion. Therefore, Hanoi plan includes motorcycle as a main transport mode to reduce traffic accidents. In Korea, motorcycle are mainly using as a delivery mode of restaurants and other stores, so the Seoul plan set up it as a target to reduce traffic accidents.

Finally, the Hanoi plan emphasizes the construction of traffic safety facilities, but the Seoul plan did not emphasized it as a main target to reduce accidents.

.

5. Conclusions

Transportation safety in Hanoi and Seoul may have improved vastly, but comparisons with other countries suggest that what happens in both cities in the future is a concern. While the number of fatalities from traffic accidents has been decreasing, one issue is it has not decreased any lower in recent years. Given the 29% and 4% increase in the number of registered vehicles in Hanoi and Seoul respectively during the period of 2011-2015 and the subsequent relative increase in traffic, one could see even a sustained sideways trend in the number of fatalities as an effect to some degree.

As these changes in the social environment continue, policies have been implemented to build and improve safety facilities in order to ensure traffic safety. It is needed to assert that although there is a limit to these effects but without a well-directed road safety program, road traffic fatalities and injuries in both cities will still remain high. This will significantly undermine the health of the nation and its economic efficiency. The national Government has taken a series of strong initiatives over the last three decades to improve the situation at the national level as well as city level.

The cited result shows an approximate 30% and 22% reduction effect in fatalities in Hanoi and Seoul respectively over the past eight year (2008-2015), from 868 and 482 in 2008 to 603 and 376 in 2015. This reduction effect can be linked to various policies, among which are continuous traffic safety services and safety devices equipped in vehicles, and are considered to have had a direct impact on safety. While the fundamental effects of traffic safety education and public awareness are not immediate, the long-term effects are believed to be quite substantial.

The achievement of the government at national level can be seen in aspect of establishment of the national road traffic safety plan (both Vietnam, 2012 and Korea, 1983), implementation of the road traffic safety law (Korea, 1983) or road traffic law (Vietnam, 2001), establishment of the inter-disciplinary agency (National Traffic Safety Committee, 1997 and National Traffic Safety Countermeasure Deliberation Committee, 2008).

Helmet wearing has been considered as the most important policy that significant contributed on the reduction of fatalities in Vietnam in general and Hanoi in particular.

However, while the situation in traffic safety has improved, the 8.2 fatalities per 100,000 persons in Hanoi and 3.8 in Seoul are hardly an acceptable level when compared to fatality figures in other Asia countries; the Philippine is at 1.3, Myanmar 3.4. These comparative results imply that the reduction effect is still not satisfactory, and further efforts are required in promoting traffic safety through various safety policies, first and foremost being education. The effects of traffic safety education and public awareness are not easily verifiable, but they cannot be dismissed as they are the most basic safety methods and most trustworthy in the long term.

Compared with Hanoi traffic safety plan, Seoul policy has more advantages. The Seoul plan set up almost transport modes (commercial vehicles, motorcycle, bicycle, and pedestrian) as the targets to reduce traffic accidents, while Hanoi plan do not consider them as main targets. With more than 30 experience years in enforcing traffic safety policies, Seoul can provide valuable lessons on implementing traffic safety policies to Hanoi to implement plans to ensure traffic safety in the next years.

Traffic safety policy toward promotion of school zone improvement can be assessed as the most successful policy that helps to reduce more than 90 percent of traffic accident for children.

References

[1] Jongmin KIM (2009), Seoul achieves traffic safety of OECD 10th level by 2011, Seoul Metropolitan Government.
[2] Hanoi Traffic Police Bureau (2016), Statistic Data.
[3] General Statistic Office, http://www.gso.gov.vn/Default_en.aspx?tabid=491
[4] https://traffic.seoul.go.kr/archives/285
[5] http://stat.seoul.go.kr/jsp3/
[6] The 2nd Seoul traffic safety basic plan, p. 261, http://opengov.seoul.go.kr
[7] TRAHUD project (2010), The Project for Traffic Safety Human Resource Development in

Study on Traffic Management in order to Reduce Congestion Surrounding Areas of Primary Schools in Center of Hanoi

Topic number: **22**. Paper Identification number: **AYRF2018-022**

Vu Van HUY[1], Nguyen The Ngoc ANH[2], Ngo Trung PHUONG[3], Dinh Van HIEP[4]

[1-4]Institute of Planning and Transportation Engineering (IPTE)
National University of Civil Engineering (NUCE), Hanoi, Vietnam
Telephone (+84-4) 3628-5578, Fax. (+84-4) 3628-5578
[1]E-mail: vanhuytbnuce@gmail.com
[2]E-mail: ngocanh23286@gmail.com
[3]E-mail: ngotrungphuong94@gmail.com
[4]E-mail: hiepdv@nuce.edu.vn

Abstract

Traffic congestion at school zones, especially in front of primary school gates, has emerged a significant issue in Hanoi. It causes serious problems for traffic safety in school zones, a low quality of life, loss of social economic, and environmental pollution. At present, most of the schools located in the central areas of Hanoi are subject to traffic jams at school gate zones during peak hours. Accompanied with this is the situation of unsafe traffic at school gate areas, especially for pupils. In Vietnam, school traffic management in general and the school gate areas in particular to propose concrete solutions are still relatively new. Therefore, this study focuses on summarizing and analyzing factors affecting the traffic congestion at school gate areas in the center of Hanoi based on the result of surveys carried out for typical primary schools. As a result, appropriate solutions and guidance for each specific case have been proposed to address those issues.

Keywords: Traffic management, Traffic congestion, Primary school, School zones, Hanoi.

1. Introduction

Viet Nam has experienced a rapid economic growth in the last decade. Hanoi is not only one of the two biggest cities but also the capital of Vietnam. The vast urbanization leads in the rapid growth of private vehicles, which is one of the main sources of serious traffic congestion situation in the city center. There were 37 congestion points identified in 2017 in as shown in Table 1.

Table 1 Number of traffic jams in Hanoi

Year	2013	2014	2015	2016	2017
Points	57	46	44	41	37

Source: HDOT [1]

Although the number of traffic jams is reducing based on some new improvement projects, the congestion situation is still serious due to rapid economic growth and significant increase of traffic volume in recent years.

Apart from the situation discussed above, the traffic congestion also occurs in the surrounding areas of school gates, paticularly primary schools. Illegal parking of parents' vehicles on streets in front of school gates and unappropriate location of schools are claimed for the mater of congestion [2].

Fig.1 shows parents of pupils who are standing on the street waiting for their children and causing traffic congestion. Fig. 2 presents an example that parents park their vehicles in front of the school gate, encroaching on one-way traffic, causing traffic disruption and congestion.

Fig. 1 Vehicles occupied at school gate areas

Fig. 2 Vehicles stopped at school gate areas

In recent years, the authority of Hanoi has given a large investment in urban transport infrastructure, which partly improves the situation of congestion. However, the congestion situation at school gates has not been successfully improved. At rush daily hour (from 16h30 to 17h00), the number of pupils and their parents' vehicles gathering at school gates is very high, causing the problem of traffic jam and congestion. Particularly in front of primary school gates where parents send their children to school and pick them up, therefore the number of people involved in traffic during the peak hours is very crowded.

2. Literature review

School traffic congestion has been a concern around the world, and various studies have been conducted. Those studies identified causes and presented measures to overcome this situation. Their findings can be summarized as follows:

a) Cause of traffic congestion [3-5, 7, 8]

- Rapid growth of the school-aged people over a relatively short time.
- Increase of private vehicle ownership and usage.
- Entry and exit routes around schools designed without consideration of overall commuting patterns.
- Construction of a new residential neighborhood.
- Inefficient traffic organization and traffic lights surrounding school zones.
- Narrow streets and lack of temporary stopping and parking spaces considering school patterns.
- Buses share the same drop-off and pick-up lanes with parents' vehicles.
- Absence of pedestrian and bike pathways and crosswalks and the presence of cars parked along the major thoroughfares leading to and from school.
- Preference of parents to drive their children to school.
- Behavior of pupil parents for their illegal parking as well as violation of traffic regulations.

b) Measures to address traffic congestion

(1) Traffic organization around school areas [3-6, 8]

- Arrange walking routes so that pupils living near the school are able to walk to school.
- Regulate certain streets one-way only during peak hours.
- Provide sign boards indicating the school areas and prohibit parking areas by painted curbs.
- Create marked crosswalks for pedestrian traffic; and synchronize the school zone lights with school dismissal times.
- Organize traffic routes and prohibit cars during peak hours, not allowed to travel across school gate areas.

(2) Traffic demand management for schools [8-10]

- Adjust the starting and ending of class times for different grades in order to manage dispersal traffic.
- Reduce the number of vehicles at peak hours by changing the time of working and the time of study.
- Organize stopping and parking spaces for vehicles to reduce traffic at school gates.
- Apply intelligent transport systems (ITS) in traffic management surrounding school areas.
- Provide additional buses for pupils only from school to the meeting point of pupils where is convenient for them to walk home.
- Utilize the "push" scheme to reduce the attraction of using private vehicles: limiting vehicles operating by hour, supplementing the list of street routes that are not allowed to stop and park vehicles.
- Utilize the "pull" scheme to encourage the use of public transport: planning public transport routes, improving quality of bus services.

(3) Awareness to pupils and parents [3-6, 8]

- Provide information to parents about the benefits of walking, biking and using public transport.
- Raise awareness about road traffic law in schools.
- Provide information to pupils' parents about right place to drop-off and to pick-up their children.
- Enhance the enforcement of traffic laws and regulations.

(4) Public transportation promotion [4, 8]

- Plan public transport in consideration with schools and provide school bus routes.
- Promote public transportation for both parents and pupils.

International experience demonstrates that traffic management and transport planning specifying the school zones and its surrounding areas are very important to ensure the convenient traffic flow and traffic safety for children. However, these issues have not yet discussed in Vietnamese standards for design of schools, only general remarks on the land area for school construction, drainage system and other infrastructure issues are provided, for example TCVN 3907:2011 [11], TCVN 8793:2011 [12], TCVN 8794:2011 [13]. There are no specific, clear specifications for organizing and managing transport for surrounding school areas.

Furthermore, there are few studies in Vietnam addressed this issue such as: *i*) Study on the application of intelligent transportation systems in managing and operating urban traffic in Vietnam presented by Dinh Van Hiep [9]. *ii*) Study on traffic safety in Vietnam [14]. *iii*) Study on traffic situation of high school pupils in Hanoi [15]. However, those studies only discussed in general transport issues in urban areas.

Given the situation, a research that addresses and analyzes the specific traffic congestion at surrounding areas of primary school gates in Hanoi is very necessary. The result of this research will be used as an useful reference for policy makers to propose solutions and regulation modifications to improve the congestion problem surrounding school zones.

3. Methodology

The research focuses on the gate area of primary schools (PrSs) in Hanoi city. Schools are selected with different locations and characteristics. They are Le Ngoc Han, To Hoang, and Yen Hoa primary schools. The survey was conducted in April, 2018.

3.1 Survey preparation

The primary schools in which the traffic congestion frequently occurs were selected for the survey. The selection of schools should reflect the typical geographic location arrangement in Hanoi. Le Ngoc Han PrS is located in the old town and To Hoang PrS is located near Ring road No.1 where the traffic is very high. Beside, Yen Hoa PrS which is located in the new urban area was also considered for the survey and for the comparison of different geographic locations.

The survey of traffic congestion was conducted at two periods of rush hours: morning peak (7h00 - 8h00) and evening peak (17h00 - 18h00).

The survey was divided into 5 components which cover main attributes of traffic situation in front of school gates:

- Number of pupils and congestion levels.
- Transport infrastructure in the surrounding areas of school gates.
- Traffic management and activities in the surrounding areas of school gates.
- Characteristics of area around schools.
- Current solutions applied to ease congestion.

The preparation of survey was combined between desk study and site survey. Some methods were implemented: *i)* observing, *ii)* measuring, *iii)* counting, *iv)* recording, and *v)* re-checking video records.

3.2 Survey results

In general, the survey result shows the traffic congestion situation happened surrounding all three PrS gates. The main reasons are the illegal parking behavior of parents, the crowded traffic in peak hours and the location of schools as shown in Table 2.

Table 2 Situation of traffic congestion surrounding the school gates

No.	Items	Le Ngoc Han	To Hoang	Yen Hoa
1	Capacity (pupils)	1,100	1,150	1,500
2	Congestion (rush hours)	Yes	Yes	Yes
3	Level of congestion	Serious	Very Serious	Serious
4	Duration of congestion	Short time	Long time	Short time
5	Cause of congestion	Parents/ Vehicles	Parents/ Vehicles	Parents

The difference in the congestion level among schools has been identified. The school experienced the most serious congestion is To Hoang PrS. The congestion occurs before, within and even after the dismissal time of pupils despite the fact that the street is quite wider compared to two remained schools (the street width of 15m as shown in Table 3). The presence of To Hoang PrS seems making the traffic situation more serious. The main reason is the location of the school near Ring road No.1, which is the main corridor for connecting East to West of the city.

For the case of Le Ngoc Han PrS, the traffic is not so high but the street is quite narrow and only two-lane street. Therefore, parent's vehicles occupy one lane which makes other vehicles difficult to move through. Regarding Yen Hoa PrS, the traffic congestion was also happened, even though the school is located in a new urban area with recently planned in comparison with other ones in the city center. This may reflect the fact that the lesson has not been learned carefully to avoid.

All schools allow parents to park their vehicles around the entrance of the schools. Only To Hoang PrS opens the gate for parents to pick-up their children inside the campus. The support of authorities, volunteers during peak hours is relatively limited.

Table 3 shows that the sidewalk conditions at school gates are relatively good, but there are few pupils/parents who walk to schools. Mostly, pupils are sent to the schools by their parent by private cars and/or motorcycles. The reason can be they are living quite far from the schools and/or parents will go to work after dropping off their children. In addition, there is the lack of bus routes and/or bus stations near schools, thus parents/pupils have no choices of using public transport to commute to/from the schools.

Table 3 Sidewalk conditions of the school gates

No.	**Items**	**Le Ngoc Han**	**To Hoang**	**Yen Hoa**
1	Street width (m)	8	15	6
2	Street traffic safety (sign, traffic light)	+	+	+
3	School gate: sidewalk width (m)	3.5	5	2.5
4	School gate: trees, lighting, facilities	+	+	+
5	Opposite school gate: sidewalk width (m)	3.5	5	5
6	Opposite school gate: trees, lighting, facilities	+	+	+

Note: "+" Yes; "-" No

Table 4 shows that there are no parking spaces reserved for the schools and vehicles are not allowed to park on sidewalk. Hence, parents are to park their vehicles on the street which occupies spaces for other throughout vehicles and causes traffic congestion**.**

Table 4 Traffic and parking situations in the school gate zones

No.	**Items**	**Le Ngoc Han**	**To Hoang**	**Yen Hoa**
1	Street of school gate	two-way	two-way	two-way
2	Traffic flow in rush hour (vehicles/hour): motorbikes, cars, bus respectively	4200; 220; 20	5350; 265; 10	3200; 120; 30;
3	Activities on sidewalk (tea drink, eating)	+	-	+
4	Parking motorcycles on sidewalk	+	-	-
5	Bus station near school gate	-	+	-
6	Parking spaces reserved for schools	-	-	-

Note: "+" Yes; "-" No

Table 5 presents traffic conditions surrounding three school gates. To Hoang PrS is located along the ring road No.1, thus the through traffic is affected by concentrated traffic in front of the school gate during peak hours. There are no available spaces near the school gates which makes difficulty for parents to drop-off and/or pick-up their children.

Table 5 Traffic conditions at school gates

No.	**Items**	**Le Ngoc Han**	**To Hoang**	**Yen Hoa**
1	Heavy traffic condition in school gate during peak hours	+	-	+
2	Available parking spaces near school gate	+	-	-
3	Around school: Residence (R) or Offices (O)	R	O	R
4	Local (L) or Through (T) traffic streets	L	T	L

Note: "+" Yes; "-" No

Tables 6 reviews some solutions that have been recently applied to solve the traffic problem surrounding three school gates. However, the measures have been utilized individually and not yet integrated with other schools as a campaign or/and a comprehensive solution. Therefore, these measures are not significantly recognized.

Table 6 Measures applied for solving the traffic congestion at school gates

No.	**Items**	**Le Ngoc Han**	**To Hoang**	**Yen Hoa**
1	Stopping/parking in school campus	-	+	-
2	Traffic guidance at school gate	+	-	-
3	Involvement of traffic management agencies	+	-	-

4	Provision of separated lane for parents to pick up their children	-	-	+
5	Differently closing time for schools	-	+	+

Note: "+" Yes; "-" No

4. Proposed solutions for Hanoi city

There are basic guidelines for addressing traffic congestion at school gates around the world. Nevertheless, these guidelines are only being applied in developed countries, where the transportation system is much different from Vietnam, especially for the use of motorcycles and the behavior of pupil parents.

Based on the experience learned from other countries and the specific characteristics of traffic and living culture in Vietnam as well as the surveyed results, the research generally presents some measures for solving traffic congestion around school gates considered Hanoi's condition:

a) Traffic organization

- Prohibit cars during peak hours to go throughout the street at school gates.
- Manage the street at school gates from two-way into one-way during rush hours for cars and motorcycles also.
- Design traffic signals considered the traffic demand of schools.
- Provide information and guidance to eliminate traffic going throughout school gates during peak hours.
- Provide enough space (bay) in front of school gates in order to protect pupils directly from throughout traffic.
- Provide stopping spaces (meeting points) for cars and motorcycles to parents to drop-off and pick-up their children.
- Manage a separated lane and/or exclusive lane for pupils to commute between schools and meeting points.
- Prohibit activities (breakfast, coffee, shopping) on sidewalk around school gates.
- Provide necessary facilities for pupils to walk safety on sidewalk surrounding school gate areas.

b) Traffic demand management

- Separate dismissal time between different class in order to reduce concentrated traffic demand.
- Manage parking spaces near schools and provide exclusive lanes for pupils and their parents to walk to/from the school.
- Apply intelligent transport systems (ITS) to manage traffic demand such as making traffic dispersal, connecting with parents by smartphone to make appointments of picking up their children, providing information to parents through smartphone.
- Integrate traffic management issues when planning and designing schools.

c) Awareness campaign

- Raise awareness of road traffic law in schools for both pupils, teachers and pupil parents.
- Provide information to parents about the reserved places to drop-off and to pick-up their children.
- Encourage parents to select schools for their children near/around their living area.
- Provide information to encourage parents and pupils to use public transport, biking, walking.

d) Public transportation

- Provide public transport network and public routes in consideration of the context of schools.
- Make a lay-out of meeting points near schools and resident areas for parents to drop-off and to pick-up their children when using public transport.
- Promote the use of public transportation for both parents and pupils.
- Integrate intelligent transport systems (ITS) along with public transport for parents to manage the journey and time schedule to drop-off and to pick-up their children.

5. Conclusions

The traffic in front of primary school gates in Vietnam has significantly different characteristics in comparison with other countries. Therefore, considering specific conditions of Hanoi, the study has proposed four groups of solutions comprised of traffic organization, traffic demand management, awareness campaign, and public transportation. Given the situation that improvement of transport infrastructure or construction of parking lots are not always applied in all cases due to the limitation of available spaces. The solution of traffic demand management and awareness campaign have been identified that more feasible in Hanoi. Another potential solution is the use of public transport which has been recently expanded and in intensively developed in Hanoi city.

In addition, it is necessary to propose the legal framework and standards for planning and designing schools in considering traffic issue and traffic safety. This is very important for new schools in the future to avoid the similar situation. Measures that are specifically applied to schools in Hanoi to reduce congestion and to increase traffic safety for pupils could be applied to other cities in Vietnam as well other countries with the same context.

Preliminarily, the study has provided an overview the traffic issues in front of school gates and suggested several guidelines to improve the congestion situation. However, the scope of the survey is still very limited and thus study need to be addressed in more details in order to acquire sufficient solutions to reduce traffic congestion in front of school gates in Hanoi city.

6. Acknowledgment

The authors would like to express acknowledgement to Institute of Planning and Transportation Engineering (IPTE), National University of Civil Engineering (NUCE) Vietnam for their support, cooperation and providing materials for the study.

References

[1] HDOT (2017), *Report of Hanoi Transport Situation*, The 11th Conference of Party Executive Committee of Hanoi, XVI, November 19th, 2017. Hanoi Department of Transport.

[2] Bao moi (2017), *Hanoi: What are the exit routes for traffic jams at school sites?*. Access date: July 16th, 2018 at the website http://hanoimoi.com.vn.

[3] Petrocelli, J. (2008), *Traffic Congestion Around Schools.* Office of Community Oriented Policing Services, USA.

[4] Vigne, N.L. (2007), *The Problem of Traffic Congestion around Schools*. University at Albany-State University of New York, USA.

[5] PPD (2004), *Easing Traffic Congestion around Barron Early Childhood School*, Neighborhood Police Officer Unit, Plano Police Department, USA.

[6] Ipek, N. Sener. (2018), An examination of children's school travel: A focus on active travel and parental effects, *Transportation Research Part A: Policy and Practice*, 2018, ISSN 0965-8564.

[7] Ming L. (2017), Congestion and pollution consequences of driving-to-school trips: A case study in Beijing, *Transportation Research Part D: Transport and Environment*, Vol. 50, 2017, pp 280-291, ISSN 1361-9209.

[8] GTZ (2009), *Transportation Demand Management, Sustainable Transport*: A Sourcebook for Policy-makers in Developing Cities. German Technical Cooperation Agency (GTZ), Eschborn, Germany.

[9] Hiep, D.V (2016), Study on the application of intelligent transportation systems in managing and operating urban traffic in Vietnam. Research project under Ministry of Construction, code RD-84-13.

[10] Hiep, D.V (2017), *Intelligent Transportation Systems for Urban Areas*, Textbook, Construction Publish House, Ministry of Construction, Vietnam.

[11] TCVN 3907:2011 (2011), *Kindergarten – Design requirement*. Vietnam National Standard.

[12] TCVN 8793:2011 (2011), *Primary school – Design requirement*. Vietnam National Standard.

[13] TCVN 8794:2011 (2011), *Secondary school – Design requirement*. Vietnam National Standard.

[14] Tuan, V.A (2015), *Study on traffic safety in Vietnam*. Vietnam Traffic Safety Committee.

[15] Minh, C.C (2016), Study on traffic situation of high school pupils in Hanoi and propose solutions for improvement. Research project in Hanoi.

Strategy for multimodal transport development: case study of Hanoi-Lao cai corridor

Topic number: 01 Paper Identification number: AYRF 2018-023

Dr.-Ing. Le Thu Huyen[1], Dr. Pham HongNga[2]

[1] Section of Transport Planning and Management, University of Transport and Communications, Vietnam
Telephone +84 934514977, Fax. +84 24 3766 4053
E-mail: lethuhuyen@utc.edu.vn/huyen318@gmail.com

[2] Section of Mathematics, University of Transport and Communications, Vietnam
Telephone +84 913430550, Fax. +84 24 3766 4053
E-mail: phamhongnga@utc.edu.vn

Abstract

The transportation and logistics sector is particularly essential as it enables the country to have a competitive supply chain and opens future markets. Unfortunately, Vietnam's multi-modal transport and logistics industry is now still at the rather infancy stage. Locating in the ideal location of the gate to the ocean, Vietnam still cannot take full use of its strength with a rather poor and inappropriate infrastructure system. A large part of the country's logistics network has not been operated in an integrated manner, resulting in a high logistics cost (around 20% GDP), nearly double that of developed nations. Inefficient air and ocean transportation system and a lack of supporting infrastructure on the landside, including warehousing and depot facilities are hampering the growth of efficient logistics practices in the country. Therefore, it has raised the need of conducting research on the master plan of infrastructure development in Vietnam. The aim of this paper is to propose the strategy to develop multimodal transportation infrastructure in one strategic transportation corridor of Hanoi – Lao cai as a case study.

Keywords: multi-modal transport, infrastructure development, logistics and multi-modal transport, integrating mode of transport and logistics

1. General Introduction

Logistics is a system to ensure an effective and smooth movement of goods. Among major components of the logistics system both in macro and in micro level, infrastructure plays an essential and vital role. Logistics management and control in transportation corridors are important elements of freight transport and traffic is increasingly contributing into the success of import-export in the whole country. Locating in the ideal location of the gate to the ocean, Vietnam still cannot take full use of its strength with a rather poor and inappropriate infrastructure system.

Vietnam's multi-modal transport and logistics industry is now still at the rather infancy stage. A large part of the country's logistics network has not been operated in an integrated manner, resulting in a high logistics cost (around 21% GDP), nearly double that of developed nations. Inefficient air and ocean transportation system and a lack of supporting infrastructure on the landside, including warehousing and depot facilities are hampering the growth of efficient logistics practices in the country.

Therefore, it has raised the need of conducting research on the master plan of infrastructure development in Vietnam.

The aim of this paper is to propose the strategy to develop multimodal transportation infrastructure in one strategic transportation corridor of Hanoi – Lao cai as a case study.

We will present the state-of-the-art of the best practice and lessons learned in the field of multi-modal transport and logistics in a first step. The current status of multimodal transport and logistics service in strategic corridors and the corridor of Hanoi-Lao cai have been shown in the next part. Also in the part, there is explanation on the field survey to explore the current status of demand and supply of multimodal transportation and logistics in the local area.

The SWOT analysis has been conducted to find out the strategy needed to be implement. The results are finally discussed to propose the strategy for developing multimodal transportation in the studied corridor. An outlook and further research steps will be drawn in the conclusions at the end of the article.

2. State-of-the-Art

At the beginning, multimodal transport has been developed in Western Europe, America and then Canada and Asia. In 1960-1970, though multimodal transport rapidly developed with the "container revolution", it still faced with limitations in technology, organization and especially in regulation among countries and regions. In the 1980s, with the adaptation of the United Nations Convention on the International Multimodal Transport of Goods, there appear several other actors joining in such as national Multimodal Transport Operators, train stations, port authorities, institutes and insurance companies. From that time, there were many conferences and workshops about the development of multimodal transport.

Multimodal transport refers to the transportation of goods by at least two different modes of transport (such as road, rail, air or inland waterway, and short- or deep-sea shipping) as part of the contract where often a multimodal transport operator (MTO) is responsible for the performance of the entire haulage contract from shipping to destination (UN, 1980). The movement of goods could be within one country or international with additional procedures such as goods clearance at customs. With the massive growth in containerization and the avoidable trend of shifting from the conventional uni-modal to an integrating systematic approach, multi-modal is currently the main common and efficient transport mode used globally. The transportation method integrates all transport modes' optimization and organization into a continuous system aiming at achieving operationally efficient and cost-effective delivery of goods in the supply chain.

A combination of different features of each transport mode normally can solve additional constraints on goods during transportation such as packaging, transportation conditions and storage. On the other hand, multimodal combines the specific advantages of each mode in one voyage, such as the flexibility of road haulage, the relatively large capacity of railways and the lower costs of short/deep-sea transport in the best possible way [11]. Moreover, in comparison with road transport, which plays a relatively dominant role in the traditional freight transport in Vietnam, several alternative modes of transport, such as rail, inland waterway and short sea shipping, are widely recognized as being less harmful to the environment as well as the social economics benefit in general.

With multiple characteristics of each mode, an added complication is the management of the whole seamless multimodal transportation process which is complex and involves different players such as freight forwarders, third-party logistic service providers, couriers, carriers of different modes of transport, MTOs, rail, sea carriers, port and intermodal terminal operators [8]. The communication between these parties has to be precise, timely and costly efficient to ensure the flawless and visible delivery process. Such requirements may be challenging due to different technologies deployed by different companies. The diverse nature of managing the multimodal transport chain is supported by a series of activities, in which each phase needs to be optimized and possibly integrated with other activities for effective and efficient business operations: transportation order handling (delivery schedule, forecasting); prepare the transportation chain (select and contract actor services); prepare transportation (loading, customs); perform transportation (reports on unloading, loading, damage); monitor transportation (track vehicles and drivers′ behaviour); and terminal operations (control loading/unloading, manage stock terminal) [9].

In the fact, it can be seen that logistics service can work only in the region and countries with the sustainable infrastructure, especially transportation infrastructure. Seaport plays a very important role, deciding the development of logistics industry in each country. The seaport is the central point to connect all other domestic transportation modes such as railway, road, inland water way, etc. Transportation is the key in improving the quality of logistics service and competition advantage of manufacturer and exports.

At the same time, logistics industry is the major economic connection going through the whole chain of goods production and distribution. Logistics acts as the essential element to push the economic development at regional seaports, international gate in order to improve the operation capacity and efficiency in the seaport as well as other transportation mode. It can be said that logistics service plays the key role in efficiently operating maritime and other transportation mode.

It is needed to emphasize that modal logistics infrastructure suffers from a number of shortcomings that are currently being addressed through infrastructure investment programs. It is important, however, that these programs must be complemented by "soft" measures to ensure optimal use of existing as well as planned infrastructure.

Currently, in some part of the world, trade data is preserved only in monetary terms. Another difficulty that has challenged many researchers is the variety of trade forms. Especially in cross border trades, where several forms of trade are generally undertaken informally. In a formal trade, transactions are conducted through proper customs procedures under government rules, regulations and supervision, whereas informal trade involves transactions that may bypass or evade these procedures. In Vietnam, choice of domestics transport is rather limited due to lack of infrastructural connectivity and services. Other types of inland transport, such as rail and IWT cannot compete with road haulage in terms of cost and flexibility. From the above-mentioned fact, Vietnam IWT network has been operated inefficiently despite of total length. The same situation can be seen in the railway industry, especially in the case that Vietnam Railway is a monopoly enterprise working in the field with a low-tech, unsafe services in a bad quality. As a result, rail is not widely used for either passengers or freight. With the current climate of global trade competition, it is obvious that the challenges in logistics and transport cost reduction could just be overcome through integration of Multimodal Transport operation.

In the context of international transport operations, classic measures of generic trade-off variables have been widely applied in several academic studies with regard to Multimodal Transport corridors. For example, Banomyong and Beresford (2000) [2] presented routing options from Vientiane (Lao PDR) to Rotterdam (Netherlands) using the Beresford Cost Model which presented the trade-offs between commercial factors such as cost, time and distance. Similarly in [3] , various international routings from Lao PDR to Marseilles (France) are presented under the Multimodal Transport operation concept. It is worth noting that for landlocked countries such as Lao PDR or Mongolia, a Multimodal Transport network can be readily used in the implementation of efficient freight movement solutions [2],[3].

Other than international corridors (i.e. Europe to Asia or Europe to Africa), regional Multimodal Transport corridors in areas such as Pacific Asia, Europe and Southeast Asia are also found in the literature. For example, in [11], Rodrigue focused on the feasibility of running Multimodal Transport systems in the Pacific Asia region (Thailand, Japan, South Korea, Taiwan, Indonesia, Singapore and Malaysia). He found that an uneven distribution of economic and transport activities exists along the corridors, which had led to inequalities of competitive advantage and thus affects economic productivity. Nevertheless, when dealing with Multimodal Transport, it should be recognized by implication as 'international' in nature, and it must cater for these inequalities.

In conclusion, integrating logistics and multi-modal transportation industry must be the focus of such developing country as Vietnam in this century. The logistics development strategy established the need for the integration of the modal development plans both in terms of infrastructure and of service development. This logistics development strategy consequently proposes further initiatives that can help support specific infrastructure development in Vietnam. The question raising now is that how this strategy can be adopted in multi-modal transport with rather limited capacity and investment source.

3. Current status of multi-modal transport and logistics service in strategic corridors

3.1 Vietnam logistics industry

In Vietnam, logistics and multimodal transportation service has just been established with the low competition. The industry is rather limited at the rate of 4-6%GDP (World Bank Report 2014). Logistics Performance Index (LPI) of Vietnam is evaluated to be at the rank of 53 (2012), 48 (2014), and 64 (2016). Toggle Rank and Score for Sub-indicators can be seen in the following table.

Table 8. Vietnam LPI Score and Rank through years

Year	LPI Rank	LPI Score	Custom	Infras.	International Shipment	Logistics Competence	Tracking & tracing	Timeliness
2016	64	2.98	2.75	2.7	3.12	2.88	2.84	3.5
2014	48	3.15	2.81	3.11	3.22	3.09	3.19	3.49
2012	53	3	2.65	2.68	3.14	2.68	3.16	3.64

Source: http://lpi.worldbank.org

It can be seen that the main reason of low performance in Vietnam logistics market is the (i) custom procedure, (ii) logistics competence and (iii) infrastructure. Among them, the worst indicator is infrastructure related to commercial and transportation service (seaport, railway, road, information technology) which are not synchronized, in bad connection. Especially, the road capacity is very bad due to congestion and traffic accident. Multi-modal transport does not develop with the unbalance among different modes of transport. The major transport is the road transport with low development, service quality cannot compete with regional countries. There has not yet established considerable logistics hub for goods centers. Inland Container Depot (ICD) have been established all around the country but not enough.

The market shares of Inland Waterway Transport (IWT) and coastal shipping in Vietnam are high, even when compared with that of the road sector. Both sectors are expected to substantially grow further in the future, but other modes, especially roads, are expected to grow faster. While

IWT currently serves mainly bulk cargo shippers and captures only a small share of container volumes, experience from Europe suggests that inland waterways, when efficiently connected to ports and roads, can carry higher-value, time-sensitive goods on a more consistent basis. IWT has a fairly strong competitive position for shipments in the 100–300 kilometer length of haul range, with a dominant position for shipments in the 100–200 kilometer range. Coastal shipping, on the other hand, dominates shipments traveling distances of 1,400–1,600 kilometers, which are mostly linked to the trade between the North and South regions. In other cases, the road sector is the main transport mode.

Vietnam's multimodal transport network, in terms of physical and regulatory infrastructure, is at an early stage of development. Indicators on logistics performance show that Vietnam's logistics costs are relatively high compared to those of some of its regional peers. Efficient handling in ports is a prerequisite for successful competition with other transport modes. The role of (Third Party Logistics (3PLs) is still limited, although numerous players have already entered the market, and their role is growing.

There is as yet no multimodal transportation corridor in Vietnam. The need to define improved freight transfers, such as between the road network and ports or airports, between the road network and railway loading bays, or between barge delivery area and trucks is becoming increasingly important.
The reason is mainly institutional. The transportation system is organized by transportation mode, and no single mode is focused on creating "multimodal chains" and "seamless transfers at nodes" that are needed to lower transportation costs.
Inadequate infrastructure has always been cited as the reason for Vietnam's high logistics costs, estimated by some at 25 percent of GDP. This is higher than China, Thailand, or Japan. Accordingly, Vietnam has embarked on aggressive programs to improve ports, road, rail, waterway, and airports infrastructure.

More than these, modern logistics demand a parallel development of the "information and communications highway." Here, one may think of electronic documents and web-portals to share travel information. And yet, logistics cannot wait for the completion of all of these elements before it can be globally competitive.

A multimodal framework is invaluable in identifying bottlenecks and weaknesses across the supply chain. Targeted intervention is the key to improving Vietnam's logistics performance. According to the World Bank 2008 survey on logistics performance, domestic transportation cost is not a main issue. Rather, the poor timeliness of shipments is at fault, which, in turn, leads to higher than needed warehousing and inventory costs. Creating electronic portals that can link the various logistics players (such as freight forwarders, Customs, Truckers, Shippers, Rail freight companies, Manufacturers, etc.) will be one important intervention. The easing of cross border trade procedures is another, since Vietnam ranked poorly on this dimension compared to other ASEAN countries.

3.2 Strategic corridors in Vietnam

Vietnam has an extensive amount of inland waterways, of which 41,900 kilometers are navigable and 15,000 kilometers are under central management. The core sections in the North and South regions (about 4,500 kilometers) are classified as the highest waterways classes. Investment projects have been defined for a few of these core sections, but public funding for improving and maintaining the waterways appears to be insufficient. Vietnam has 7,000 river ports and landing stages, but only about 30 are of major importance for cargo flows. A large number of the landing stages are neither licensed nor regulated, and while they are convenient to the industries located along the river bank, they also hinder navigation and safety. Vietnam also has 49 seaports, of which the most important ones are located in the North region, around Haiphong, and in the South region, around HCMC. Vietnam is expected to encounter various impediments to the use of larger vessels because of infrastructure bottlenecks. It is also worth noting that the rapid scaling up in Western Europe and in the Netherlands, in particular, was facilitated by government tax advantages and other financial incentives. While Vietnam has not resorted to any incentives so far in the scaling up of its fleet, which was largely driven by market forces, incentives could speed up the modernization and scaling-up process.

The transport corridor is defined as a set of transport routes parallel with each other, comprising one or more transport modes, bringing about significant impacts on socio- economic development on the area located alongside, and forming arterial system of national transport network in integration with other transport corridors. The transport corridor intends to connect main urban areas and production centers each other with transport modes for trade of goods and visits by people. Therefore, the transport corridor is expected to provide the users with efficient seamless and cost-effective services all the year round.

The role of transport infrastructure in such a corridor is to maintain, strengthen and accelerate the economic growth in relevant economic regions and to keep up the trade competitiveness of the country in particular. Therefore, the development of transport corridor should be planned strategically taking into account the vision for economic growth, narrowing the regional disparity and strengthening the competitiveness and effectiveness of logistics performance.

In JICA (2009), five (5) types of transport corridors in Vietnam have been identified as follows:

(1) National Backbone Corridor
(2) International Gateway Corridor
(3) Land-bridge Corridor
(4) Regional Corridor; and
(5) Metropolitan Ring Corridor

Main problems facing with the strategic corridors in Vietnam can be summarized in different aspects as follows:

- Traffic congestions are rather serious with the unbalance of supply and demand side.
- Flooding/drainage, traffic safety and parking are main problems.
- Logistics infrastructure:
  - Freight transportation depends much on road network
  - Most of cities suffer from limited capacity of marine ports (if any), inland waterway, railway system and road network
  - Lack of modern and advanced logistics infrastructure and facility
  - Lack of intermodal transportation system
  - 10-60% of urban roads including national, provincial and city roads are in poor surface conditions.
  - Road hierarchy is unclear in many cities. In some cities, urban and inter-city traffic are mixed in urban areas
  - Maintenance is lacking in all cities.
- Communication network and IT application:
  - Internet and communication network has been developed in almost MSCs
  - Most of enterprises combine IT and manual measurements in logistics management system. The highest ratio of IT application is in the field of order management.

– Resettlement is becoming increasingly a serious concern.
– Funding is insufficient and unstable for infrastructure development.

3.3 The corridor of Hanoi-Lao cai

Hanoi – Lao cai corridor belongs to group 3, acting as an important link in the freight flow of Hanoi – Haiphong/Quang ninh – Lao cai – Kun Ming.

Fig. 1 The corridor of Hanoi-Lao cai

This corridor includes 5 provinces (Hanoi, Vinh Phuc, Phu Tho, Yen Bai and Lao Cai) and its length is around 260 km from the Hanoi Outer Ring Corridor stretching north-west up to China border. Due to the accession to the World Trade Organization (WTO) by both countries the cross-border trade has been increasing rapidly in terms of both passenger and freight traffic. Because of the policy change of Chinese Government with respect to the overseas travel permit to Chinese citizen, the number of Chinese travelers has been rapidly increasing since 10 years ago. The topography is generally moderate along the Hong River valley, but the road gradient is partially steep on the hilly area surrounded by mountains. This corridor forms a part of Asian Highway Network as well as the Kunming Singapore Railway Link. To improve this international corridor, various infrastructure projects are promoted led mainly by ADB.

The total population in the influence area of this transport corridor is around 7.5 million as of 2016 and is forecasted to grow to 10 million in 2030. The average growth rate of GRDP in the past 10 years was around 14%, which is rather higher than the national average.

The main modes of transport of this corridor are road (NH2 and NH70) and railway, though the Hong River is sometimes used for inland water transport. The road and the railway are situated in parallel with a certain distance apart from each other. The corridor itself is straight forward with a few intersecting roads.

The cross-sectional traffic of all modes at present is about 6-34 thousand passengers/day and 9-31 thousand tons/day for passenger and freight, respectively. The demand obviously becomes small near the China border. Passenger traffic is shouldered by bus, car and railway, while freight traffic depends on truck and railway at present. In this corridor, the use of railway is intense both for passenger and freight transport, almost comparable to that of the North-South Coastal Corridor.

The condition of the roads of this corridor needs improvement. 40% of NH2 is in "bad" condition, and NH70 is further worse with 35% in "very bad" and 20% in "bad" condition. In contrast, the bridges are relatively well maintained. Road structure should be strengthened.

The railway is relatively well maintained reflecting probably the intense use at present. Speed restriction on the bridges is only up to 30km/h, which is better than the Hanoi-Saigon line. However, the railway faces a major problem in relation to alignment. Since the track is on the slope along the river, it is often damaged by landslides and soil erosion. If drastic measures are required for capacity expansion, realignment should be seriously considered.

Inland waterway of this corridor is designated by VIWA's master plan as "Core Axis". The expected role is to transport bulky cargoes such as apatite, phosphate, coal and cement. To do this, the current water channel needs a considerable improvement to a width of 50m and a depth of 1.5m at least.

At present the container traffic of this corridor is limited because of a lack of container handling equipment at freight stations and rolling stock needed for container transport.

In terms of geography, this corridor run through a mountainous area. In the hilly/mountainous part of this corridor, special attention is required for soil erosion and possible earthquakes.

Logistics service in recent years have sufficiently served business and export & import activities in Hanoi and NFEZ provinces. However, logistics industry still face a lot of problems. The research has developed a survey in 278 enterprises, including logistics providers and customers.

During the survey, logistics providers pointed out problems in supplying the service in the selected corridors. Some criteria have been evaluated as "serious", for example "delivering timely and correctly as request" (70% respondents), competition with other companies (65%), and infrastructure condition (55%).

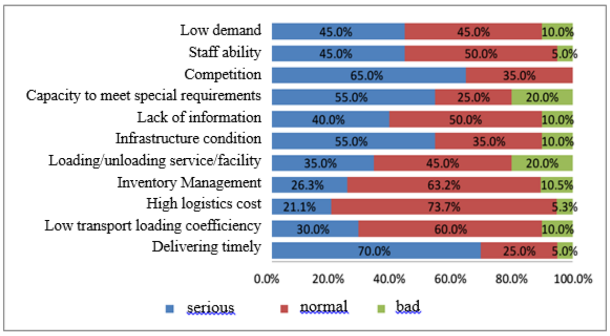


Fig. 2 Problems and challenges of logistics providers

The main reason leads to the problem of goods delivering is the transport infrastructure. The survey also focused in evaluating the transport infrastructure from logistics providers. The respondents evaluated the challenges by grading from 1 ("very serious") to 5 ("no problem"). Most of the items of infrastructure is rated as below the middium (less than 3 points). The following table shows the results.

Table 2: Challenges in transport operation

Items	**Average Grade**
a. Geographic road design	1,54
b. Road conditions (e.g. pavement,…)	1,53
c. Traffic condition (congestion)	1,47
d. Loading/unloading condition, facility	2,9
e. Parking	2,19
f. Road and other fees	1,49
g. Operation license	2,31
h. Fees for operation license	2,83
i. Fee adjustment	2,89
j. Competition	1,57
k. Cost for new vehicles	1,57
l. Cost for purchasing materials, accessories, v.v...	2,97
m. Maintenance service quality	2,85
n. Driver	2,25
o. Low demand	2,14
p. Police enforcement	1,57

Logistics customers have been asked for their satisfaction when using outsourcing services (with the grades from 1 ("very unsatisfied") to 5 ("very unsatisfied")). The following table shows the results of evaluating logistics service provided by enterprises:

Table 3: Satisfaction of enterprises when using outsourcing logistics

Item	**Average Grade**
a. International transportation	
- Maritime	3,79
- Airlines	3,45
- Road	3,37
- Railway	3
- Inland waterway	3,21
b. Domestics transportation	
- Maritime	3,49
- Airlines	3,48
- Road	3,52
- Railway	3,03
- Inland waterway	3,11
c. Other Logistics services	
- Customer agents	3,28
- Warehousing service	3,36
- Inventory/distribution center service	3,43
- Freighforward service with shippers/airlines agents	3,48
- Payment service	3,29
- Service of transport planning, inventory management, goods order management	3,2
- Other goods services (packaging, labelling, consolidating,…)	3,16
- Procedure for C/O, quality assurance…	2,88

It can be seen that logistics services related to railway, inland waterway are evaluated as the services with lowest satisfation from customers.

4 Strategy solutions for developing multimodal transport and logistics service

4.1 SWOT analysis

SWOT analysis has been established from the field survey ((as mentioned above) and expert interview. Such experts are chosen from national to provincial authority, research institutions and consultants, who are very familiar with the corridor.

Strength:

- ✓ The corridor plays a strategic role in the North Economic zone.
- ✓ Along the corridor, there is development of transportation modes, including the highway of Hanoi-Laocai, railway and inland waterway, with comfortable conditions to develop multi-mode transportation, in order to highly support logistics development.
- ✓ In recent years, provinces paid a lot of attention into improving transportation infrastructure, especially road and railway network, as well as communication system.

Weakness:

- Inland waterway and railway transportation still cannot take full advantages along the corridor
- Lack of multi-modal connection with transportation and warehouse system, lack of standardized chain and network connection
- Most of logistics suppliers just provide single services, the service of 3PL has not been reached; the service is unreliable and unforecasted for the freight forwarding.
- Lack of well-educated human resource for managing logistics and supply chain;
- Low rate of IT application in service logistics providers with the expensive international communication.

Opportunity

- ✓ Available modern and advanced logistics facility can reduce the pressure (temporarily) and provide chances for potential logistics industry to develop
- ✓ The high demand for logistics service in the region and surrounding
- ✓ Vietnam becomes a WTO member, signed the TPP and other international convention
- ✓ VN has positively purged commerce through the border gate, especially with countries in the extended GSM;
- ✓ Large FDI can bring new technology and help supporting modern and advanced logistics service in Vietnam;
- ✓ Mutual commerce and transportation charter with Laos, Cambodia, Thailand, and China will help reducing logistics barrier in importing and exporting goods, improving forwarding time;

Challenges

- State protection institution over logistics service may slow down the 3PL development.
- Global economics crisis.
- Increasing oil price in the long-term trend and global climate change lead to increase in transportation cost.

4.2 Proposed strategy for the corridor of Hanoi-Lao cai

In terms of logistics development initiatives, Vietnam has a rather ideal geographical position (connection point from inland to the sea) to establish a world-class logistics system. From that perspective, two main objectives have been put forward:

(i) To enhance trade facilitation with the aim of increasing cost efficiency, customer responsiveness and reliability and security.

(ii) To create added value for the logistics and other supporting industries.

Despite the level of the logistics development initiatives, key considerations of both objectives strongly reflect the shippers' need to elevate their performance in the current competitive global market. The aim of increasing cost efficiency, customer responsiveness and reliability, security and value are, with slight variation, embedded in the core of all shippers' business strategies. These two objectives are divided into five logistics develop strategies, which are: (i) business logistics improvement, (ii) transport and logistics network optimization, (iii) logistics service internationalization, (iv) trade facilitation enhancement and (v) capacity building.

From such analysis, it is proposed the strategic target for the government to develop the regional connectivity to enhance the capacity of multimodal transportation in the selected corridor. The main objective cargo to be focused within the logistics system shall be importing and transition cargo (in both directions) through seaports, railway, road and airline, aiming at container.

Then, the study conclude with the following strategy for the corridor of Hanoi-Laocai.

- Development Target:
  - ✓ To enhance trade facilitation with the aim of increasing cost efficiency, customer responsiveness and reliability and security.
  - ✓ To create added value for the logistics and other supporting industries.
- Development Objectives:
  - ✓ Establishing the chain of logistics services in the Northern Economics Focal Zone, with the selected corridor of Hanoi (Hai phong/Quang Ninh)-Lao Cai-Kunming acting as the backbone strategic corridor of multimodal transportation;
  - ✓ Vietnam NEFZ plays an important role as the gate of logistics chain into ASEAN and APEC countries;
  - ✓ Developing a comprehensive and inter-connection logistics network for Hanoi and surrounding area.

Aiming at such targets and objectives, in order to overcome the challenges and weaknesses, as well as take full use of opportunity and strength, it is required to develop the integrated system of logistics and multimodal transport in the corridor with the following strategy:

Issues	Recommendation	Action Plan
1. Limited capacity of multi-modal transport	Investment on infrastructure Enhancing capacity of communication and IT application in management Ensuring terminal connection with national logistics system	• Standardizing infrastructure and service • Developing and applying IT in managing transport network and terminal • Further developing the system
2. Limited capacity of inland waterway	Improving inland waterway network	• Upgrading inland waterway ports and improving multi-modal connection
3. Limited capacity of road network	Enhancing capacity and improving standards of road transport system	• Controlling the axle loading capacity • Applying road certification
4. Limited capacity of railway system	Improving national and local railway system	• Improving the management of railway freight transportation • Designing and using the system of monitoring freight and wagon. • Centralized controlling trains
5. Lack of interconnection and modern logistics infrastructure and facility	Developing logistics centers/parks to improve the logistics system Improving connection and standardizing national distribution network	• Developing regional logistics centers/parks • Establishing distribution centers at national, regional and local levels • Implementing master plan of multi-modal transport and logistics network

5. Conclusion

From the study, it can be concluded that the logistics performance of Vietnam in general and the corridor of Hanoi-Laocai in particular is not comparable to its potential.

Main issues facing with logistics and multi-modal transport can be mentioned as:

- Accelerating urbanization requires sustainable and balanced urban/regional development;
- Big gaps in planning and management capacity;
- Logistics infrastructure limitation and low capacity, quality;
- Inappropriate management and operation in logistics enterprises.
- Low capacity in both government and local management, as well as service providers

The strategy and solutions in developing multi-modal transportation infrastructure lead to the following lessons learned for strategic corridors:

- Enhancing the capacity of multi-modal transportation service in the strategic corridor is essential in the current context;

- The highest priority is standardizing and integrating the system of multi-modal transport and logistics services in terms of (i) connecting and integrating technical infrastructure; (ii) logistics and transportation technology standardized with countries in the selected corridor; (iii) capacity of supplying and using logistics services of enterprises.
- Other elements needed in developing the multi-modal transport shall be:
    - Conducting the master plan of logistics infrastructure with the support from inter-connecting transportation network (national and regional).
    - Developing logistics centers/parks at regional and local areas.
    - Developing communication network and IT application, improving logistics service.
    - Enhancing capacity from authority, management to enterprises operating in the logistics field
    - Controlling the process of master planning and implementation
    - Developing convenient conditions for private section to invest into constructing and operating logistics and multi-modal transport infrastructure

The study just stop in proposing the strategy and action plan for developing multimodal transport in Hanoi-Laocai corridor. The feasibility and efficiency of the proposal are not yet mentioned. It should be the next step in conducting the research.

6. Acknowledgment

This research is supported by National Foundation for Science and Technology Development (NAFOSTED) of Vietnam, project code: 101.99-2016.20.

References

[1] Banomyong, R., P. Cook, and P. Kent. 2008. Formulating regional logistics development policy: the case of ASEAN. *International Journal of Logistics Research & Applications*, Vol. 11, No. 5, pp. 359–379.

[2] Banomyong, R. 2000. Multimodal Transport Corridors in South East Asia: A Case Study Approach. Cardiff: Cardiff University. *Cardiff Business School PhD thesis*.

[3] Banomyong, R., P. Cook, and P. Kent. 2007. Regional Logistics Policy Formulation: The Case of ASEAN. *Logistics Research Network (LRN) Annual Conference Proceedings*. Hull, United Kingdom. 5–7 September. pp. 536–542.

[4] Liberatore, M. J., and T. Miller. 1995. A Decision Support Approach for Transport Carrier and Mode Selection. *Journal of Business Logistics*. 16 (2) pp. 85–115.

[5] Chikan, A., (2001) Integration of production and logistics – in principle, in practice and in education, *Int. J Pro Econ 69* (2):129-140.

[6] Federal Ministry of Transport, Building and Urban Development of Germany (2010) *Freight transport and Logistics Action Plan – Logistics Initiative for Germany*

[7] Friozenzo-Catalano, M.F., (2007) Choice Set Generation in Multi-Modal Transportation Networks, *Doctoral Thesis in TU Delft*.

[8] G. Marchet, A. Perego, S. Perotti (2009) An exploratory study of ICT adoption in the Italian freight transportation industry, *Int. J. Phys. Distrib. Logist. Manag.*, 39 (9), pp. 785–812

[9] INFOLOG (1999) INFOLOG: Intermodal Information Link for Improved Logistics. *Public summary report*.

[10] Rodrigue, J.P. (1996), Transportation corridors in pacific Asian urban regions, in *Proceedings of: the 7th World Conference on Transport Research*, Hensher, D., King, J. and Oum, T.H. (Eds.), Pergamon, Oxford, pp. 571-587

[11] Zaheer, R., (2008). Multimodal transport and logistics: best practices, achieving greater efficiency and challenges. *Proceedings of the 1st Arab Logistics & Multimodal Transport Conference*. Amman, Jordan.

Estimation of Disaster Damage Costs by Urban Flood and Impacts of Adaptation Policies - The Case Study of Khon Kaen, Thailand

Paper Identification number: AYRF18-024

Noriyasu TSUMITA[1], Hiroki KIKUCHI[2], Atsushi FUKUDA[2]

[1]Program of Transportation Systems Engineering
Graduate School of Science and Technology, Nihon University
Telephone +81-47-469-5355, Fax. +81-47-469-5355
E-mail: csno18006@g.nihon-u.ac.jp

[2]Department of Transportation System Engineering
College of Science and Technology, Nihon University
Telephone +81-47-469-5355, Fax. +81-47-469-5355
E-mail: hiroki.kikuchi@nihon-u.ac.jp, fukuda.atsushi@nihon-u.ac.jp

Abstract

In recent years, disasters such as rain, drought and sea level rise are occurring frequently due to the extreme weather, which is thought to be the influence of the global warming problem. Especially, many urban areas in developing countries are suffering from flooding, and the damage is extremely serious. Therefore, this research aims to estimate the damages on urban activities caused by flooding and evaluate the impact of adaptation policies on reduction of its damage. Many adaptation policies are related to not only transportation system but also urban planning so that its impact should be evaluated by employing the Land Use Transport Interaction model (LUTI model). In this research, the Metropolitan Activity Relocation Simulator was employed and applied in the case of Khon Kaen city in Thailand. The simulation was carried out for 20 years from 2010 to 2030. Acceding to strategies against to flood in Thailand, the elevation of major roads and population of migration from high-risk zones to low-risk zones were nominated as the adaptation policies. As the indicators to clarify the impact of the adaptation policies, travel time reduction, average travel time, and population distribution were obtained as well as damage costs about housing and workplaces. It is observed through our simulation that adaptation policies reduce the average travel time by a maximum of 16 minutes in the northeastern zone. Further, the total of travel time reduction is reduced travel time leading to movement saving 876 mil-THB in 20 years. In terms of land use, migration of adaptation policy reduced population in the high-risk zone with housing damage about 588 mil-THB in 20 years. Therefore, we show that adaptation policies can help in mitigation the damages in this research.

Keywords: Flood, Adaptation policy, Flooding damage costs, System dynamics, Khon Kaen

1. Introduction

In recent years, mitigation policies for CO_2 emissions reduction are implemented in a solution for global warming problem in many cities. However, it is expected to take a long time before these effects are exerted. In the meanwhile, urban disasters occur frequently, and the damages are increasing by climate change, in the Asian region. Thus, adaptation policy should implement in order to reduce the damages of urban disaster. In this regard, many researches have been done to estimate the costs and an impacts of adaptation policy. However, urban disaster used to occur unexpectedly and frequently so that the costs and impacts should be estimated for certain time period in a dynamic way.

Therefore, this research focused on estimation of flooding damage costs related to implementation in adaptation policies and dynamic evaluation of adaptation policies on transportation and land use fields. The impacts of adaptation policy and damage costs were estimated by using the MARS developed by Pfaffenbiher (2003) and flooding model based on system dynamics theory (SD).

2. Literature Reviews

There have been a number of researches discussed adaptation policies to reduce the damages. For example, Aprico, et al. (2017) are indicated that limitation of adaptation policies and potential impacts on transportation filed, in addition to evaluate a sustainability in long-term and preference in short-term. Moser (2012) summarized the tradeoff between mitigation policies and adaptation policies. Stamos, et al. (2015) indicated that climate change and extreme weather are impacts of urban activities and transportation networks. And this research developed a roadmap of adaptation policies for reduction of vulnerability and risk. Pregnolato, et al. (2015) assessed the impact of flooding on the network performance using macroscopic urban travel time which researches used GIS to compare the different perception conditions.

Moreover, many existing studies modeled on land use to evaluate any adaptation policies for floods risk and water damage by climate change. For example, Koks, et al. (2014) developed land use, inundation and damage models to estimate expected annual damage (EAD) by flooding. Feyen, et al. (2009) assessed difference condition about comparison older condition (1960-1990) and future predictive condition (2070-2100) EAD using by climate change and urban land use changes model in each European Country. This research shows that EAD changes 1.2 million Euro to 9.3 million Euro about 7.85 times in Denmark. Freedy, et al. (2016) summarized transition of relationship land use pattern and flood risk around the Mediterranean. This research is shown that the high variability of damage is bigger the spatial human activities than natural variability. And some existing researches are discussed urban disasters in Asia cities. For example, Sawada, et al. (2014) understood causing land price and workplace location choice influence on flood risk in Bangkok. Madan, et al. (2015) summarized adaptation policies for transportation infrastructure to consider the risk of climate change. On the other hands, some researches have developed any model by using SD. For instance, Preston, et al. (2007) modeled by using SD to discuss adaptation policies for reduction of damages caused to climate change. Bazkar, et al. (2013) developed a flood and land use model by using SD in order to investigate the most effective factor of flooding in Tehran, Iran. Hasse (2013) developed any models concerning about flood risk by using SD.

However, these existing researches are not estimated quantitatively flooding damages costs and not evaluated adaptation policies on transport and land-use fields dynamically. Therefore, in this research, the damage costs caused by flooding was estimated dynamically by using the MARS and flooding model based on system dynamics theory.

3. Methodology

3.1 Study Area

In this research, Khon Kaen city was selected as a case study. Fig. 1 shows the location of Khon Kaen city in Thailand. It covers an area of 551 km^2 and has a population of 0.25million in 2010.

Fig. 1 Location of case study area

In recent years, the inundation is affected by flood occurrences in the rainy season (from June to October) in this city. Fig. 2 shows the probability of the inundation areas that could be affected by flooding based on the statistical data from 2005 to 2016. (Thailand Flood Monitor, 2018). In this research, Khon Kaen city by 50 zones is separated by using GIS and expressed probability of inundation in each zone. In particular, zone 47 and 48 in the south area are the high probability of inundation (probability of inundation respectively: 75%, 66.7%).

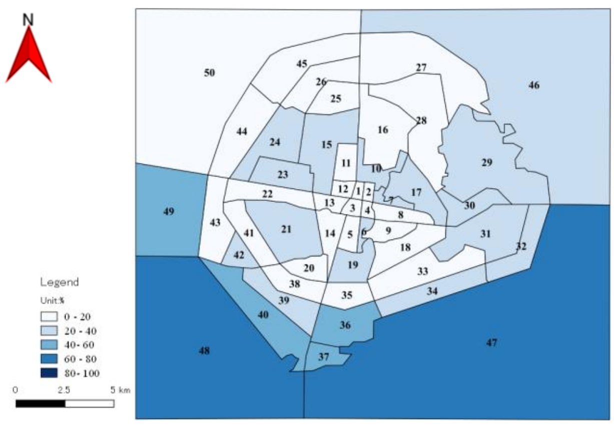


Fig. 2 Probability of inundation in Khon Kaen

And Fig. 3 shows the actual condition of flood occurrence in Khon Kaen. People who are living in the urban area are suffered from flood occurrences in every rainy season as shown in these photos.

Fig. 3 Inundation situations on flood occurrence in Khon Kaen

3.2 Overview of MARS

This research assessed adaptation policies for the flood occurrences by using the Metropolitan Activity Relocation Simulator (MARS) based on principles of system dynamics and implemented in Vensim®. Fig. 4 shows that overview of the MARS.

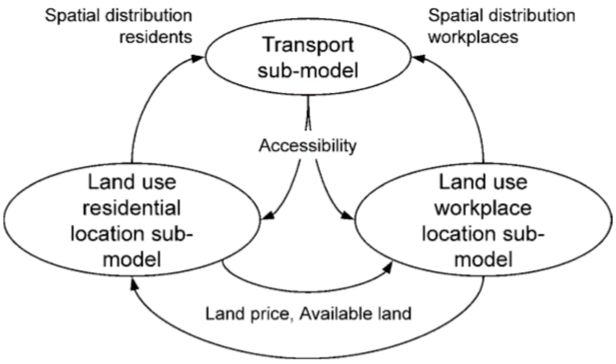


Fig. 4 Overview of MARS (Pfaffenbichler, 2003)

The MARS is one of the transport and land use interaction (LUTI) model. This model is composed of transport sub-model and land use sub-model. Transport sub-model simulates passenger trip about the trip generation, trip distribution and mode choice which is calculated based on the gravity-type model. The MARS accounts for pedestrian, bicycle, car, motorcycle, rail, and bus (this research focused on bicycle, car, motorcycle, and bus). The trip purpose is subdivided into working and others. Land Use sub-model simulated population migration within the different zones based on the attractiveness of each zone which attractiveness is calculated accessibility by Transport sub-model, housing costs, and recreational areas. Each sub model is feedback action by using accessibility and population distribution.

3.3 Flooding Model

This research is d the flooding model to simulate the risk of inundation. Fig. 5 shows the structure of the flooding model.

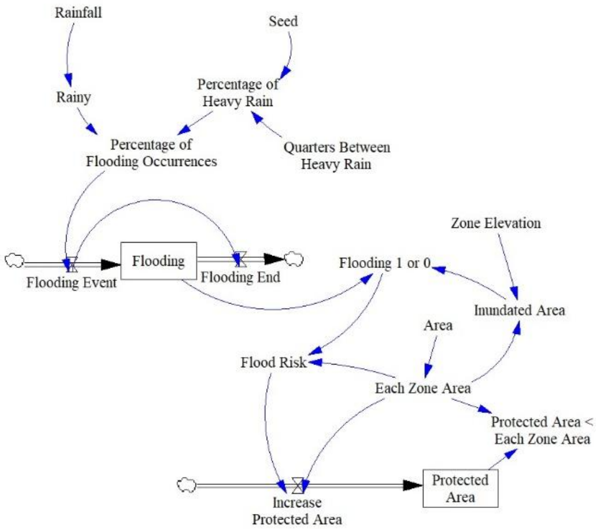


Fig. 5 Structure of flooding model

This figure shows that probability of flooding occurrence was simulated by using equation (1) - (3). Equation (1) shows the difference between Flooding End and Flooding Event about flooding. And this equation is expressed the flooding occurrence. Equation (2) is calculated the percentage of flood occurrences used random function including rainfall data based on statistical data in the past about Flooding Event. Additionally, Equation (3) is shown about Flooding End. This equation represents a disappearance of flood and is calculated by flow variable of Flooding Event in the delay function. 100 times. This research was decided to if the value of flooding exceeds more than 1.0, the flood occurs.

Fig.6 shows that the result of the sensitivity analysis of flood occurrences. This model is calculated probability of flooding occurrence based on equation (1) – (3)

Flooding =
INTEG (Flooding Event-Flooding End, 0) (1)

Flooding Event =
RANDOM POISSON (0, 99999, Percentage of Flooding Occurrences, 0, 1, 0) (2)

Flood End =

DELAY FIXED (Flooding Event, 0.25, 0) (3)

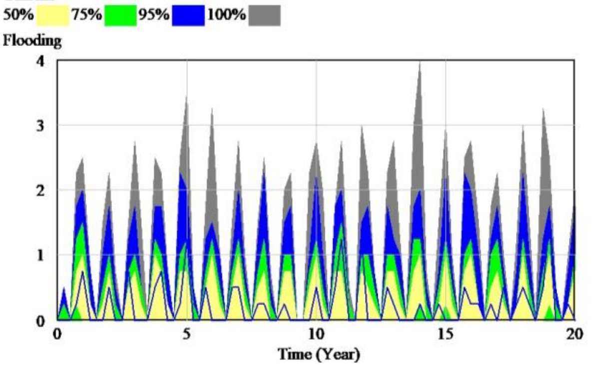


Fig. 6 Result of the probability of flooding each quarter by sensitivity analysis (For example, Flooding = 1.0 is meaning to the probability of flood occurrence as 100%)

In order to calculate the risk of flood occurrences in each zone, Flood Risk is shown in equation (4). This equation represents a degree of inundation each zone when the flood occurs.

Flood Risk= Flooding 1 or 0/Zone Area (4)

Finally, Protected Area is calculated by the increase of protected area which is calculated by Flood Risk and Zone Area. The definition is shown in equation (5).

Protected Area = INTEG (Increase Protected Area, 0) (5)

3.4 Scenario Setting

This research summarized representative adaptation policies for flood occurrences on land use and transportation fields from existing researches as shown in Table 1 (Stamos, et al. (2015)). Moreover, these fields are subdivided into 2 groups according to between intangible and tangible.

Table 1 Summary of adaptation policies for flood occurrences

Fields		Policies/Measures
Transportation	Intangible	Providing Traffic Information
		Improvement of Prediction of Flood Frequency
		Providing Disaster Information in the Past
	Tangible	Elevation of Roads and/or Railroads
		Providing Emergency Evacuation Route
		Promptly Construction of Infrastrucure
Land Use	Intangible	Hazard Map
		Corvered by Disaster Insurance
	Tangible	Construction of Embankment
		Bounty for Remodelment and Large-scale Repair
		Building Restriction

This research was built on three scenarios as shown in Table 2. Scenario A represents business as usual baseline case, which is not introducing adaptation policy. Scenario B represents introducing the elevation of the highway (with introducing adaptation policy in transportation field). Scenario C represents introducing the population migration from high-risk zones to low- risk zones (with adaptation policy in land use filed).

Table 2 Summary of scenarios

Scenario	Measure	Details
A	Flood Occurrences: **Without** adaptation measure	**Not** implemented a adaptation measures
B	Flood Occurrences: **With** adaptation measure on transportation field	Implemented a adaptation measure of elevation of major arterial road
C	Flood Occurrences: **With** adaptation measure on land use field	Implemented a adaptation measure of population migration from high risk zone to low risk zone

Road sections affected by flood occurrence and road section which will be elevated as adaptation policy was depicted in Fig. 7. Most of the road section in the south area is suffered from flood occurrence.

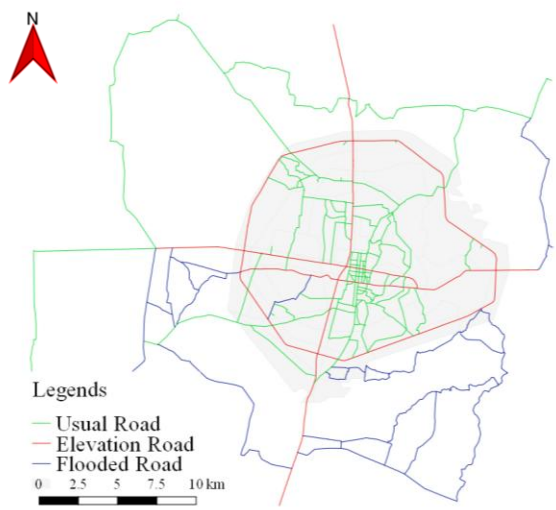


Fig.7 Inundation of road section

Adaptation policy on land use filed is that high- risk zones have increased the prohibition of the development of area based on the probability of inundation on the past which is shown in Fig. 2. Hence, they are difficult to develop new housing for reduction of an area the available. Therefore, people intend to migrate to the low- risk zone and, the housings and workplaces area also constructed here.

4. Results

4.1 Average Travel Time (Each Zone)

Adaptation policy on transportation field was implemented as a scenario B (With case). In this research, the scenario B was compared with a scenario A (BAU). As the results, some high-risk and low-risk zones have been decreased average travel time because the adaptation policy of "elevation of the major roads" was shown impacts.

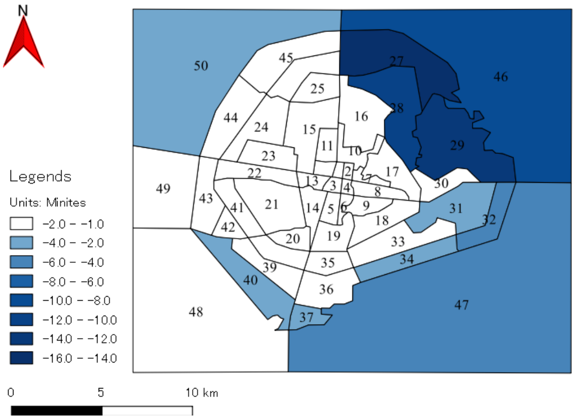


Fig. 8 Average travel time on flood occurrence

However, Fig. 8 is shown that the diminution of average travel time in high-risk zones in the south area such as zone 47 and 48 are less than it's in low-risk zones in the northern area. This reason is shown in Fig. 9. This figure shows the rate of change in traffic volume each road which was calculated by traffic demand software.

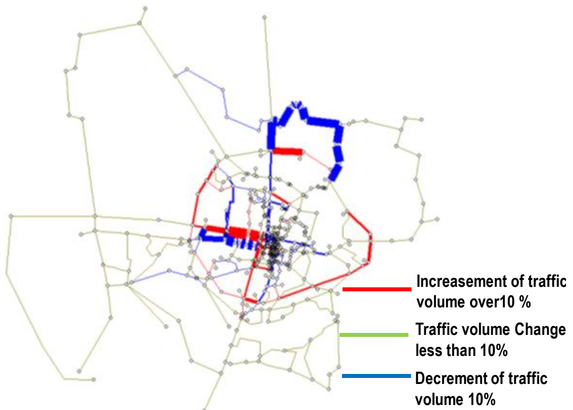


Fig. 9 Result of traffic assignment

As shown the result of traffic assignment, the traffic volume in the northeast area tends to decrease travel distance and improve travel speed. In

contrast, it's in the south area tends to improve travel speed only.

4.2 Benefit from Travel Time Reduction

In order to show the impact of implemented adaptation policy on transportation field, the benefits of travel time reduction were estimated based on equation (6) and (7) (Ministry of Land, Infrastructure, Transport and Tourism, 2018).

$$BT_i = \sum\sum\left(Q_{ijl} \times T_{ijl} \times a_j\right) \times 365 \qquad (6)$$

$$BT = BT_o - BT_w \qquad (7)$$

Where,

i: Present, *w* and Absent, *o*, BT_i : Amount of running cost on maintenance *i* (THB/year), Q_{ijl} : Traffic volume of maintenance *i*, distance l of OD and mode *j* (unit/day), T_{ijl} : Running time maintenance *i*, distance *l* of OD and mode *j* (min), a_j : Units of mode *j* (THB/min)

Fig. 10 shows the benefit from the travel time reduction not including social discount rate on every quarter. As shown in this figure, its benefit was generated when the floods occur. And, total benefit from travel time reduction including social discount rate was estimated at 876 million THB for 20 years.

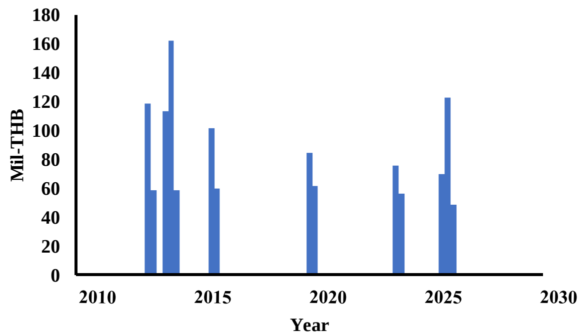


Fig. 10 Benefit from travel time reduction every quarter

4.3 Population Distribution

Fig. 11 shows population each zone that compared with the scenario A (BAU) and scenario C (With adaptation policy on land use filed) in 2010, 2020 and 2030. The result of scenario A has not largely changed population in each zone. In contrast, the result of scenario C has changed it because of people intending to avoid living in high-risk zones by affected on the adaptation policy of population migration. Consequently, in zones of south parts, the population has been decreasing gradually as shown in this figure.

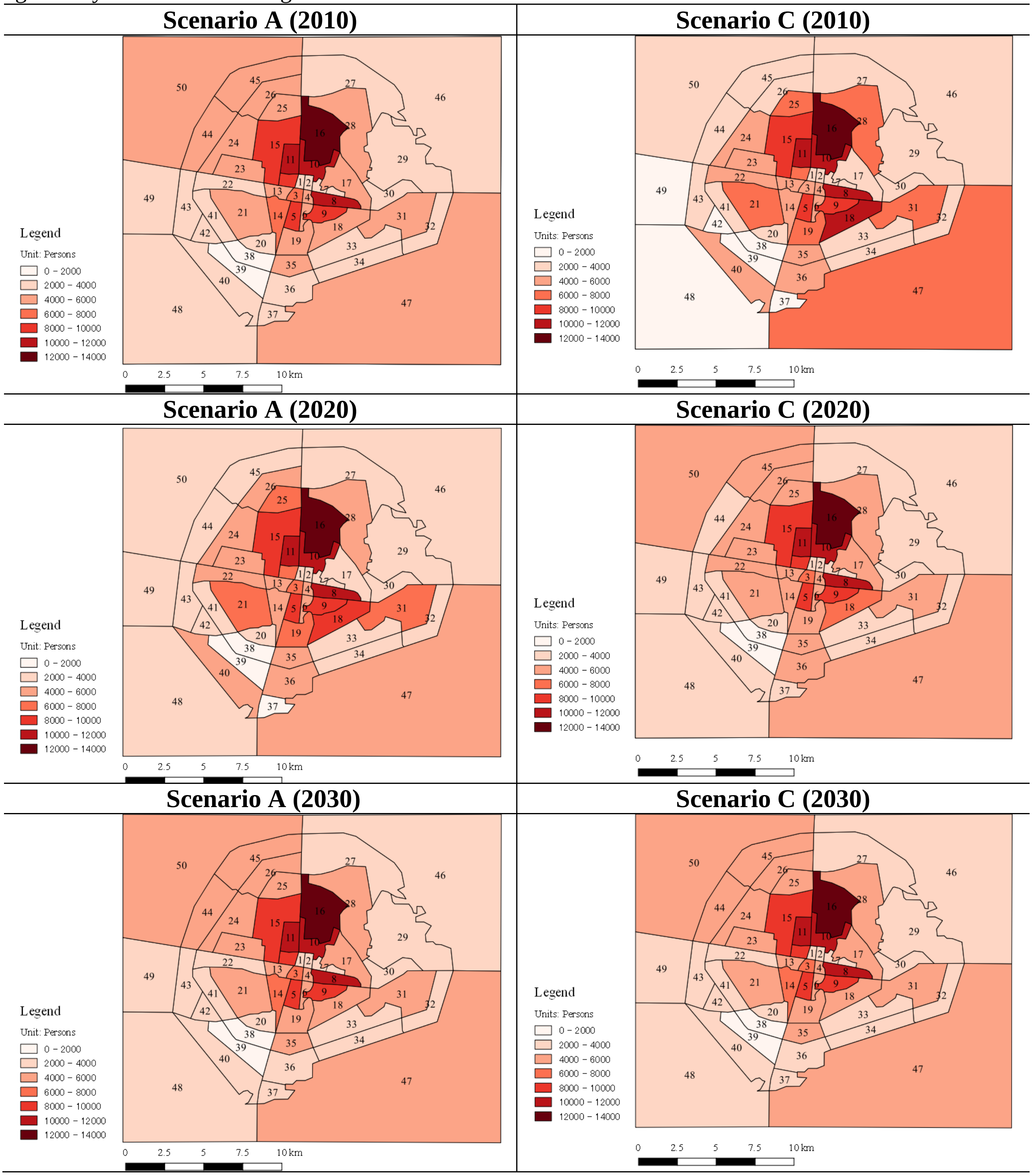


Fig. 11 Population distribution on scenario A and C (2010 - 2030)

4.4 Flooding Damage Costs about Housing ad Workplaces

Finally, this research estimated the flooding damage cost for 20 years based on flooding control economic survey manual (Ministry of Land, Infrastructure, Transport and Tourism, 2013). The equation (8) to (10) which are to calculate its cost are as follows:

$$\text{Housing Damage Costs} = 0.05\left(\text{Mil-THB/m}^2\right) \times \text{Inundation Area}\left(\text{m}^2\right) \times \text{Inundation Depth by Height Rate (\%)} \quad (8)$$

$$\text{Home Appliance Damage Costs} = 4.38\ \text{(Mil-THB/ Person)} \times \text{Affected Employed Person (Persons)} \times \text{Inunation Depth by Height Rate (\%)} \quad (9)$$

$$\text{Damage Property Costs} = 3.55\ \text{(Mil-THB/Person)} \times \text{Affected Employed Person (Persons)} \times \text{Inundation Depth by Height Rate (\%)} \quad (10)$$

Flooding damage cost was estimated as shown in Fig. 12. This figure shows that adaptation policy on land use leads to saving flooding damage cost about 588 million THB for 20years. This reason is that population each zone tends to migrate from high-risk of inundation area to its low-risk area as a mentioned above section.

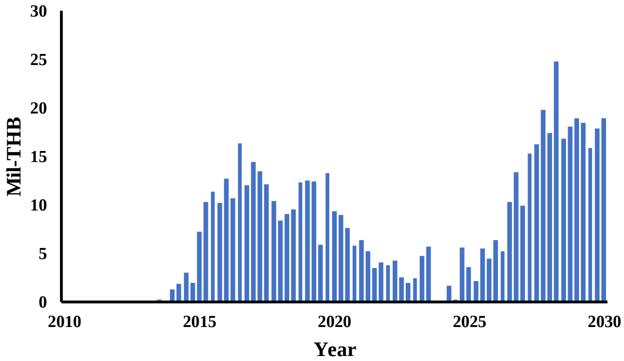


Fig. 12 Flooding damage costs

5. Conclusion& Discussion

This research focused on the estimation of flooding damage costs with implementation of adaptation policies on transportation and land use fields. To simulate related urban activities and flood occurrences, the dynamic model was used. Moreover, there were set 3 scenarios in order to evaluate the effect of the adaptation policies.

As the results, in transportation fields, average travel time each zone was decreased from 0 to 16 minutes. And, the benefit of travel time reduction was estimated at 876 Mil-THB for 20 simulation years. On the other hands, in land use field, the adaptation policy was contributed that population in high-risk zones attempt to move to low-risk zones. Also, flooding damage costs of housing and the workplace were estimated at 588 Mil-THB for 20 simulation years. Thus, these adaptation policies were concluded that any flooding damages and its costs were mitigated.

As the result, it is concluded that the adaptation policies of "elevation of major roads" and "population migration from high-risk zones to low-risk zones" are contributed to mitigating flood damages and reducing the flooding damage costs. Thus, this research is showed that not only adaptation policies on land use filed but also adaptation policies on transportation filed have full effects on flooding damages and flooding damage costs. The results of this research indicate that adaptation policies on transportation filed have to been needed many discussions for the near the future. In further research, it is necessary to include actual inundation depth data or estimation of this data in the flooding model for comparison estimated flooding damage costs and actual flooding damage costs. And this research is assessed one adaptation policy in each scenario. It is expected that the combination of adaptation policies on transportation and land use fields will have more effects. In that case, it is necessary to assess such combination dynamically.

References

[1] Aprico A. (2017) Transport Adaptation Policies in Europe: from Incremental Actions to Long-Term Visions, Transportation Research Procedia 25C, pp.3553-3541.

[2] Bazkar M, Fathian F and Eslamian S. (2013) Runoff Modelling in order to Investigate the most Effective Factors in Flood Events using System Dynamic Approach (Case Study: Tehran watershed, Iran). Journal of Flooding Engineering 4(1): pp.39-56.

[3] Feyen L, Barredo J and Dankers R. (2009) Implications of Global Warming and Urban Land Use Change on Flooding in Europe, Water & Urban Development Paradigms- Towards an Integration of Engineering, Design and Management Approaches, pp.217-225.

[4] Freddy V, Saidi M, Douvinet J and Fehri N. (2016) Urbanization and Land Use as a Driver of Flood Risk, pp.563-575.

[5] Guha-Sapir D, Hoyois P and Below R. (2013). Annual Disaster Statistical Review 2012: The Numbers and Trends. Brussels: CRED.

[6] Hasse D. (2013) Participatory Modelling of Vulnerability and Adaptive Capacity in Flood Risk

Management, Natural Hazards, Vol.67, Issue1, pp.77-97.

[7] Koks E, Model H, Aerts J and Bouwer L. (2014) Effects of Spatial Adaptation Measures on Flood Risk: Study of Costal Floods in Belgium, Regional Environmental Change, Vol. 14, Issue1, pp. 413-425.

[8] Madan B.R. and Trang L. (2015) Building Resilient Societies: Towards a Safe, Climate Adaptive and Disaster Resilient Transport System for Asia. Proceedings of the 9th Regional Environmentally Sustainable Transportation Forum in Asia.

[9] Mimura N. (2006) Adaptation against Global Warming, Global Environmental Research, Vol. 11, No. 1, pp.103-110 (in Japanese).

[10] Moser S (2012) Adaptation, Mitigation and Their Disharmonious Discontents: An Essay, Climate Change, Vol. 111, Issue2, pp.165-175.

[11] Pfaffenbichler P. (2003) The Strategic, Dynamic and Integrated Urban Land Use and Transport Model MARS (Metropolitan Activity Relocation Simulator): Development, Testing and Application. PhD Thesis, Vienna University of Technology, Austria.

[12] Pregnolato M, Ford A and Dawson R (2015) Analysis of the Risk of Transport Infrastructure Disruption from Extreme Rainfall, 12th International Conference on Applications of Statics and Probability in Civil Engineering, Vancouver, Canada.

[13] Stamos I, Mitsakis E and Grau J. (2015) Roadmap for Adaptation Measures of Transportation to Climate Change, Transportation Research Record Journal of the Transportation Research Board, pp.1-21.

[14] Thailand Flood Monitor: http://flood.gistda.or.th/ (Accessed on June 2018.)

Reliability of Breadth First Search finding missing link of Bluetooth data collection: Case study Bangkok, Thailand

Paper Identification number: AYRF18-025

Rattanaporn KASEMSRI[1], Piyapong SUWANNO[2], Atsushi FUKUDA[3], Tetsuhiro ISHIZAKA[4], Sorawit NARUPITI[5]

[1]Department of Transportation Systems Engineering, College of Science and Technology
Nihon University
Telephone +8147-469-5355
E-mail: rattanaporn7777@gmail.com

[2]Department of Transportation Systems Engineering, College of Science and Technology
Nihon University
Telephone +8147-469-5355
E-mail: piyapong.su@rmutsv.ac.th

[3]Department of Transportation Systems Engineering, College of Science and Technology
Nihon University
Telephone +8147-469-5355
E-mail: fukuda.atsushi@nihon-u.ac.jp

[4]Department of Transportation Systems Engineering, College of Science and Technology
Nihon University
Telephone +8147-469-5355
E-mail: ishizaka.tetsuhiro@nihon-u.ac.jp

[5]Department of Civil Engineering, Faculty of Engineering
Chulalongkorn University
Telephone 0-2218-6460
E-mail: kong@chula.ac.th

Abstract

Bluetooth technology is used in this study to observe the travel route of vehicles by detecting MAC address and time stamp. However, Bluetooth detection rate is not so high which lead to some links in that observed travel route is expected to be undetected, those undetected link in the observed travel route stated as a missing link. The effectiveness of detection of travel routes by Bluetooth is reduced by existence of missing links. Therefore, the aim of this study is to seek for those missing links to complete the observed travel route from undetected scanners. The Breadth First Search (BFS) which is one of the most well-known algorithms for shortest path is used based on the average travel time. The objective function is to minimize the absolute value of the shortest path travel time estimation of the missing trip and received travel time from Bluetooth detected data. Moreover, this study examined the reliability of proposed method by using RMSE. The results show that using observed link travel time data can be sufficiently efficient way to recover missing link. Moreover, the proposed method (BFS) can provide the efficient results.

Keywords: Bluetooth data collection, missing link, travel time

1. Introduction

The Bluetooth data collection is a sensor for traffic measurement since 2005 and it is the recent popular tools. It apparently presents the cost efficiency method comparing to the other sensors, also less manpower comparing to traffic count by human. There are many researches that relevance to Bluetooth technology and traffic management was conducted and report in many cities. Bangkok, Thailand is well known as the top among most traffic congestion city in the world. The traffic planner had paid a lot of efforts to improve traffic situation both planning and operation for decade. Therefore, we apply Bluetooth technology in Bangkok as a case study.

The concept of using Bluetooth technology has two components which are MAC address and detected time. The detected time of the same Mac address is sorted in an increasing order then we can determine the difference between the detected times which refer to the travel time of that equipment on that link. According to this concept we can conclude that the Bluetooth scanner can be used to collect travel time of each individual when traveling from one intersection to another intersection in both directions.

However, due to the technology itself which provide the short range detectable data also the environmental state which is always fluctuate and affect to the detectors. As the results of the low sampling rate obtained by Bluetooth data is the critical issue for reliability of the route searching approach. Moreover, the mac address was detected time from origin to destination but some parts in the route detected by Bluetooth is missing lead to the intra-route data possibly imprecise or even unknown. The missing trip rate of Bluetooth detection is huge, which is almost 80 percent in this study. The missing link is may strongly effects for estimation in arterial urban road network unlike freeway that have been study in the past. Therefore, this study is seeking to preliminary preparing Bluetooth data with reliability.

The initial step is to trim the outlier that possibly strongly influence with the results. Z score method is used as it have been studied and concluded by Peter J. Rousseeuw (2011) that has more robust than the others method. The next step is to fix the uncompleted route (found out the missing link and their travel time) subsequently validate those results from actual data. The Best-First-Search is an algorithm used for searching the missing link in this study. It is the algorithm that traverses a graph in search of one or more goal nodes. This method is proper to acknowledge about the problem that helps direct search to more promising paths. This information can significantly relate the decision making on both provider and user of traffic planning.

2. Literature review

There are many works relevance to Bluetooth technology in traffic management which was conducted and reported in many cities. This section would like to discuss whether what type of traffic information has been studied so far. These reviews can be classified following by these studied topics: the definition, the data accuracy, the O-D estimation and finally recovering the missing path. There was only one study for the recovering path that has found which become our motivation to study.

Chung and et.al (2009) introduced the concept of framework of Bluetooth detection by Duration and coverage zone concept which can be described as in Fig. 1. Fig. 1 shows that each scanner has its own coverage zone. The time stamp will be first detected by the scanner when that vehicle exits the coverage zone of first scanner. Then the time stamp will be detected again when the vehicle exits coverage zone of next scanner. According to this concept, we can compute the "Duration" which is the different time spend between first scanner's exit and second scanner's exit. This duration can be defined as the travel time of a vehicle from each consecutive scanners pair.

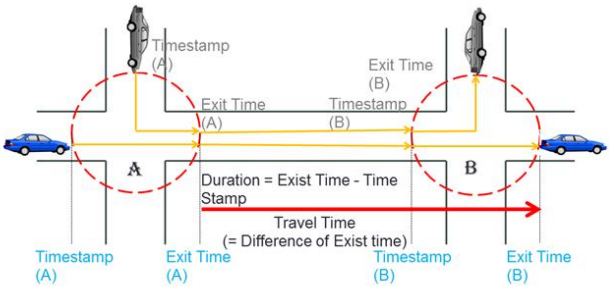


Fig. 1 The concept of framework of Bluetooth detection studied by Chung et al (2009)

Araghi, B. N. and et. (2015) mainly aims to solve the congestion through speed regulation and queue warning inside and around the Limfjord tunnel in Aalborg, Denmark. Therefore, to going to use those Bluetooth data, they validated the accuracy of them.

Carpenter, and et. (2012) conducted Bluetooth data along the corridor road outside the central area of Jacksonville at Jacksonville, Florida in 2012. The objective of this research is to find the route specific OD matrix on the corridor road. Yucel. et al. (2013) conducted Bluetooth data in 2013 in the city of Ankara, turkey. The purpose of this study is to define the vehicular travel pattern or proportion due to the major land use change because of the construction of a large health campus. Suzuki, H. (2014) estimated dynamic origin-destination (O-D) travel time and flow on a long freeway. A neural Kalman filter in this study was formulated which originally developed by the authors.

Michau, G. and et.al (2014) developed the missing detection algorithm to cope with the missing detection situation. They use the concept of shortest path by using the numbers of scanners along the path as the cost of the path.

3. An experiment application

The Bluetooth data was conducted as the case study in arterial urban road network, central Bangkok, Thailand which is one of the most well-known for critical traffic congestion problem. It was the project that collaborated with Chulalongkorn University and College of Science and Technology, Nihon University. The purpose of this collaborative is to investigate the traffic condition and travel behavior via the emerging technology here is Bluetooth signal. There are 44 stations of Bluetooth detectors where were installed in police box which is used for controlling traffic signal at intersection, represents with scope of long 12 km and width 7 km in Fig 2. Those detectors operate 24 hours a day and 7 days a week from January 28, 2018 to February 13, 2018 in total 17 days.

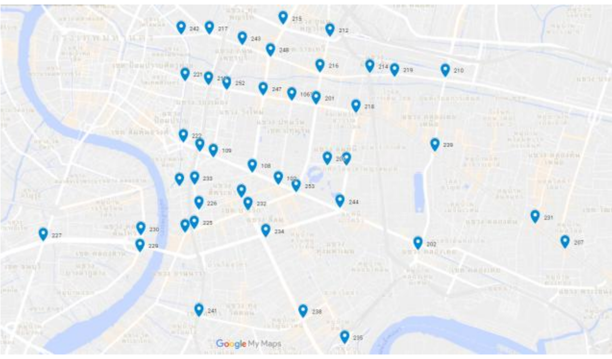


Fig. 2 The Bluetooth station map with scope area 12*7 km^2

Firstly, the summary number of detected Bluetooth data is shown in Table 1 including the number of the complete trip, the missing trip from the total observed trip which is 243,806 trips.

Table 1 The number of observed trips

	Complete trip	Missing trip	Total
Weekday	32,232	113,173	145,405
Weekend	22,530	75,871	98,401
Total	54,762	189,044	243,806

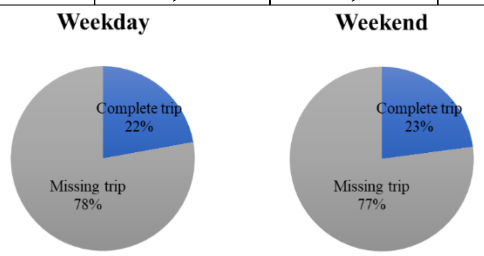


Fig. 3 The proportion of complete trip and missing trip

It can be seen clearly in Fig. 3 that the missing trip take an enormous amount compared with the complete trip, approximately 78 and 77 percent on weekday and weekend. Therefore, we focus to complete on those missing trips by using those complete trip data that can be observed by Bluetooth detectors.

4. Methodology

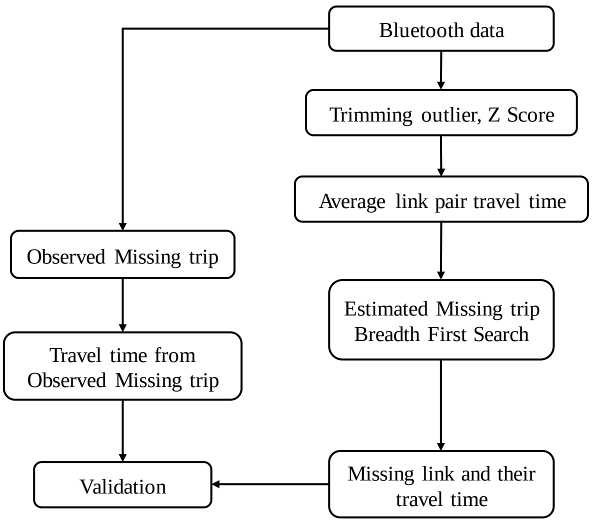


Fig. 4 The conceptual framework of the study

According to the Bluetooth scanner technology itself, some of Bluetooth data is detected improperly due to environmental states such as the weather fluctuation. For example, from the data that was detected in this study, from device ID 201-247 which has the distance approximately 300 meters was recorded different stamp time just only 1 second. It means that vehicle move with speed 1,080 km/hr which known as it is impossible. This called as outlier which cause problems because they may strongly influence the result. Outlying observations may be errors, or they could have been recorded under exceptional circumstances such as stopping or parking. Therefore, this study begins from the trimming outliers. Then, preparing link pair travel time for those missing trips which will be the benchmark used for validation with the missing trip that estimated by BFS. This framework process is shown in Fig. 4.

This study uses Z-score for trimming the outlier which has proved their robustness for outlier removing by Peter J. Rousseeuw (2011). Z score is the classical rule that people often use to detect outliers, equation (1).

$$Z_i = (x_i - \bar{x})/s \qquad (1)$$

Where s is the standard deviation. More precisely, the rule flags x_i as outlying if $|Z_i|$ exceeds designated value.

Missing link is an absent link member that needed to complete a series or resolve a problem. For example, in Fig. 5 is the trip from origin A to destination G. In fact, the A-G trip travel by route A-B-D-E-G. However, the Bluetooth can detect that mac address only from A-B and then E-G. The possible route is probably will should A-C-D-E-G instead of real route A-B-D-E-G if we consider only the shortest path problem. Thus, this study sets the objective function is to choose the link pair in those O-D pair which has the summation as close as possible with the detected data, equation (2).

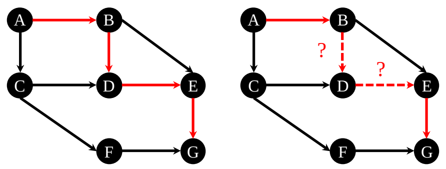


Fig. 5 The example of the missing link

This study uses the Breadth First Search (BFS) algorithm for completing the missing links in missing trips. It is the algorithm that traverses a graph in a breadthward motion and uses a queue to remember to get the next vertex to start a search. While using certain graph algorithms, it must be ensured that each vertex of the graph is visited exactly once. The traverse from node to the graph in Fig.5 is presented in Fig. 6.

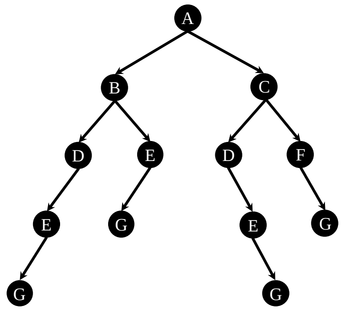


Fig. 6 The example of BFS traverses a graph

The defining characteristic of this search is that, whenever BFS examines a maze cell c, it adds the neighbors of c to a set of cells which it will to examine later. BFS maintains a queue of cells which have been visited but not yet examined (an examination of a cell c consists of visiting all its neighbors). Thus, a cell can have three states:

- Unvisited: The cell has not yet been visited by BFS.
- Visited but not examined: The cell has been discovered but BFS has not evaluated whether its neighbors should be added to the queue.
- Examined: The cell has not yet been visited and all its neighbors are/have been in the queue (for example they are already "Visited but not Examined" or "Examined".

This method is proper to acknowledge about the problem that helps direct search to more promising paths. The ended result is that BFS will visit all the cells in order of their distance from the entrance. The order in which the vertices are visited are important and may depend upon the algorithm or question that you are solving. First, it visits all locations one step away, then it visits all locations that are two steps away, and so on, until an exit is found. Because of this, BFS has the nice property that it will naturally discover the shortest route through the maze. It employs the following rules and represented by Fig. 7.

- Rule 1: Visit the adjacent unvisited vertex. Mark it as visited. Display it. Insert it * in a queue.
- Rule 2: If no adjacent vertex is found, remove the first vertex from the queue.
- Rule 3: Repeat Rule 1 and Rule 2 until the queue is empty.

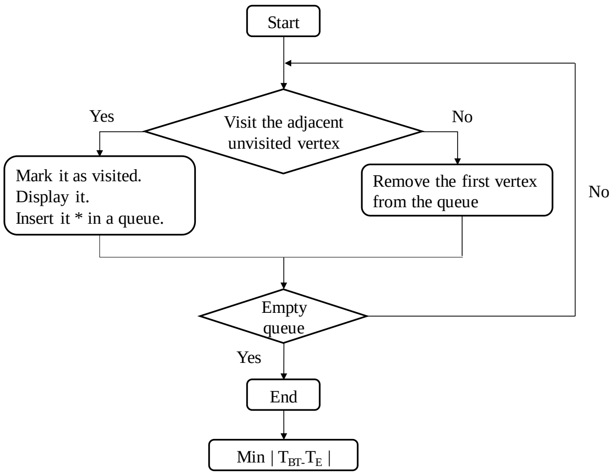


Fig. 7 The rules of BFS algorithm

4.1 Objective function

The objective function is to minimize the absolute travel time from O-D travel time and estimated O-D travel after using BFS by summarizing each link pair travel time.

$$\min\left|TB_{ij}^{h} - TE_{ij}^{k}\right| \qquad (2)$$

$$TE_{ij}^{k,h} = \sum_{h=1}^{h}\sum_{k=1}^{k} t_{ij}^{k,h}$$

The objective function (2) is to minimize the absolute value of observed travel time and estimated travel time by BFS method. Where as TB_{ij}^{h} is the travel time of that missing trip, which is the travel time from origin node i to destination node j at hour h. This can be detected by the Bluetooth scanners. $TE_{ij}^{k,h}$ is the travel time from all possible trip k from i to j by BFS estimation. $TE_{ij}^{k,h}$ is the summation of travel time sub link pair $t_{ij}^{k,h}$ on trip k at hour h which contain average travel time by hour. Where $i \in N$, $j \in N$ and N is the set of nodes. k is the possible trip i to j from BFS. h is the time duration by hour so $h = 24$.

5. Analysis results

The outcome of this study is to complete the missing link and their travel time for each node pair. This section is separated for two steps. First is the trimming outlier which is the process to remove the outlier in section 5.1. Second is the Breadth First Search algorithm which is the process to find out the missing also shows their reliability.

5.1 Trimming outlier

The data was summarized for individual both categorized by exact time and time of day. Fig. 8 presents the travel time of individual trip. It illustrates that the travel time for any link at any time has trend to average approximately 2,500 second. However, there are many data plot which has possibility to become outlier. Thus, we have focused on the minor details at each link pair to consider about outlier issues. Fig. 9 is an example of the link pair that has the possibility of the outlier.

The initial step that we have done is to trim outlier which they may strongly influence the results. The trimming outlier by Z-score method is represented as robust method by Peter J. Rousseeuw (2011). The method uses Z-score to be the criteria for trimming outlier as the results in Fig. 10 for overall link pair and example link pair in Fig.11.

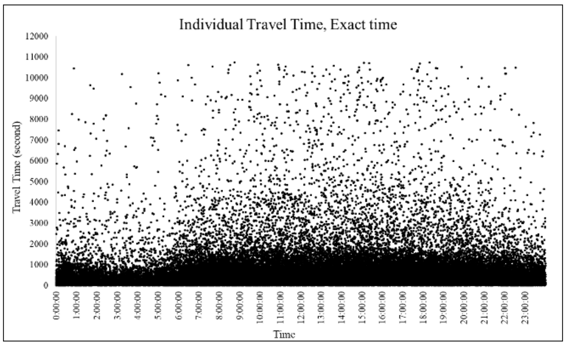


Fig. 8 Individual observed travel time

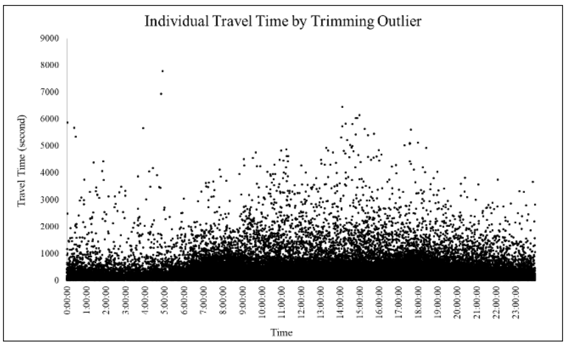


Fig. 9 Individual observed travel time after trimming outlier

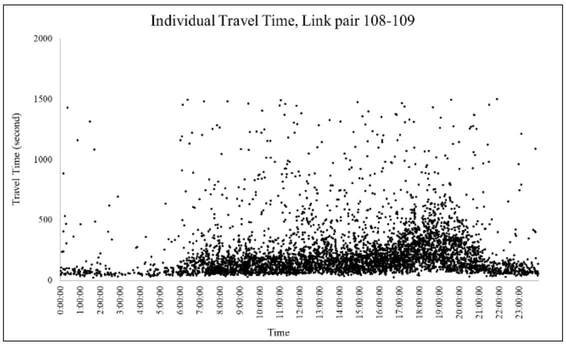


Fig. 10 The example of link pair travel time

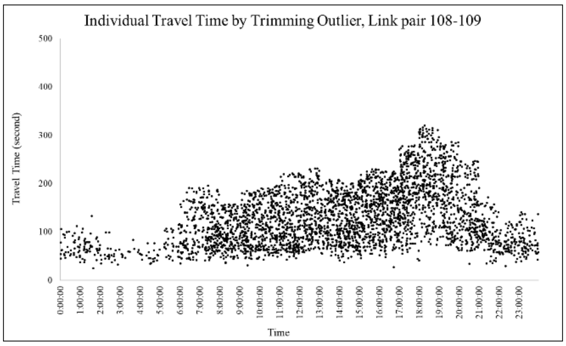


Fig. 11 The example of link pair travel time after trimming outlier

5.2 Breadth First Search

The example from BFS estimation is explained in Table 2. Here the missing trip has the origin node 215 to the destination node 247, the detected travel time is 565 second at 12:06 pm which is classified in 12:00 hour time duration. There are three possible trips k which contain their own possible link pairs. The travel time is calculated by summation of average travel of historical detected Bluetooth data in their own hour time, here use at 12:00. The objective function is to minimize the absolute travel time of detected data and estimated data. From the table, the possible trip 1 is selected due to it is the most closed to the observed trip which has the absolute value of travel time at 68 second.

Table 2 The example of BFS

Missing trip example, 215-247 at time 12:00			
TB_{ij}^{h}	565 second		
Possible trip (k)	Link pair	TE_{ij}^{k}	$\min\lvert TB_{ij}^{h} - TE_{ij}^{k}\rvert$
1	215-212-216-248-247	97+163+254+119 =633	|565-633|=68

Table 2 The example of BFS (cont.)

Possible trip (k)	Link pair	TE_{ij}^{k}	$\min\lvert TB_{ij}^{h} - TE_{ij}^{k}\rvert$
2	215-248-243-252-247	134+83+973+185 =1375	|565-1375|=810
3	215-248-247	134+126 =260	|565-260|=305

Fig. 12 shows the correlation between observed travel time and estimated BFS travel time. Linear regression analysis is the one model that probably common use to measure correlation between the observed data and estimated data. The graph shows that the result has strong relation with R^2=0.88. It can be concluded that the proposed method BFS provide the suitable results.

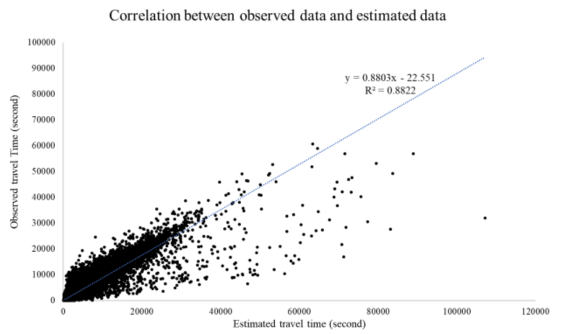


Fig. 12 The correlation between observed data and estimated data

This study uses the Root Mean Square Error (RMSE) shown in Fig. 13 to evaluate the error. The minimum RMSE is 0 which means the observed data fit perfect with the estimated data. Even though we found that some RMSE is rather high than the others, this can happen from the outlier that possibly remain. However, the RMSE in average is acceptable value that is 2.52.

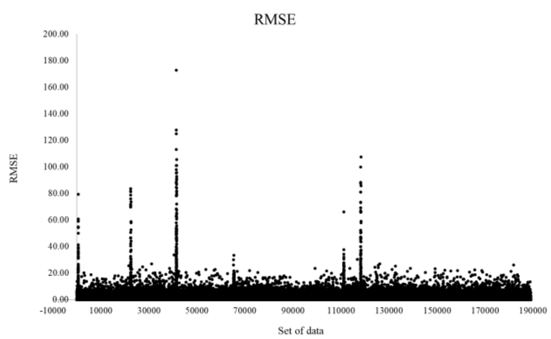


Fig. 13 The RMSE plotting

6. Conclusion

The application of Bluetooth technology is used for observing vehicle travel time in this study. The totals of 44 Bluetooth detectors were installed in central of Bangkok, Thailand. However, the observed data from Bluetooth scanners is detected with low rate because of the short range detectable data also the environmental sensitivity. The missing trip occurs in total 189,044 trips from obtained all 243,806 trips which is approximately 78 percent. The Breadth First Search (BFS) algorithm is proposed for seeking those missing links. Two steps were divided in this study, which are the trimming outlier by using Z Score and find out missing link by using BFS based on the historical travel time. The average historical travel time is calculated by each link pair from the observed data. The results show that using historical link travel time can be sufficiently efficient way to recover missing link with high R^2 = 0.88. The BFS has ability to find out the suitable results with acceptable RMSE = 2.52.

5. Acknowledgement

This study was carried out with the fund from the Japan Society of Traffic Engineer. We would like to thank the JSCE. Also, we would like to express our gratitude to Mr. Thanat Rungwanichsukanon, Mr. Thana Potanon, Mrs. Pitchaya Panwan, Mr. Onnz Kittipong and the students of Chulalongkorn University for their cooperation to carry out data collection and analysis.

References

[1] Peter, J. Rousseeuw (2011) Robust statistics for outlier detection, *John Wi ley & Sons, Inc .*, Vol.1, pp.74-79.

[2] Araghi, B.N., Pedersen, K. S., Christensen, L. T., Krishnan, R., & Lahrmann, H. (2015). Accuracy of travel time estimation using Bluetooth technology: Case study Limfjord tunnel Aalborg. *International Journal of Intelligent Transportation Systems Research*, Vol. 13(3), pp. 166-191.

[3] Carpenter, Fowler, and Adler (2010). Generating Route - Specific Origin - Destination Tables Using Bluetooth Technology. *Transportation Research Record Journal of the Transportation Research Board.* Vol.2308(1), pp. 96-102

[4] Yucel, S., Tuydes-Yaman, H., Altintasi, O., and Olzen, M. (2013) Determination of Vehicular Travel Patterns in an Urban Location using Bluetooth Technology. *ITS America's 23rd Annual Meeting & Exposition.*

[5] Suzuki, H. (2014). Dynamic Estimation of Origin-Destination Travel Time and Flow on a Long Freeway Corridor: Neural Kalman Filter. *Transportation Research Record: Journal of the Transportation Research Board*

[6] Michau, G., Nantes, A., Chung, E., Abry, P., & Borgnat, P. (2014). Retrieving dynamic origin-destination matrices from Bluetooth data. Transportation Research Board 93rd Annual Meeting

Analysis of Park and Ride Usage in Bangkok Metropolitan Region -Case of Adjacent Area Along Purple Line

Topic number: …. Paper Identification number: **AYRF18-026**

Hiroto NUMA[1], Hironori OZAWA[2], Malitham SATHITHA[3], Atsushi FUKUDA[4,] ,
Varameth VICHIENSAN[5], Thawatchai KONGSUWAN[6]

[1]Course of Transportation Sysems Engineering, Graduate School of Science and Technology,
Nihon University
Telephone & Fax. +81-47-469-5355
E-mail: cshi18011@g.nihon-u.ac.jp

[2]Course of Transportation Sysems Engineering, Graduate School of Science and Technology,
Nihon University
Telephone & Fax. +81-47-469-5355
E-mail: cshi17006@g.nihon-u.ac.jp

[3] PSK Consultant co., Itd. d
Telephone 026-170429, Fax. 026-170426
E-mail: malaitham.sathita@gmail.com

[4]Department of Transportation Systems Engineering, College of Science and Technology
Nihon University
Telephone & Fax. +81-47-469-5355
E-mail: fukuda.atsushi@nihon-u.ac.jp

[5]Department of Civil Engineering, Faculty of Engineering
Kasetsart University
Telephone 043-261457, Fax. 043-261457
E-mail: varameth@kku.ac.th

[6]Department of Civil Engineering, Faculty of Engineering
Kasetsart University
Telephone 043-261457, Fax. 043-261457
E-mail: Thawatchai.ksw@hotmail.com

Abstract

In Bangkok metropolitan area, urban railway systems have been developed to against the rapidly increased traffic congestion problem. However, the city has been developed in a form dependent on the car, so the street network centered on the railway station has not been systematically planned. Thus, it is not clear how and from where railway users are accessing the railway station. Therefore, there is a problem that the station sphere of force, which is the standard for determining the maintenance density of the future railway network, can't be clearly established. So, the purpose of this research is set to grasp the catchment area from stations along Purple Line by grasping the current situation of trip end modes through questionnaire survey for P&R user. The questionnaire survey had been held at 4 stations on Purple Line which have P&R facility. And from the survey result, the relation between the distribution of P&R users and the supposed station sphere of force, egress mode of P&R users are grasped. In the city center, by arranging terminal transportation means other than walking in the suburbs, it is possible to expand the range covered by the route, and the range covered by the route can be expanded. In addition, by using the catchment area, we can calculate the station area where the impedance is taken into the network and clarify where we need maintenance.

Keywords: Trip End Modes, P&R, GIS, Bangkok

1. Introduction

In Bangkok, after year 2000, urban railway systems have been developed to against the rapidly increased traffic congestion problem. However, the city has been developed in a form dependent on the car, so the street network centered on the railway station has not been systematically planned. Thus, it is not clear how and from where railway users are accessing the railway station. Therefore, there is a problem that the station sphere of force, which is the standard for determining the maintenance density of the future railway network, can't be clearly established.

This research aims to clarify how the station sphere of force is formed, along the Purple Line
developed in the Bangkok metropolitan area.

2. Literature Review

There have been a lot of research discussed P&R in Bangkok. For example, Fukuda. (2017) indicated that the number of urban railway users is about 500,000 per day as of 2017, which is said to be about 2% of all trips in the Bangkok metropolitan area. And it has been shown that conversion from use of automobiles to urban railway has not progressed well. This research pointed out land developing by private companies near urban railway before the opening of urban railway, and claims it makes a lack of coordination between urban railway maintenance and land development around the stations. Land development premised on access with using car by a private company realizes low accessibility to the station. For example, at the station along the Airport Rail Link (hereafter, ARL), the walking area is very narrow, and it is known from the past research that there are many accesses by kiss and ride (hereafter, K & R), park & ride (hereafter, P & R), motorcycle taxi, motorcycle.

Table 1 Trip end modes around stations of Purple Line

	Bus	Van Taxi	Songthaew	Motorcycle Taxi
Yaek Tiwanon Station	1. Route 18 (Tha It-Victory Monument) 2. Route 30 (Nonthaburi-Sai tai kao) 3. Route 65 (Wat Paknam Nonthaburi-Sanamluang) 4. Route 97 (Ministry of Public Health - VictoryMonument) 5. Route 505 (Pakkred-Lumpini Park)	–	1. Route Soi Si li Chai – The mall Ngamwongwa	Waiting Position 3
Yaek Nonthaburi 1 Station	1. Route 18 (Tha It-Victory Monument) 2. Route 134 (Buatong Keha Village - Mochit2) 3. Route 191 (KlongChan - Ministry of Commerce) 4. Route 203 (Tha It-Sanamluang)	1. Route Bang Bua Thong – The mall Ngamwongwan. 2. Route Preuksa 3 - The mall Ngamwongwan. 3. Route Talad Bang Bua Thong – Kasetsart University. 4. Route Si Lom – Bang Yai. 5. Route Chatuchak - Bang Bua Thong. 6. Route Phong Phet – Talad Bang Yai.	1. Route Thanam Nonthaburi - Wat Yai Sawang Arom. 2. Route Bang Bua Thong - Nakorn-In. 3. Route CentralPlaza Rattanathibet - Thanam Nonthaburi. 4. Route Tha It – Big C Rattanathibet.	Waiting Position 3
Bang Rak Noi Tha It Station	1. Route 18 (Tha It-Victory Monument) 2. Route 69 (Tha IT-Victory Monument) 3. Route 134 (Buatong Keha Village - Mochit2) 4. Route 177 (Bang Bua Thong -Victory Monument)	1. Route Bang Bua Thong – The mall Ngamwongwan. 2. Route Preuksa 3 - The mall Ngamwongwan. 3. Route Talad Bang Bua Thong – Kasetsart University. 4. Route Si Lom – Bang Yai. 5. Route Chatuchak - Bang Bua Thong. 6. Route Phong Phet – Talad Bang Yai.	1. Route Bang Bua Thong - Nakorn-In. 2. Route Tha It – Big C Rattanathibet.	Waiting Position 2
Talad Bang Yai Station	1. Route 32 (Pakkred-Wat Pho) 2. Route 127 (Bang Bua Tong-BangLamphu) 3. Route 134 (Buatong Keha Village - Mochit2) 4. Route 177 (Bang Bua Thong -Victory Monument) 5. Route 516 (Buatong Keha Village-Thewet) 6. Route 680 (Rangsit – Bang Yai)	1. Route Pata - Bang Bua Thong. 2. Route Pata - Preuksa 3. 3. Route Pata – Preuksa 14. 4. Route Central Pinklao – Sai Noi. 5. Route Ban Kluai - Sai Noi – Pata. 6. Route BangBuaTong 4 – Pata. 7. Route Mo Chit – Suphan Buri. 8. Route Preuksa 3 - Tha mall Ngamwongwan. 9. Route Preuksa 14 - Tha mall Ngamwongwan. 10. Route Bang Bua Tong Village - Tha mall Ngamwongwan. 11. Route Ban Kluai - Sai Noi – Tha mall Ngamwongwan.	1. Route Preuksa 3 – Soi Kantana. 2. Route Sri Pa wat - Debsirin School. 3. Route Talad Bang Yai City – Wat som keang. 4. Route Wat Chalo - Bang Yai City. 5. Route Save E – Bang Yai. 6. Rout Bang Bua Thong - Nonthaburi Market.	Waiting Position 8

Ikeshita, et al. (2010) conducted a questionnaire survey about the attributes and purpose of users for P & R users facility installed at 3 stations along the Blue Line in Bangkok. As a result, it showed that there is a possibility that a commuter and school trip where is possible to move on the egress by walking / bicycle may be converted to P & R use. In addition, Chalermpong, et al. (2016) investigated actual usage of P & R at the major city railway station in Bangkok, Thailand and selected the stations that need to improve P & R facility in the future. However, in this survey, the Purple Line is not covered.

3. Trip End Modes along Purple Line

There are private cars, Buses, Van Taxis, Songthaews, MC taxis etc. as trip end modes around the stations of Purple Line. The following Table.1 shows summarization of number of routes or waiting spaces for trip end modes at 4 stations of Purple Line, Yaek Tiwanon, Yaek Nonthaburi 1, Bang Rak Noi Tha It, and Talad Bang Yai only at Yaek Tiwanon station, Van Taxis don't run through. In addition, Facilities for P & R have been developed at Yaek Nontaburi 1 and Bang Rak Noi Tha It. From Table. 1, buses, Van Taxi,Songthaew are operating around each station, and it can be seen that the destinations and routes are diversified. On the other hand, these traffic modes have operated before the opening of Purple Line, and they are not necessarily assumed access to stations. In the bellowing, the trip end modes around stations of Purple Line will be described in more detail. Trip end modes are considered separately. Some modes like P & R have been systematically introduced by providing parking space, and other have been naturally started like Bus and Van Tax.

3.1 P&R

The station where the P & R facility are currently installed is shown in Fig.1 In the figure, red parking marks express the stations along Purple Line which has a P & R facility. Purple line has 4 stations which have P&R facilities, Khlong Bang Phai, Sam Yaek Bang Yai, Bang Rak Noi Tha It, and Yaek Nontaburi 1. Table 2 shows details of P&R facilities of each station.

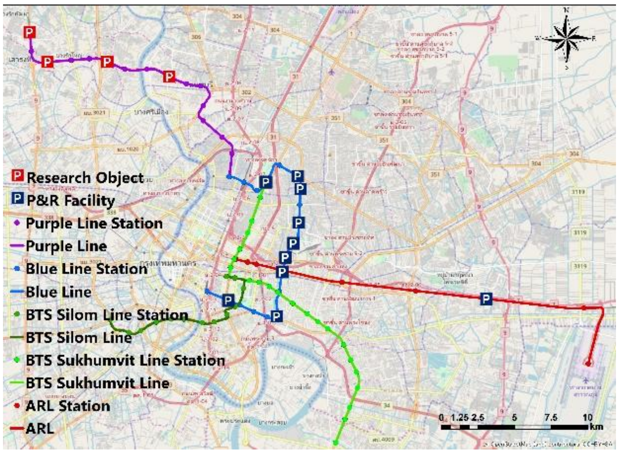


Fig. 1 Location of P & R facility

Table 2 P & R facilities along Purple Line [4]

P&R		Khlong Bang Phai	Sam Yaek Bang Yai	Bang Rak Noi Tha It	Yaek Nonthaburi 1
Number of parking space		1800	1460	1070	435
Number of stories		3	10	10	4
Openning hours		AM 5：00~AM 1：00			
Parking Fees	Hourly rates	Purpleline User :10THB/2hour Purpleline Non-user :20THB/1hour			
	Monthly rates	1000THB/month			

3.2 Walking

Fig. 2 shows catchment area in 5minutes, 10minutes, and 15minutes. Walking speed was set to 40 m/min, and a walking distance zone was created to impedance the distance from the actual road network. Because walks are greatly affected by distance and time, and they can't move a long distance. Moreover, it seems that the accessibility on foot to the station wasn't able to be considered.

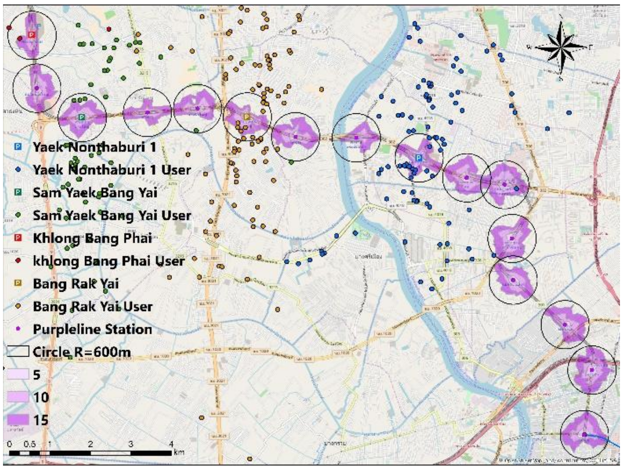


Fig. 2 Catchment area by walk

3.3 Bus

There are 12 routes through the vicinity of the station on the purple line, of which 8 routes pass through a station with P & R facilities. A map of the bus route map is shown in Fig.3 Some pass through almost the same route as Purple Line. The usage fee is from 7.5 THB, the fee changes depending on the destination, it is relatively inexpensive compared to the railway.

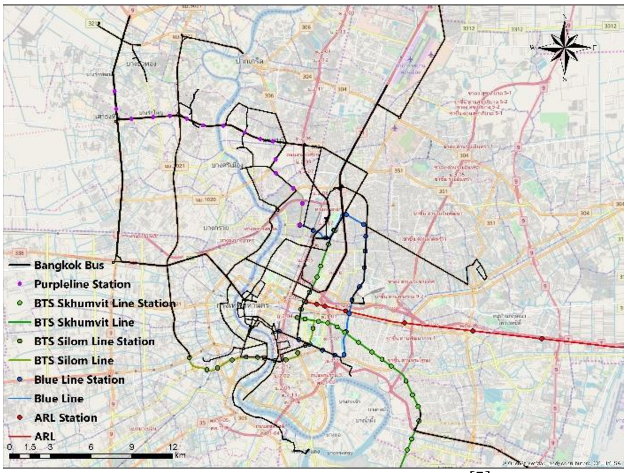


Fig. 3 Bus route in Bangkok [5]

3.4 Van Taxi

Van Taxi has a departure point and destination on the side of the vehicle, but it is not decided its route and what time it will come. The usage fee is 15 THB, and it is cheaper than the railway, and Van Taxi is cheaper depending on bus stops getting off. The distance from the actual road network. Because walks are greatly affected by distance and time, they can't move a long distance. Moreover, it seems that we can't consider the accessibility on foot to the station because we installed the station on the main road.

3.5 Songthaew

The number of Songthaew that can be stopped by each station is different. There are only two at Yaek Tiwanon station and Bang Rak Noi Tha It station where there are many houses around. On the other hand, there are 4 to 6 stops for Songthaew at the Talad Ban Yai station and the Yaek Nonthaburi 1 station where shopping malls exist in the vicinity. From the above, it is conceivable that the stop of Songthaew Stop is set to access surrounding facilities rather than to access to the stations.

3.6 Motorcycle

The P & R facility also has a parking lot for motorcycles. However, the parking space is installed outside the facility and the parking space is small. For that reason, as shown in Figure 4, a lot of motorcycles parking near the entrance.

Fig. 4 Street parking by motorcycle near the entrance of the station

4. Analysis of P&R Usage

4.1 Questionnaire Survey

To grasp the actual condition of P & R users, from November 24 to 29, 2017, the questionnaire survey was conducted in interview format for P&R users on the stations where have a parking for P&R which is installed systematically. During the survey, respondents were interviewed face-to-face randomly using questionnaire sheet. They were asked to answer questions about their socio-economic data, origin & destination and trip purpose, P&R usage, and MRT Purple Line frequency usage together with egress modes. Furthermore, the respondents were asked to draw the route they choose on a map.

4.2 Result of Park and Ride Usage

The distance based on the actual network was calculated as the impedance within the catchment area of speed 20 km/h in 5 minutes, 10 minutes, 15 minutes. It is understood that when this catchment area and the distribution map are dropped, it is distributed within catchment area. As for the Khlong Bang Phai station, there are many people who are accessing from the north side where the route is not continuing, which is the end point

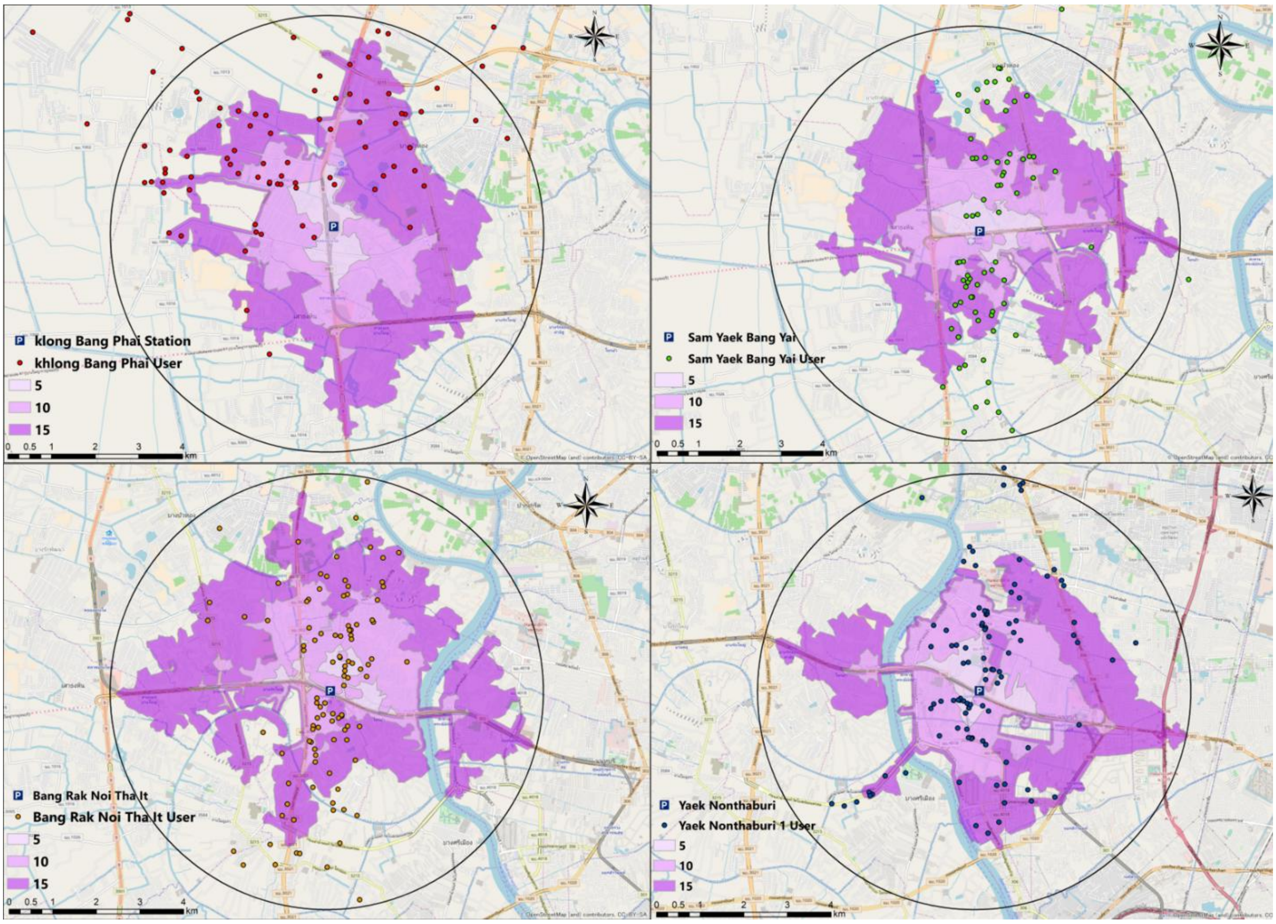


Fig. 5 Catchment area by P & R

station, and it is understood that it is not caught in the catchment area.

Other stations tend to use the nearest station from the departure place because there are adjacent stations and it is found that it is distributed along the main road.

Table 3 Density of station catchment area

(㎢)	Khlong Bang Phai	Sam Yaek Bang Yai	Bang Rak Noi Tha It	Yaek Nonthaburi 1
5min	2.2	2.1	1.2	2.0
10min	8.4	7.6	8.6	9.9
15min	22.0	22.5	24.0	16.0
Total	32.5	32.2	33.9	27.9
Circle	78.5			
Density	41.4%	41.0%	43.2%	35.5%

The stations that P&R users got off together with egress mode choice from the stations to the destination were summarized in Fig 6. From this figure, it can be seen that many P&R users get off at the MRT Blue Line station. On the other hand, fewer people get off at BTS Sukhumvit Line or BTS Silom Line. Only one user was found to get off at Silom Line station. This situation is because it is necessary to transfer more than twice. Besides, there is the different operators between BTS Skytrian and MRT and the IC cards are not unified. In addition, BTS Skytrian operates by Bangkok Mass Transit System Public Company Limited (BTSC) while MRT Blue Line and Purple Line operates by Bangkok Expressway and Metro Public Company Limited (hereinafter, BEM). Thus, it is difficult to transfer. After getting off the railway, walking as egress mode has the highest share rate, following by motorcycle taxi (hereinafter MC Taxi) and bus.

The relationship between the egress modes and the distance to the destination is presented in Fig.7. Many people are likely to walk when the destination points locate within 1,000 m from stations. As the distance to the destination becomes 1,000 m or more, fewer people choose to walk and more people tend to use MC taxi as egress mode. As for the egress means of P & R users coming from the suburbs, it is clear that if the distance from the getting-off station to the destination is within 500 m, the share of walking exceeds 90%.

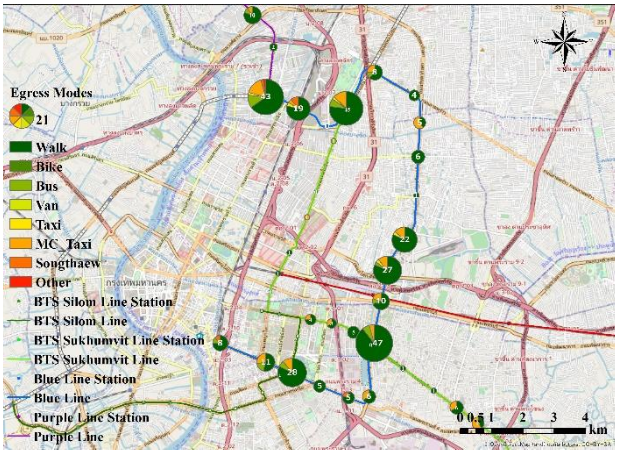


Fig. 6 Egress modes by stations

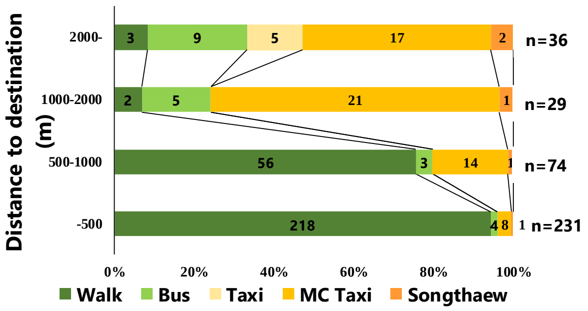


Fig. 7 Distance to destination by egress modes

5. Conclusion & Future Issue

This research focused on not being a street centering on the railway station and aimed to calculate the more detailed station area by creating a catchment area with the network impedance along Purple Line. In addition, to confirm the consistency of the calculated catchment area, the consistency with the distribution of users obtained from the questionnaire survey results was confirmed. As a result, only the Khlong Bang Phai station is the terminal station and there are noncatchment adjacent stations, so the station area is wider. At other stations, it is located within a circle with a radius of 5 Km, and users are accessing the nearest station from the departure point, most of the distribution was within the catchment area created. However, this catchment area only considers P & R. As a future task, it is necessary to visualize the areas that have been maintained by clarifying existing situations and access methods along the Purple Line, and to show the areas which should be developed. It is also suggested that by clarifying the density currently covered from the walking area in the central area, it is possible to encourage railway use by clarifying the range of customers in the Bangkok metropolitan area station too.

6. Acknowledgement

I would like to express my sincere gratitude to Dr. Pattamaporn Wongwiriya from Khon Kaen Univsersity, Dr. Sathita Malaitham and Ms. Rattanaporn Kaewkluengklom to assist the questionnaire survey. And I appreciate Dr. Varameth Vinchiensan and Mr. Thawatchai Kongswan for providing the field survey data about trip end modes around stations of Purple Line.

References

[1] Atsushi FUKUDA. (2017) Current Situation of Land Development in the Area along Rail Based Public Transport Systems in Bangkok - Limit and Possibility-: IBS Fellowship, Vol.20

[2] BANGKOK EXPRESSWAY AND METRO PUBLIC COMPANY LIMITED : http://www.bangkokmetro.co.th/mapPPL.aspx?Menu=184&Lang=En

[3] Hidenori, I, Atsushi F, Kanji, A, Masaya, C, Isaret R, Usage situation of P&R parking lot in Bangkok, Thailand, The 37th Kanto Branch of Japan Society of Civil Engineer, 2pp., 2010

[4] Toyota mobility FOUNDATION, Sathorn Model Project Report Park & Ride

[5] Transit Bangkok : https://www.transitbangkok.com/bangkok_buses.html

ผลกระทบของความกว้างช่องจราจรสำหรับรถจักรยานยนต์ต่อประสิทธิภาพของการจราจร

Effects of Motorcycle Lane Width on Traffic Efficiency

หมายเลขบทความ: AYRF2018-028

จตุวิทย์ สุวรรณรงค์

Jatuwit Suwannarong

ภาควิชาวิศวกรรมโยธา คณะวิศวกรรมศาสตร์
มหาวิทยาลัยสงขลานครินทร์
โทรศัพท์ 0-9502-0440 โทรสาร 0-7445-9396
E-mail: s.jatuwit@hotmail.com

บทคัดย่อ

อุบัติเหตุทางถนนจากการใช้รถจักรยานยนต์เป็นสาเหตุหลักของการเสียชีวิต บาดเจ็บ และพิการในประเทศไทย โดย มีผู้เสียชีวิตสูงประมาณร้อยละ 73 ของผู้ใช้ทางทุกประเภท สาเหตุหนึ่งของการเกิดอุบัติเหตุและความรุนแรงของอุบัติเหตุรถจักรยานยนต์มาจากการใช้ช่องจราจรร่วมกันระหว่างรถจักรยานยนต์กับรถยนต์ประเภทอื่น บทความนี้นำเสนอการศึกษาผลกระทบของการใช้ช่องจราจรสำหรับรถจักรยานยนต์ขนาดต่าง ๆ ต่อประสิทธิภาพของการจราจร (เวลาการเดินทาง, ความล่าช้า และระดับการให้บริการ) โดยเลือกช่วงถนนสายหลักระหว่างวงเวียนคณะวิศวกรรมศาสตร์ถึงวงเวียนคณะทรัพยากรธรรมชาติ ภายในมหาวิทยาลัยสงขลานครินทร์ เป็นกรณีศึกษา ในการศึกษาได้แบ่งความกว้างของช่องจราจรสำหรับรถจักรยานยนต์ออกเป็น 1.50 1.80 และ 2.00 เมตร ตามลำดับ และใช้แบบจำลองสภาพการจราจรระดับจุลภาคที่พัฒนาขึ้นเพื่อวิเคราะห์หาประสิทธิภาพของการจราจรบนความกว้างที่ต่างกัน รวมทั้งนำผลที่ได้มาคำนวณหาอัตราส่วน ผลประโยชน์ต่อต้นทุน (BCR) จากการปรับปรุงช่องจราจร ผลการศึกษาพบว่า ช่องจราจรความกว้าง 1.80เมตร มีความเหมาะสมมากที่สุด(BCR=1.56) โดยลดเวลาการเดินทาง 37.99 % ลดความล่าช้า 85.03 % และเพิ่มระดับการให้บริการขึ้นจากระดับ D เป็นระดับ A

คำสำคัญ: ช่องจราจรสำหรับรถจักรยานยนต์, ความกว้างช่องจราจร, แบบจำลองสภาพการจราจรระดับจุลภาค

Abstract

Road accidents from motorcycles are the main cause of deaths, injuries and disabilities in Thailand, in which the fatalities from motorcyclists are about 73% of the fatalities from all road users. One cause of accident and severity of the motorcycle accidents is the mixed use of travelling lane between motorcycle and other motorized vehicles. This paper presents the effects of motorcycle lane on traffic efficiency (travel time, delay, and level of service). The main road section between Faculty of Engineering roundabout and Faculty of Natural Resources roundabout in the Prince of Songkla University was selected as the case study. In the study, the motorcycle lane widths were divided into 1.50, 1.80 and 2.00 meters. The traffic microsimulation models, developed in this study, were applied to evaluate the traffic efficiency based on the different lane widths, and to determine the benefit to cost ratio from the motorcycle lane improvement. The results showed that the width of 1.80 meter was the most suitable (BCR = 1.56) in which the travel time was reduced by 37.99 %, the delay time was decreased by 85.03 %, and the level of service was improved from level D to level A.

Keywords: Motorcycle lane, Lane width, Traffic microsimulation model

1. บทนำ

อุบัติเหตุทางถนนจากการใช้รถจักรยานยนต์เป็นสาเหตุหลักของการเสียชีวิต บาดเจ็บ และพิการในประเทศไทย โดยมีผู้เสียชีวิตสูงประมาณร้อยละ 73 ของผู้ใช้ทางทุกประเภท[1] ซึ่งสอดคล้องกับปริมาณการใช้รถจักรยานยนต์ที่มีสูงเมื่อเทียบกับภูมิภาคอื่นทั่วโลก

มหาวิทยาลัยสงขลานครินทร์ วิทยาเขตหาดใหญ่ นอกจากเป็นพื้นที่ประกอบด้วยอาคารเรียน หอพักบุคลากรและนักศึกษาซึ่งมีประชากรรวมกันมากกว่า 30 ,000 คนแล้ว ยังเป็นที่ตั้งของโรงพยาบาลขนาดใหญ่ อีกทั้งเป็นพื้นที่สำหรับพักผ่อนและออกกำลังกายของประชาชนชาวอำเภอเมืองหาดใหญ่ พื้นที่ภายในวิทยาเขตหาดใหญ่ได้รับการพัฒนามาโดยตลอด ส่งผลให้จำนวนนักศึกษาและบุคลากรเพิ่มขึ้นอย่างต่อเนื่อง เมื่อพิจารณาสัดส่วนการใช้ยานพาหนะของนักศึกษาและบุคลากรภายในวิทยาเขตหาดใหญ่ พบว่ากว่าร้อยละ 52.77 ใช้รถจักรยานยนต์เพื่อการเดินทางเป็นหลัก รองลงมาร้อยละ 46.57 ใช้รถยนต์ส่วนบุคคล [4] นอกจากการใช้ยานพาหนะทั้งสองประเภทที่ก่อให้เกิดปัญหาอุบัติเหตุแล้ว ยังก่อให้เกิดปัญหาการจราจรติดขัดในชั่วโมงเร่งด่วนอยู่บ่อยครั้ง สาเหตุหลักประการหนึ่งที่ทำให้เกิดปัญหาดังกล่าวมาจากการใช้ช่องจราจรร่วมกันระหว่างรถทั้งสองประเภทที่มีขนาดและการใช้ความเร็วที่แตกต่างกันสัญจรร่วมกัน การจัดการพื้นที่ช่องจราจรสำหรับยานพาหนะที่แตกต่างกันจึงมีความสำคัญและสามารถเป็นเครื่องมือที่จะช่วยลดจำนวนอุบัติเหตุและความสูญเสียที่อาจเกิดขึ้น อีกทั้งยังมีส่วนช่วยเพิ่มประสิทธิภาพการจราจรในช่วงถนนได้ [2]

จากที่กล่าวมาข้างต้น งานวิจัยนี้ มีเป้าหมายเพื่อเสนอแนะแนวทางในการจัดการจราจรระหว่างรถจักรยานยนต์และรถยนต์ โดยใช้ช่วงถนนสายหลักภายในมหาวิทยาลัยสงขลานครินทร์ วิทยาเขตหาดใหญ่ เป็นกรณีศึกษา และใช้แบบจำลองสภาพการจราจรระดับจุลภาคเป็นเครื่องมือในการประเมินผลเพื่อหาความกว้างช่องจราจรสำหรับรถจักรยานยนต์ที่เหมาะสมซึ่งขึ้นกับ ประสิทธิภาพการจราจร และ ความคุ้มค่าในการลงทุน ผลการวิจัยนี้จะเป็นแนวทางให้หน่วยงานที่รับผิดชอบนำไปใช้ในการปรับปรุงแก้ไขช่วงถนนในพื้นที่ศึกษา และเป็นแนวทางเบื้องต้นในการศึกษามาตรการทางวิศวกรรมในการแก้ไขปัญหาอุบัติเหตุสำหรับรถจักรยานยนต์ในประเทศไทยต่อไป

1.1 วัตถุประสงค์

บทความนี้ มีวัตถุประสงค์ 2 ประการ ประกอบด้วย

1) เพื่อศึกษาผลกระทบของความกว้างช่องจราจรสำหรับรถจักรยานยนต์ (1.50 1.80 และ 2.00 ม.) ต่อประสิทธิภาพของการจราจร (เวลาในการเดินทาง ความล่าช้า และระดับการให้บริการ)

2) เพื่อศึกษาหาความกว้างที่เหมาะสมของช่องจราจรสำหรับรถจักรยานยนต์โดยพิจารณาจากต้นทุนและผลประโยชน์จากการปรับปรุง

1.2 ขอบเขตงานวิจัย

1) ศึกษาผลกระทบของความกว้างช่องจราจรสำหรับรถจักรยานยนต์ (1.50, 1.80 และ 2.00 ม.) ต่อประสิทธิภาพของการจราจร (เวลาในการเดินทาง ความล่าช้า และระดับการให้บริการ)

2) หาความกว้างของช่องจราจรสำหรับรถจักรยานยนต์ที่เหมาะสมสำหรับพื้นที่กรณีศึกษา โดยวิเคราะห์ต้นทุนและผลประโยชน์ก่อนและหลังปรับปรุง

2. ทบทวนงานวิจัยที่เกี่ยวข้อง

2.1 มาตรการจัดช่องจราจรสำหรับรถจักรยานยนต์

บนถนนที่มี ยานพาหนะ ขนาดใหญ่ ซึ่งสัญจร ด้วยความเร็วสูง เช่น รถยนต์ และรถบรรทุก เป็นต้น ใช้ช่องจราจรร่วมกับรถจักรยานยนต์ที่สัญจรด้วยความเร็วต่ำ จะทำให้การจราจรเกิดความขัดแย้ง หากสามารถแยก การจราจร ของรถจักรยานยนต์ออกจากกระแสจราจร ยานพาหนะขนาดใหญ่ ได้ ไม่เพียงแต่จะลดอันตรายของผู้ใช้รถจักรยานยนต์เท่านั้น แต่ยังทำให้การไหลของกระแสจราจรดีขึ้น โดยเฉพาะอย่างยิ่งกับเมืองที่มีรถจักรยานยนต์เป็นจำนวนมาก [3]

จตุวิทย์ สุวรรณรงค์ (2561) ได้ศึกษารูปแบบ มาตรการการจัดช่องจราจรสำหรับรถจักรยานยนต์ ในประเทศต่าง ๆ ที่มีปริมาณการใช้รถจักรยานยนต์ในกระแสจราจรสูง โดยส่วนใหญ่อยู่ในแถบ ทวีปเอเชีย พบว่า การจัดช่องจราจรสำหรับรถจักรยานยนต์มีรูปแบบแตกต่างกันไปตามตำแหน่ง ขนาด และทิศทางการเดินรถในช่องจราจร ซึ่งขึ้นกับพื้นที่หรือประเภทถนน โดยสามารถแบ่งออกได้ 3 รูปแบบ คือ 1) การจัดช่องจราจร สำหรับรถจักรยานยนต์บนไหล่ทาง (Shoulder Lane) โดยมีการตีเส้นขาวทึบตลอดแนว พร้อมติดตั้งป้ายจราจร (ตัวอย่างดังรูปที่ 1) พบเห็น ได้ โดย ทั่วไปในประเทศไทย 2) การจัด ช่อง จราจร สำหรับรถจักรยานยนต์ร่วมกับรถประเภทอื่น (Shared Lane) โดยมีการตีเส้นเกาะสี และเครื่องหมายจราจรบนพื้นทาง พร้อมติดตั้งป้ายจราจรเพื่อใช้ถนนร่วมกันระหว่างรถจักรยานยนต์และรถประเภทอื่น พบได้ในไต้หวัน ประเทศจีน และประเทศฟิลิปปินส์ เป็นต้น (ตัวอย่างดังรูปที่ 2ก และ รูปที่ 2ข) หรืออาจกำหนดให้ใช้ช่องจราจรร่วมกับรถประจำทางดังตัวอย่างในกรุงจาการ์ตา ประเทศอินโดนีเซีย และกรุงลอนดอน ประเทศอังกฤษ (ดังรูปที่ 2ค และ รูปที่ 2ง) 3) การจัด ช่อง จราจร เฉพาะสำหรับรถจักรยานยนต์ (Exclusive Lane) ทำได้โดยการแยกช่องจราจรสำหรับรถจักรยานยนต์ออกจากกระแสจราจรทั่วไปอย่างชัดเจน ด้วยการ กั้นแบ่งช่องจราจรสำหรับรถจักรยานยนต์ออกจากช่องจราจรรถยนต์ทั่วไป พบได้ในประเทศมาเลเซียซึ่งมีขนาดความกว้างอยู่ในช่วง 2.00 - 3.50 เมตร [4] (ตัวอย่างดังรูปที่ 3)

รูปที่ 1 ตัวอย่างการจัดช่องจราจรสำหรับรถจักรยานยนต์บนไหล่ทาง (Shoulder Lane)

ก) ประเทศจีน ข) ประเทศฟิลิปปินส์

ค) ประเทศอินโดนีเซีย ง) ประเทศอังกฤษ

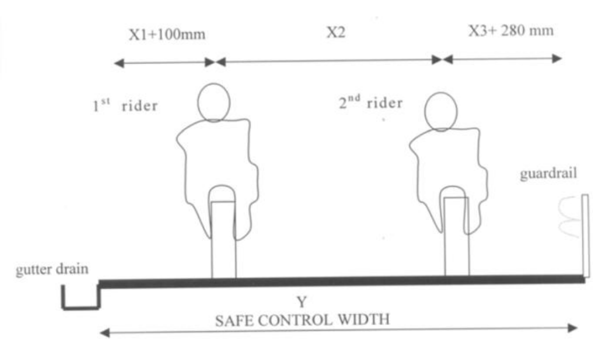
รูปที่ 2 ตัวอย่างการจัดช่องจราจรสำหรับรถจักรยานยนต์ร่วมกับรถประเภทอื่น (Shared Lane)

ที่มา: ก) [5], ข) [6], ค) [7], ง) [8]

รูปที่ 3 ตัวอย่างการจัดช่องจราจรเฉพาะสำหรับรถจักรยานยนต์ (Exclusive Lane)

ที่มา: [9]

Teik Hua LAW (2005) ทำการวิจัยหาความกว้างช่องจราจรเฉพาะสำหรับรถจักรยานยนต์ที่เหมาะสม และเกิดความปลอดภัยแก่ผู้ขับขี่โดยใช้วิธีวิเคราะห์ถดถอยโลจิสติกส์ ตัวแปรคือสถานะที่เกี่ยวกับระดับความสะดวกสบายของผู้ขับขี่ในการแซง ซึ่งได้สรุปความกว้างของช่องจราจรสำหรับรถจักรยานยนต์ที่เหมาะสม คือ 3.81 เมตร โดยมีระยะ X1, X2 และ X3 เท่ากับ 1.19, 1.14 และ 1.18 เมตร[10] ตามลำดับดังรูปที่ 4



รูปที่ 4 ช่องจราจรสำหรับรถจักรยานยนต์

ที่มา: [10]

2.2 การใช้แบบจำลองสภาพการจราจรระดับจุลภาคในการจัดการจราจรสำหรับรถจักรยานยนต์

แบบจำลองสภาพการจราจรระดับจุลภาค เป็นการจำลองพฤติกรรมการเคลื่อนที่ของยานพาหนะแต่ละประเภทที่อยู่ในโครงข่ายถนน สามารถจำลองรูปแบบและสถานการณ์ต่าง ๆ ได้เสมือนจริง ช่วยเพิ่มข้อมูลในการตัดสินใจเลือกรูปแบบในการแก้ไขปัญหาจราจรให้มีประสิทธิภาพสูงสุด ก่อให้เกิดการประหยัดเวลาและงบประมาณ

ชัยวัฒน์ ใหญ่บก [11] ได้ศึกษาและสรุปโปรแกรมที่นิยมใช้ในการจำลองสภาพจราจรระดับจุลภาคที่ใช้ในปัจจุบัน ได้แก่ AIMSUN FRESIM CORSIM NETSIM PARAMICS และ VISSIM เป็นต้น โดยแต่ละโปรแกรมมีคุณสมบัติและประสิทธิภาพในการทำงานที่แตกต่างกัน อย่างไรก็ตามโปรแกรม VISSIM เป็นโปรแกรมที่มีคุณลักษณะเหมาะสมสำหรับใช้ในการพัฒนาแบบจำลองสภาพการจราจรระดับจุลภาคที่มีการจำลองพฤติกรรมการขับขี่ของรถจักรยาน และรถจักรยานยนต์ ซึ่งโปรแกรมมีฟังก์ชั่นที่สามารถกำหนดระยะในการขับขี่ตามกัน และระยะห่างด้านข้างระหว่างยานพาหนะแต่ละคัน นอกจากนี้ โปรแกรม VISSIM สามารถกำหนดให้ยานพาหนะวิ่งแซงยานพาหนะด้านหน้าที่มีความเร็วช้ากว่าภายในช่องจราจรเดียวกันได้ ซึ่งจากฟังก์ชั่นเกี่ยวกับการขับขี่รถจักรยานยนต์ที่กล่าวมาข้างต้น ปัจจุบันยังไม่มีโปรแกรมใดจำลองได้เสมือนจริงเท่าโปรแกรม VISSIM

วราศักดิ์ ปะสังติโย [12] ได้วิเคราะห์การจัดการจราจรสำหรับรถจักรยานยนต์ บริเวณทางแยกที่มีสัญญาณไฟจราจร โดยแบ่งการจัดการจราจรสำหรับรถจักรยานยนต์ ออกเป็น 2 มาตรการ ประกอบด้วย การกำหนดพื้นที่หยุดรอสัญญาณไฟจราจรสำหรับรถจักรยานยนต์ และการกำหนดช่องทางด้านซ้ายเฉพาะสำหรับรถจักรยานยนต์ร่วมกับการกำหนดให้รถจักรยานยนต์วิ่ง Hook Turn เมื่อต้องการเลี้ยวขวา ผลการศึกษา พบว่า ทั้งสองมาตรการสามารถเพิ่มประสิทธิภาพของระดับการให้บริการบริเวณทางแยกได้อย่างมีนัยสำคัญ โดยส่งผลให้เวลาในการเดินทาง ความล่าช้า และ ความยาวของแถวคอยลดลง และยังช่วยลดปริมาณก๊าซมลพิษทางอากาศได้อีกด้วย

Matsumoto et al. [13] ประเทศญี่ปุ่นมีกฎจราจรในการขับขี่รถจักรยานยนต์ร่วมกับรถประจำทางอยู่ 2 รูปแบบ คือกฎโตเกียว ที่ระบุไว้ว่า รถจักรยานยนต์ไม่สามารถขับขี่ในช่องจราจรสำหรับรถประจำทาง และกฎของคานาวะ ระบุไว้ว่า อนุญาตให้รถจักรยานยนต์สามารถขับขี่ในช่องจราจรสำหรับรถประจำทางได้ จากการศึกษา ผู้วิจัยได้มีการเสนอกฎใหม่เพื่อให้รถจักรยานยนต์สามารถใช้ช่องจราจรร่วมกันกับรถโดยสารประจำทางได้และเกิดความสมดุล ซึ่งอาจลดอุบัติเหตุจราจรได้ โดยมีวัตถุประสงค์เพื่อวิเคราะห์ผลกระทบของการควบคุมการจราจรด้วยกฎจราจรรูปแบบใหม่ กรณีศึกษา เมืองคานากาวะ และเมืองโตเกียว ประเทศญี่ปุ่น โดยใช้โปรแกรม VISSIM ในการจำลองสภาพการจราจรภายใต้เงื่อนไข คือ การใช้ช่องจราจรสำหรับรถจักรยานยนต์ สัดส่วนผสมผสานของรถจักรยานยนต์และยานพาหนะอื่น ๆ และปริมาณการจราจรของรถจักรยานยนต์ในแต่ช่องจราจร โดยผลจากการวิเคราะห์การจราจรในกฎจราจรรูปแบบต่าง ๆ นั้น ทำให้ทราบว่า ปริมาณการจราจรของยานพาหนะแต่ละช่องจราจรของกฎจราจรรูปแบบใหม่มีค่าที่ลดลง เมื่อเปรียบเทียบกับรูปแบบอื่น ๆ ดังนั้น การจราจรของกฎจราจรรูปแบบใหม่ที่ได้ สามารถลดความเสี่ยงของการเกิดอุบัติเหตุการจราจรลงได้

ซุลกีฟลี มามะ [14] พยายามพัฒนารูปแบบและความกว้างมาตรฐานสำหรับรถจักรยานยนต์ในประเทศไทย ซึ่งพิจารณารูปแบบที่เหมาะสมจากข้อมูลอุบัติเหตุเทียบกับตัวแปรของความเร็วและปริมาณจราจร โดยกำหนดช่วงความกว้างช่องจราจรสำหรับรถจักรยานยนต์เริ่มต้นลงในแบบจำลองสภาพการจราจรระดับจุลภาคด้วยโปรแกรม VISSIM เพื่อวิเคราะห์หาความสัมพันธ์ระหว่างปริมาณจราจร ความกว้างของช่องจราจร และระดับการให้บริการ ผู้วิจัยได้ทำการทดลองจัดช่องจราจรจริงในสนามเพื่อเก็บข้อมูลความเร็วตามการเปลี่ยนแปลงขนาดช่องจราจรเพื่อเทียบกับความสัมพันธ์ระหว่างความเร็วและการลดอุบัติเหตุ จากผลการวิจัย พบว่า ความกว้างช่องจราจร 2.00 – 3.00 เมตร เป็นขนาดที่มีประสิทธิภาพสูงสุดสำหรับรูปแบบการจัดช่องจราจรสำหรับรถจักรยานยนต์ร่วมกับรถประเภทอื่น (Shared Lane) และผู้วิจัยได้เสนอความกว้างที่เหมาะสมสำหรับการจัดช่องจราจรเฉพาะสำหรับรถจักรยานยนต์ (Exclusive Lane) อยู่ในช่วง 3.00 – 4.00 เมตร

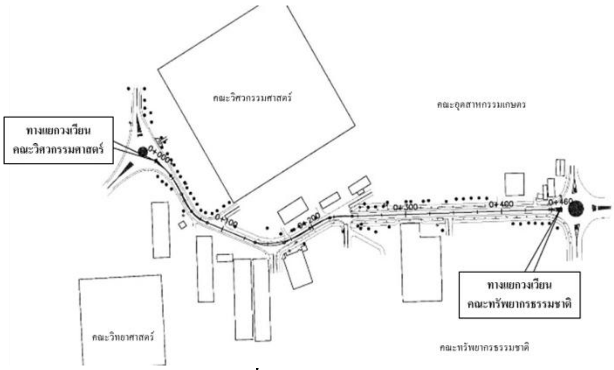
จตุวิทย์ สุวรรณรงค์ [3] ได้สร้างแบบจำลองสภาพการจราจรระดับจุลภาคด้วยโปรแกรม VISSIM โดยใช้รูปแบบการจัดช่องจราจรสำหรับรถจักรยานยนต์ร่วมกับรถประเภทอื่น (Shared Lane) โดยใช้ช่วงถนนภายในมหาวิทยาลัยเป็นเส้นทางศึกษาเพื่อวิเคราะห์หาประสิทธิภาพการจราจร และประเมินความปลอดภัยก่อนและหลังปรับปรุง ผลการศึกษาพบว่า การปรับปรุงช่วงถนนช่วงดังกล่าวสามารถเพิ่มประสิทธิภาพการจราจรและความปลอดภัยได้อย่างมีนัยสำคัญ โดยสามารถลดเวลาเดินทางเฉลี่ยในการสัญจรผ่านเส้นทางศึกษาลงได้ร้อยละ 37.93 ลดเวลาล้าช้าเฉลี่ยลงได้ร้อยละ 84.53 และสามารถเพิ่มระดับการให้บริการ โดยรวมในเส้นทางศึกษาจากระดับ D เป็นระดับ A

จากการศึกษารูปแบบการจัดช่องจราจรสำหรับรถจักรยานยนต์ และจากการรวบรวมงานวิจัยที่เกี่ยวข้องกับการหาความกว้างของช่องจราจรสำหรับรถจักรยานยนต์ พบว่า มีความแตกต่างกันไป ทั้งนี้ อาจเนื่องมาจากพื้นที่ศึกษาหรือประเภทถนนซึ่งมีผลต่อการใช้ความเร็วและปริมาณจราจรที่แตกต่างกันไป

3. วิธีการศึกษา

3.1 พื้นที่ศึกษา

ในงานวิจัยครั้งนี้ พื้นที่ศึกษางานวิจัย คือ เส้นทางถนนบริเวณทางแยกวงเวียนหน้าคณะวิศวกรรมศาสตร์ ถึง ทางแยกวงเวียนคณะทรัพยากรธรรมชาติ มหาวิทยาลัยสงขลานครินทร์ วิทยาเขตหาดใหญ่ อำเภอหาดใหญ่ จังหวัดสงขลา มีระยะทางประมาณ 460 เมตร (รูปที่ 5) ทั้งนี้ถนนดังกล่าวเป็นเส้นทางสายหลัก สายหนึ่ง ในการสัญจรเข้า-ออกมหาวิทยาลัย โดยเส้นทางดังกล่าวได้ถูกออกแบบและใช้งานมาเป็นระยะเวลานาน ทำให้ มีลักษณะทางกายภาพและการจัดการจราจร ไม่สอดคล้องกับสภาพการจราจรในปัจจุบัน และปัญหาผิวจราจรชำรุด ก่อให้เกิดอุบัติเหตุบ่อยครั้ง โดยเฉพาะกับผู้ใช้รถจักรยานยนต์ ประกอบกับปริมาณการจราจรสูงและมีแนวโน้มเพิ่มขึ้นอย่างต่อเนื่องในแต่ละปี ส่งผลให้เกิดปัญหาการจราจรติดขัดในชั่วโมงเร่งด่วนเช้าและเย็น ดังนั้น พื้นที่ดังกล่าวจึงมีความเหมาะสมในการศึกษา การวิเคราะห์ หามาตรการจัดการจราจรให้ดีขึ้น เพื่อเป็นแนวทาง ให้หน่วยงานที่รับผิดชอบนำไปใช้ในการปรับปรุงแก้ไขช่วงถนนสายดังกล่าว



รูปที่ 5 เส้นทางศึกษา

ที่มา: [3]

3.2 ข้อมูลภาคสนาม

ข้อมูลที่จำเป็นต่อการพัฒนาแบบจำลองสภาพการจราจรระดับจุลภาคของช่วงถนนที่ศึกษา ในการศึกษานี้ ประกอบด้วย ลักษณะทางกายภาพ และข้อมูลการจราจร ซึ่งงานวิจัยในครั้งนี้ ผู้วิจัยได้อ้างอิงผล

การสำรวจลักษณะทางกายภาพ และข้อมูลการจราจรจากงานวิจัยเรื่อง การวิเคราะห์การจัดการจราจรสำหรับรถจักรยานยนต์ กรณีศึกษา มหาวิทยาลัยสงขลานครินทร์ ที่นำเสนอในการประชุมวิชาการวิศวกรรมโยธาแห่งชาติ ครั้งที่ 23 [3] โดยมีรายละเอียดพอสังเขป ดังนี้

1) ข้อมูลลักษณะทางกายภาพ

การพัฒนาแบบจำลองสภาพการจราจรของช่วงถนนที่ศึกษา จำเป็นต้องใช้ข้อมูลลักษณะทางกายภาพในพื้นที่ศึกษาจริงในปัจจุบัน ซึ่งประกอบด้วย แนวและระดับของถนนเดิม ขนาดความกว้างและจำนวนของช่องจราจร ลักษณะพื้นที่และการจัดการจราจรบริเวณทางแยก ทางเดินเท้า และระบบสาธารณูปโภคที่เกี่ยวข้อง เช่น เสาไฟฟ้า ท่อน้ำประปา เป็นต้น โดยทำการสำรวจด้วยกล้องสำรวจและนำข้อมูลต่างๆ มาเขียนแบบสภาพของถนนเดิมเพื่อใช้การสร้างแบบจำลองฐานต่อไป

2) ข้อมูลการจราจร

ข้อมูลการจราจรที่จำเป็นในการสร้างแบบจำลองสภาพการจราจรประกอบด้วยข้อมูลปริมาณการจราจร และข้อมูลความเร็ว ในส่วนของข้อมูลปริมาณการจราจรผู้วิจัยได้ทำการสำรวจโดยแบ่งเป็น 2 ลักษณะคือ ทำการสำรวจปริมาณการจราจรบริเวณทางแยก (Turning Movement Count) ของทางแยกแต่ละจุดในเส้นทางศึกษา และทำการสำรวจปริมาณการจราจรบริเวณช่วงถนน (Mid-Block Count) เพื่อใช้เป็นข้อมูลในการปรับแก้ข้อมูลปริมาณการจราจรโดยรวมของพื้นที่ศึกษา ซึ่งแบ่งการสำรวจออกเป็น 2 ช่วงเวลา คือ ช่วงเร่งด่วนเช้า (7:45 - 09:45 น.) และช่วงเร่งด่วนเย็น (15:45 - 17:45 น.) ทำการบันทึกข้อมูลปริมาณการจราจรในทุก ๆ 15 นาที และแบ่งประเภทยานพาหนะออกเป็น 4 ประเภท ประกอบด้วย รถจักรยาน รถจักรยานยนต์ รถยนต์ส่วนบุคคล และรถบัสโดยสารสาธารณะ โดยมีผลการสำรวจปริมาณการจราจรบริเวณช่วงถนน ในช่วงเช้า (7:45 - 09:45 น.)และเย็น (15:45 - 17:45 น.) ของวันศุกร์ที่ 24 มีนาคม และวันจันทร์ที่ 27 มีนาคม พ.ศ. 2560 พบว่า ปริมาณการจราจรในช่วงเร่งด่วนเช้าและเย็นของวันศุกร์ มีค่าเท่ากับ 898 PCU/ชั่วโมง (8:00 - 9:00 น.) และ 1,095 PCU/ชั่วโมง (16:30 - 17:30 น.) ตามลำดับ และสำหรับวันจันทร์ มีค่าเท่ากับ 1 ,020 PCU/ชั่วโมง (8:00 - 9:00 น.) และ 1,224 PCU/ชั่วโมง (16:30 - 17:30 น.) ตามลำดับ ผู้วิจัยจึงเลือกใช้ข้อมูลปริมาณจราจรในชั่วโมงเร่งด่วนเช้าของวันจันทร์เป็นตัวแทนในการสร้างแบบจำลองฐานสำหรับงานวิจัยในครั้งนี้ และใช้ข้อมูลปริมาณการจราจรในช่วงชั่วโมงเร่งด่วนเย็นตรวจสอบความถูกต้องของแบบจำลอง

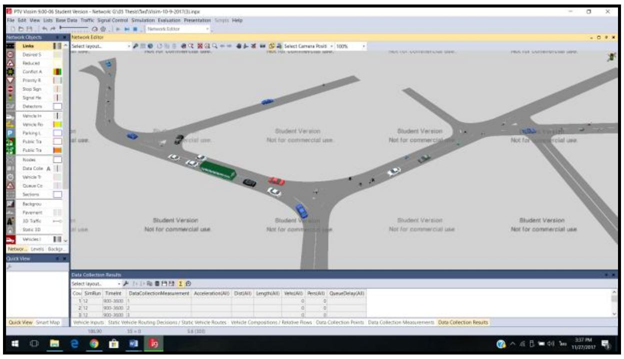
นอกจากนี้ผู้วิจัยได้นำข้อมูลปริมาณจราจรข้างต้นวิเคราะห์หาสัดส่วนการกระจายการเดินทางระหว่างจุดต้นทางและปลายทาง และใช้ข้อมูลจากการสำรวจความเร็วเฉลี่ย (Space Mean Speed) ของยานพาหนะที่ขับผ่านเส้นทางศึกษาวิเคราะห์การกระจายความเร็ว เพื่อนำข้อมูลดังกล่าวไปประกอบการพัฒนาแบบจำลองต่อไป

3.3 การพัฒนาและประยุกต์ใช้แบบจำลอง

คณะผู้วิจัยได้ประยุกต์ใช้โปรแกรม VISSIM รุ่น 8.0 ในการพัฒนาแบบจำลองสภาพการจราจรระดับจุลภาคบริเวณเส้นทางศึกษา โดยมีขั้นตอนดังนี้

1) การสร้างแบบจำลองฐาน

การสร้างแบบจำลองฐาน หรือแบบจำลองสภาพการจราจรปัจจุบันเป็นการจำลองสภาพการจราจรก่อนการใช้มาตรการจัดการจราจร โดยสร้างแบบจำลองตามลักษณะทางกายภาพและสภาพการจราจรปัจจุบันของพื้นที่ศึกษา ที่ได้จากการสำรวจลักษณะทางกายภาพและสภาพปัญหาการจราจร ดังแสดงในรูปที่ 6



รูปที่ 6 ตัวอย่างหน้าจอการพัฒนาแบบจำลองการจราจรระดับจุลภาคของพื้นที่ศึกษาสภาพปัจจุบัน

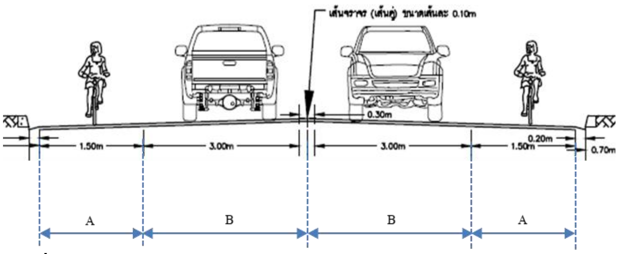
2) การปรับเทียบแบบจำลองและการตรวจสอบความถูกต้องของแบบจำลอง

แบบจำลองฐานที่ได้จากข้อ 3.3 (1) ได้ถูกนำมาปรับเทียบ โดยนำผลลัพธ์ที่ได้จากแบบจำลองมาเปรียบเทียบกับข้อมูลปริมาณจราจรในชั่วโมงเร่งด่วนเช้า ซึ่งเป็นช่วงเวลาที่มีปัญหาการจราจรติดขัดมากที่สุด ผลลัพธ์ที่ได้จากแบบจำลองครั้งนี้จะต้องผ่านเกณฑ์ GEH < 5 ซึ่งถือว่ายอมรับได้ จากนั้น นำแบบจำลองที่ปรับเทียบแล้ว มาตรวจสอบความถูกต้อง โดยใส่ข้อมูลปริมาณจราจรในชั่วโมงเร่งด่วนเย็น แล้วเปรียบเทียบปริมาณการจราจร ความเร็ว และเวลาในการเดินทางเฉลี่ย ให้ผลลัพธ์ใกล้เคียงอยู่ในเกณฑ์ที่ยอมรับได้

3) การประยุกต์ใช้แบบจำลองสภาพการจราจร

สำหรับการประยุกต์ใช้แบบจำลองสภาพการจราจรเพื่อหาขนาดช่องจราจรที่เหมาะสมสำหรับรถจักรยานยนต์ จะแบ่งมาตรการออกเป็น 4 รูปแบบ แต่ละรูปแบบใช้ตัวแปรขนาดความกว้างช่องจราจรสำหรับรถจักรยานยนต์ (A) และช่องจราจรสำหรับรถยนต์ทั่วไป (B) แตกต่างกันออกไป (รูปที่ 7) ซึ่งมีรายละเอียดคือ รูปแบบปัจจุบัน เป็นการจำลองตามสภาพเส้นทางที่ศึกษาปัจจุบัน ซึ่งมีผิวถนนเดิมกว้าง 9.00 เมตร ความกว้างช่องจราจรละ 4.50 เมตร ไม่มีไหลทาง รูปแบบการจำลองที่ 1, 2 และ 3 มีความกว้างผิวจราจรวม 9.00 9.60 และ 10.00 เมตร ตามลำดับ โดยแบ่งเป็นช่องจราจรสำหรับรถจักรยานยนต์กว้าง 1.50 ,

1.80 และ 2.00 เมตร ตามลำดับ ซึ่งเป็นช่วงความกว้างต่ำสุดที่ขนาดรถจักรยานยนต์สัญจรได้เนื่องจากสภาพพื้นที่ศึกษาที่มีข้อจำกัดในการขยายความกว้าง และมีช่องจราจรรถยนต์กว้าง 3.00 เมตรเท่ากัน สามารถสรุปรายละเอียดดังแสดงในตารางที่ 1



รูปที่ 7 ตัวอย่างหน้าตัดถนนกรณีจัดช่องจราจรรถจักรยานยนต์ 1.5 เมตร
ที่มา: ผู้วิจัย

ตารางที่ 1 ขนาดความกว้างช่องจราจรแต่ละแบบจำลองสภาพการจราจร

รูปแบบการจำลอง	ทิศทางขาเข้า		ทิศทางขาออก	
	A (ม.)	B (ม.)	B (ม.)	A (ม.)
ปัจจุบัน	0.00	4.50	4.50	0.00
1	1.50	3.00	3.00	1.50
2	1.80	3.00	3.00	1.80
3	2.00	3.00	3.00	2.00

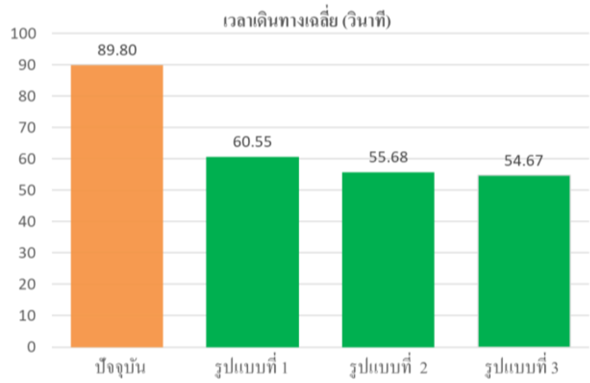
ที่มา: ผู้วิจัย

4. ผลการวิจัยและอภิปรายผล

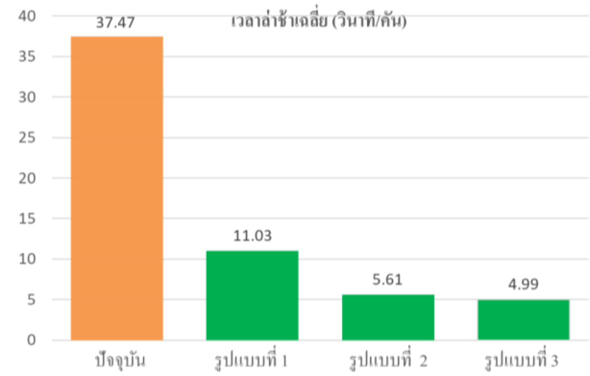
4.1 ผลการวิเคราะห์สภาพการจราจรจากแบบจำลองที่พัฒนา

ผู้วิจัยได้นำแบบจำลองสภาพการจราจรระดับจุลภาคที่พัฒนาขึ้นมาวิเคราะห์หาเวลาเดินทางเฉลี่ย เวลาล่าช้าเฉลี่ย และระดับการให้บริการ ตามรูปแบบการจำลองที่นำเสนอในหัวข้อ 3.3 (3) ผลดังแสดงในรูปที่ 8 และรูปที่ 9

จากผลการศึกษา พบว่า มาตรการจัดช่องจราจรสำหรับรถจักรยานยนต์ แต่ละรูปแบบ (รูปแบบจำลองที่ 1 , 2 และ 3 ตามลำดับ) เทียบกับรูปแบบปัจจุบันส่งผลให้เวลาเดินทางเฉลี่ยลดลง 32.57 % 37.99% และ 39.12% ตามลำดับ รวมถึงเวลาล่าช้าเฉลี่ยที่มีค่าลดลงเท่ากับ 70.56% 85.03% และ 86.68 % ตามลำดับด้วย นอกจากนี้ เมื่อพิจารณาระดับการให้บริการ ในภาพรวมทุกรูปแบบ พบว่า มีแนวโน้มที่ดีขึ้นอย่างมีนัยสำคัญตามลำดับ ซึ่งสามารถสรุปได้ดังตารางที่ 2 ทั้งนี้ เนื่องจากการแยกรถจักรยานยนต์ออกจากกระแสจราจรรถยนต์ ส่งผลให้กระแสจราจรไหลดียิ่งขึ้น และจากแบบจำลองแต่ละรูปแบบแสดงให้เห็นถึงพฤติกรรมของผู้ขับขี่รถจักรยานยนต์ในการตัดสินใจแซงที่แตกต่างกัน เนื่องจากขนาดช่องจราจรที่แตกต่างกันมีผลต่อระยะห่างระหว่างรถจักรยายนต์และรถยนต์ในช่องจราจรหลัก



รูปที่ 8 เวลาเดินทางเฉลี่ย (Travel Time)



รูปที่ 9 เวลาล่าช้าเฉลี่ย (Delay Time)

ตารางที่ 2 ตัวชี้วัดความแตกต่างของแบบจำลองแต่ละรูปแบบในการจัดการจราจรระดับจุลภาค

รูปแบบการจำลอง	เวลาเดินทางเฉลี่ย (วินาที)	ความแตกต่าง		เวลาล่าช้าเฉลี่ย (วินาที/คัน)	ความแตกต่าง		ระดับการให้บริการ
		วินาที	ร้อยละ		วินาที	ร้อยละ	
ปัจจุบัน	89.80	-	-	37.47	-	-	D
1	60.55	-29.25	+32.57 %	11.03	-26.44	+70.56 %	A
2	55.68	-34.12	+37.99 %	5.61	-31.86	+85.03 %	A

3	54.67	-35.13	+39.12 %	4.99	-32.48	+86.68 %	A

4.2 การวิเคราะห์อัตราส่วนต้นทุนต่อผลประโยชน์จากการดำเนินมาตรการจัดการจราจรสำหรับรถจักรยานยนต์

ผลจากการวิเคราะห์มาตรการการจัดการจราจร แต่ละรูปแบบสามารถลดปัญหาการจราจรลงได้ แต่ในทางปฏิบัติแล้ว หน่วยงานที่เกี่ยวข้องกับการปรับปรุงลักษณะทางกายภาพของทางแยกอาจมีข้อจำกัดด้านงบประมาณ ดังนั้น งานวิจัยนี้จึงได้วิเคราะห์ต้นทุน ผลประโยชน์ รวมทั้งวิเคราะห์หาอัตราส่วนต้นทุนต่อผลประโยชน์ของแต่ละรูปแบบที่ได้นำเสนอ โดยมีรายละเอียดดังนี้

1) การวิเคราะห์ต้นทุน

การวิเคราะห์ต้นทุนเป็นการประมาณค่าใช้จ่ายในการปรับปรุงในแต่ละรูปแบบที่ได้นำเสนอ โดยการคำนวณเนื้องานของแต่ละรูปแบบ โดยใช้ราคากลางจากสำนักงานพาณิชย์จังหวัดสงขลา พ.ศ. 2560 [15] เพื่ออ้างอิงราคาในการก่อสร้าง ทั้งนี้ ค่าใช้จ่ายในการปรับปรุงจะรวมถึงค่ารื้อย้ายระบบสาธารณูปโภคในพื้นที่ศึกษา ประกอบด้วย เสาไฟฟ้าและท่อระบายน้ำ ซึ่งปริมาณที่ต้องรื้อย้ายขึ้นกับขนาดความกว้างในการขยายถนนแต่ละรูปแบบ ผลจากการประมาณต้นทุนรูปแบบต่าง ๆ แสดงดังตารางที่ 3

2) การวิเคราะห์ผลประโยชน์

การคำนวณผลประโยชน์จากมาตรการในการจัดการจราจรของแต่ละรูปแบบ ผู้วิจัยได้พิจารณาผลประโยชน์จากเวลาในการเดินทางและความล่าช้าที่ลดลง โดยเปรียบเทียบค่าปัจจุบันกับค่าหลังดำเนินการในแต่ละรูปแบบ โดยในงานวิจัยนี้ประยุกต์ใช้ค่าจากผลการศึกษาของการทางพิเศษแห่งประเทศไทย (2557) [16] ซึ่งได้ศึกษามูลค่าของเวลาในการเดินทางและมูลค่าของเวลาในการรอรถในพื้นที่ของจังหวัดสงขลา สามารถแสดงรายละเอียดการวิเคราะห์ได้ดังตารางที่ 4

3) การวิเคราะห์หาอัตราส่วนผลประโยชน์ต่อต้นทุน

ในการวิเคราะห์หาอัตราส่วนของผลประโยชน์ต่อต้นทุนสามารถคำนวณได้จากค่าของผลประโยชน์จากเวลาในการเดินทางที่ลดลง (บาท/ปี) หารด้วยต้นทุนค่าก่อสร้าง (บาท) โดยผลที่ได้แต่ละรูปแบบจำลองแสดงดังตารางที่ 4

ตารางที่ 3 ต้นทุนการปรับปรุงของแต่รูปแบบจำแนกตามประเภทงานบริเวณเส้นทางศึกษา

ประเภทงาน	รูปแบบที่ 1	รูปแบบที่ 3	รูปแบบที่ 2
งานดินและชั้นคันทาง	44,058.60	46,506.30	58,744.80
งานโครงสร้างทางและผิวจราจร	1,001,095.07	1,056,711.46	1,334,793.42
งานโครงสร้าง	1,116,076.52	1,130,317.69	1,401,845.86
งานเบ็ดเตล็ด	3,584,306.19	3,591,410.08	3,659,725.18
งานรื้อย้ายระบบสาธารณูปโภค	82,500.00	90,000.00	165,000.00
รวม	5,828,036.38	5,914,945.53	6,620,109.26

ที่มา: ผู้วิจัย หน่วยเป็นบาท

ตารางที่ 4 การวิเคราะห์อัตราส่วนต้นทุนต่อผลประโยชน์

รูปแบบการจำลอง	**ประโยชน์จากเวลาในการเดินทางเฉลี่ยที่ลดลง (วินาที/คัน)**	**ผลประโยชน์จากเวลาในการเดินทางที่ลดลง (บาท)**	**ต้นทุนค่าก่อสร้าง (บาท)**	**สัดส่วนผลประโยชน์ต่อต้นทุน**	**ลำดับความคุ้มทุน**
1	29.25	7,935,688.80	5,828,036.38	1.36	3
2	34.12	9,240,668.73	5,914,945.53	1.56	1
3	35.13	9,530,965.72	6,620,109.26	1.44	2

ที่มา: ผู้วิจัย

5. สรุปและข้อเสนอแนะ

บทความนี้นำเสนอการศึกษาผลกระทบของการใช้ช่องจราจรสำหรับรถจักรยานยนต์ขนาดต่าง ๆ ต่อประสิทธิภาพของการจราจร โดยเลือกช่วงถนนสายหลักระหว่างวงเวียนคณะวิศวกรรมศาสตร์ถึงวงเวียนคณะทรัพยากรธรรมชาติ ภายในมหาวิทยาลัยสงขลานครินทร์ วิทยาเขตหาดใหญ่ เป็นกรณีศึกษา โดยแบ่งความกว้างของช่องจราจรสำหรับรถจักรยานยนต์ออกเป็น 1.50 , 1.80 และ 2.00 เมตร ตามลำดับ และใช้แบบจำลองสภาพการจราจรระดับจุลภาคเป็นเครื่องมือในการวิเคราะห์หาประสิทธิภาพของการจราจร รวมทั้งนำผลที่ได้มาคำนวณหาอัตราส่วนต้นทุนต่อผลประโยชน์จากการปรับปรุง (BCR)

จากผลการวิเคราะห์หาประสิทธิภาพการจราจรแต่ละรูปแบบ ซึ่งประกอบด้วยเวลาเดินทางเฉลี่ย เวลาล่าช้า และระดับการให้บริการ พบว่า การจัดช่องจราจรสำหรับรถจักรยานยนต์แยกออกจากการจราจรของรถยนต์รูปแบบที่ 1 , 2 และ 3 สามารถเพิ่มประสิทธิภาพการจราจร

ของช่วงถนนที่ศึกษาได้ดีขึ้นตามลำดับ และเมื่อพิจารณาผลประโยชน์จากการปรับปรุง พบว่า อัตราส่วนต้นทุนต่อผลประโยชน์ของรูปแบบที่ 2 (ความกว้างช่องจราจรสำหรับรถจักรยานยนต์ เท่ากับ 1.80 เมตร) มีความเหมาะสมในการปรับปรุงเป็นลำดับที่ 1 โดยมีค่าเท่ากับ 1.56 รองลงมาคือ รูปแบบที่ 3 และรูปแบบที่ 1 โดยมีอัตราส่วนต้นทุนต่อผลประโยชน์เท่ากับ 1.44 และ1.36 ตามลำดับ ผลการศึกษานี้จะเป็นแนวทางให้หน่วยงานที่เกี่ยวข้องตัดสินใจนำไปจัดการการจราจรบริเวณที่ศึกษาดังกล่าวต่อไป สำหรับงานวิจัยนี้ยังขาดผลจากการวิเคราะห์ด้านความปลอดภัย ซึ่งจะเป็นประเด็นสำหรับงานวิจัยในอนาคต เช่น การวิเคราะห์ประเด็นความปลอดภัยของช่องจราจรโดยใช้โปรแกรม Surrogate Safety Assessment Model (SSAM)

6. กิตติกรรมประกาศ

ผู้วิจัยคนที่ 1 ขอขอบพระคุณทุนศิษย์ก้นกุฏิ คณะวิศวกรรมศาสตร์ มหาวิทยาลัยสงขลานครินทร์ พ.ศ. 2558 ที่สนับสนุนทุนการศึกษา

เอกสารอ้างอิง

[1] WHO (2016). World Health Statistics 2016 : Monitoring health for the SDGs.

[2] วิวัฒน์ สุทธิวิภากร และศักดิ์ชัย ปรีชาวีรกุล (2548). การศึกษาการปรับปรุงระบบกายภาพการจราจร (การปรับปรุงเส้นทางหลัก และการปรับปรุงระบบการจอดรถ) มหาวิทยาลัยสงขลานครินทร์ วิทยาเขตหาดใหญ่. คณะวิศวกรรมศาสตร์ มหาวิทยาลัยสงขลานครินทร์ , หน้า 1-2

[3] Radin Umar R.S., Mackay M.G., and Hill B.L. (1995). Preliminary Analysis of Exclusive Motorcycle Lanes Along the Federal

[4] จตุวิทย์ สุวรรณรงค์ และปรเมศวร์ (2561). การวิเคราะห์การจัดการจราจรสำหรับรถจักรยานยนต์. การประชุมวิชาการวิศวกรรมโยธาแห่งชาติ ครั้งที่ 23, หน้า TRL 243

[5] Lea, T.Q., Nurhidayatib, Z. A. (2016). A Study of Motorcycle Lane Design in Some Asian Countries. Procedia Engineering 142, 292 – 298.

[6] Bautista, G. E. (2017). Motorcycle lanes alone won't make riding safer; safe riding attitude will (Online).Available :http:// www.malaya.com.ph [2017, December 5]

[7] Putranto, L. S., Suardika, G. P., Sunggiardi, R., Munandar, A. S., and Lutfi, I. (2011). The Performance of Motorcycle Lanes in Jakarta and Sragen. In Proceedings of the Eastern Asia Society for Transportation Studies (Vol. 2011). Eastern Asia Society for Transportation Studies. pp. 290–290.

[8] Farrell, S. (2011). London's bikes in bus lanes scheme made permanent (Online). Available :http://www.motorcyclenews.com [2017, December 5]

[9] Hinchliffe, M. (2017). UN suggests separate motorcycle lanes (Online). Available :http://www.motorbikewriter.com [2017, December 5]

[10] Law, T.H., and Sohadi, R.U.R. (2005). Determination of Comfortable Safe Width in an Exclusive Motorcycle Lane. Journal of the Eastern Asia Society for Transportation Studies, 6, 3372–3385.

[11] ชัยวัฒน์ ใหญ่บก. (2558). การปรับปรุงการจราจรบริเวณสี่ทางแยกบนถนนกาญจนวนิชย์ในเมืองหาดใหญ่ . วิทยานิพนธ์ปริญญาวิศวกรรมศาสตร์มหาบัณฑิต สาขาวิศวกรรมโยธา มหาวิทยาลัยสงขลานครินทร์

[12] วราศักดิ์ ปะสังติโย, ธเนศ เสถียรนาม, วิชุดา เสถียรนาม, และอรรถ พลสีดำ (2556). การวิเคราะห์การจัดการจราจรสำหรับรถจักรยานยนต์ที่ทางแยกสัญญาณไฟจราจร. การประชุมวิชาการวิศวกรรมโยธาแห่งชาติ ครั้งที่ 18, หน้า TRP 236 – TRP 242.

[13] Matsumoto, W., Fukuda, A., Ishizaka, T., and Hashino, Y. (2014). Study on Effective lane usage including bus exclusive lane for motorcycles. 7th ATRANS Symposium: Young Researcher's Forum. August 22, 2014, Bangkok, Thailand.

[14] Sulkiflee Mama, and Pichai Taneerananon. (2016). Effective Motorcycle Lane Configuration Thailand: A Case Study of Southern Thailand. ENGINEERING JOURNAL Volume 20 Issue3, ISSN 0125-8281, 113 – 121.

[15] สำนักงานพานิชย์จังหวัดสงขลา ราคาวัสดุก่อสร้าง กระทรวงพาณิชน์ (2560). :http://www.price.moc.go.th/price/struct/, สืบค้นเมื่อ ธันวาคม 2560.

[16] การทางพิเศษแห่งประเทศไทย. (2557). โครงการศึกษาความเป็นไปได้สำรวจและออกแบบเบื้องต้นทางพิเศษเพื่อพัฒนาระบบโลจิสติกส์ระหว่างประเทศ. รายงายฉบับสมบรูณ์, มิถุนายน 2557.

A Study on the Effect of Motorcycle Traffic Safety Workshop for High School and University Students in Phnom Penh, Cambodia

Topic number: (5) Paper Identification number: AYRF18-029

Toshiki KOYANAGI[1], NagahiroYOSHIDA[2], Yuto KITAMURA[3]

[1]Department of Faculty of Engineering
Osaka City University
Telephone +81-6-6605-2730, Fax. +81-6-6605-3077
E-mail: m17td014@vh.osaka-cu.ac.jp

[2]Department of Faculty of Engineering
Osaka City University
Telephone +81-6-6605-2730, Fax. +81-6-6605-3077
E-mail: yoshida@eng.osaka-cu.ac.jp

[3] Graduate School of Education
The University of Tokyo
Telephone +81-3-5841-0261, Fax. +81-3-5841-0261
E-mail: yuto@p.u-tokyo.ac.jp

Abstract

In Cambodia, motorcycle use has spread rapidly in recent years, and serious accidents involving motorcycles have increased. In particular, many young motorcyclists have been involved in traffic accidents, and various issues in traffic safety are remained. To understand the current situations related to these issues in Phnom Penh, Cambodia, a questionnaire survey on driving attitude and behavior of motorcycle users in high school and university and a video observation survey of driving situations were conducted. Based on the results, a traffic safety workshop was held to improve their risk perception ability and basic riding skills. In this study, statistical analysis were conducted to compare driving behavior on arterial roads before and after the workshop. The results showed that some behavioral changes were considered to be effects of the traffic safety workshop, and especially, driving skill learning was thought to have had an effect on aggressive behavior side while the risk perception training was thought to have had an effect on defensive behavior side.

Keywords: Motorcycles, Hazard perception, Traffic behavior, Traffic safety, Traffic education

1. Introduction

In Cambodia, motorcycle use has spread rapidly in recent years, and the proportion of accidents involving motorcycles has also increased. According to an OECD report, the number of traffic fatality in 2016 was 1852 (11.8 per 100 thousand people), and 73% of these fatalities were riders of "motorized two wheelers" [1]. Motorcycle accidents have accounted for more than 90% in the 15-24 age group, and main factors were identified as excessive speed, drink driving, and dangerous overtaking. In response to these situations, a review of driving license system for motorcycles was underway, while a mandatory helmet law for motorcycle drivers was passed when riding a motorcycle of 49cc or above in 2007, and in 2015, it was made compulsory for motorcycle passengers to wear a helmet and the law regarding traffic violations was toughened.

Regarding road infrastructure, the Asian Highway Network including arterial roads in Cambodia are being improved, and traffic signals and a traffic control center are introduced in the capital city, Phnom Penh. With regard to traffic safety education, some activities are supported by NGOs, and the content of the education has been included in the compulsory education curriculum. However, judging from the current situation regarding traffic accidents occurring among young people, both the quantity and the quality of this education is considered insufficient and some advanced knowledge and skills for road safety education in practical ways are required.

As described above, the International Association of Traffic and Safety Sciences carried out the following three activities described below to understand specific knowledge about driving behaviors and related traffic safety education. First, a questionnaire survey on motorcycle driving attitude and behavior for young people in Phnom Penh and an observation survey using video cameras attached on motorcycles were conducted to gain some insights from actual traffic condition. Next, based on these results, a traffic safety workshop (WS) for the participants in the behavior survey. The workshop consisted of two parts: a classroom portion, and a driving portion. In classroom learning, after explaining the situation of traffic accidents in Cambodia, a training aimed at improving hazard prediction ability was carried out using dangerous driving scenarios extracted from the video observation of driving behavior. In driving portion, basic driving training was given by an instructor. Finally, video observation of driving behavior was carried out again to examine the impact of the traffic safety workshop.

In this study, with the aim of clarifying issues relating to fundamental driving behaviors that contribute to motorcycle traffic safety, such as travel speed, the risk perception results and the behavioral video observation results were compared, and statistical analysis of driving behavior before and after the workshop was conducted.

2. Literature review

Many studies on motorcycle traffic safety examined problems especially in Asian countries including analysis of risk behavior in Thailand [2], [3], risk analysis of accidents at intersections in Malaysia [4], and accident data analysis related to motorcycles in Indonesia [5], and various issues have been identified such as helmet use, alcohol, training, daytime running lights, driving licenses, and risk taking behaviors [6].

With regard to driver education, there are many studies on hierarchical models for driving behavior [7], [8], and their extension [9], as well as specific assessment methods [10]. In research on motorcycle use and the effects of education, there are studies on the relationship between education and traffic safety behavior [11], behavioral intention [12], educational content and license system [13], and educational methods and children's developmental stage [14]. In particular, to improve traffic safety performance among young people, dealing with risk-taking behavior [15], and the importance of move advanced driving skill training in addition to the conventional training have been identified [16].

On the other hand, in order to better understand these driving behaviors, the importance of traffic safety measures based on evidence, such as naturalistic driving observation studies [17] and development of on-board devices [18], has been pointed out [19].

As described above, there are various research results regarding traffic safety education of young people on motorcycle, but information about the current situation of motorcycle driving behavior in young people in Cambodia is limited. So we focus on driver behavioral changes in young people and the possibility of more practical traffic safety education. The aim of the traffic safety education presented in the project was to improve so-called hazard perception ability, and although there are studies relating to similar objectives [20], [21], this study is characterized by analyzing whether hazard perception education and training affects the development of more defensive driving behavior in young people, based on the comparative observation of actual driving behavior.

3. Methodology

3.1 Overview of questionnaire survey on driving attitude / behavior

In this research, a questionnaire survey result of 1,079 high school and university students in Phnom Penh city in 2015 was used. In the analysis, only data from 557 respondents with motorcycle driving experience was used after excluding unanswered data in all questions. The number of respondents by attribute is shown in Table 1. The questionnaire consisted of 8 questions on individual attributes, 22 questions on risk perception in one's own driving behavior, and 24 questions on one's own driving attitude. In the 22 questions on risk perception in driving behavior, four levels of response to each driving conditions were obtained- from "1. I don't think it's dangerous at all " to "4. I think it's very dangerous ". In the analysis, the responses to each question were quantified by scoring for risk perception - "1. I don't think it's dangerous at all": -2 "2. I don't think it's particularly dangerous ": -1 "3. I think it's dangerous ": 1 "4. I think it's very dangerous ": 2).

Table 1 Attributes of questionnaire respondents

attribute			sample size
High school student	Male	Driving experience：Less than 1year	39
		Driving experience：More than 1 years	78
	Female	Driving experience：Less than 1year	25
		Driving experience：More than 1 years	117
University student	Male	Driving experience：Less than 1year	43
		Driving experience：More than 1 years	86
	Female	Driving experience：Less than 1year	39
		Driving experience：More than 1 years	130
Total			557

3.2 Video observations of actual driving behavior

In order to confirm the actual situation regarding driving behaviors included in the questionnaire results, video cameras were attached on the motorcycles (50 ~ 125 cc) of students who commute to high school or university within the city of Phnom Penh, and an observation survey was conducted. In the survey, the routine route between their home and school was recorded during two different periods: one from December 2015 to January 2016 and one at the end of July 2017 after the safety workshop described below. The subjects were a total of 27 people who responded to an appeal for cooperation in the survey through a local university. Four of 27 people were common samples before and after the workshop. In the analysis, driving behavior was compared by separating the 27 people into two groups: one is subjects who had not attended the workshop (before WS) and another one is subjects who had attended the workshop (after WS). Individual attributes were summarized in Table 2.

The equipment used for video observation was the action camera GARMIN VIRB Elite with built-in GPS function. The measured viewing angle was 123°, which is roughly the same as the angle of view of a human being (120°). Using the video data, in addition to average speed in terms of non-intersection intervals of road, the number of times the subject changed lanes, passed other motorcycle, and was passed by other motorcycle were counted as driving behaviors indicating driving conditions, and the number of times the subject exhibited eight driving behaviors in common with risk perception in the questionnaire survey were counted. As a result, data for 1014 non-intersection intervals totaling 160.5 km was extracted (Table 3). Although the number of subjects in the video survey was small compared to the questionnaire survey, but an analysis of key driving behaviors observed repeatedly under different interval/traffic conditions was performed.

Table 2 Individual attributes of subjects fitted with cameras

	Before WS	After WS	Total
Date of observation	Dec. 2015-Jan. 2016	Jul. 2017	
No. of people observed	17	10	27※
Gender	8 males/ 9 females	5 males/ 5 females	13 males/ 14 females
Student category	9 high school students / 8 University students	5 high school students / 5 University students	14 high school students / 13 University students
Driving experience	Less than 1 year:5 people / more than 1 year:12 people	Less than 1 year:0 people / more than 1 year:10 people	Less than 1 year:5 people / more than 1 year:22 people
Motorcycle category	50cc：4 people / 90-125cc：13 people	50cc：3 people / 90-125cc：7 people	50cc：7 people / 90-125cc：20 people
Number of intervals	584	430	1014
Observation time period	Morning：327 intervals /afternoon：143 intervals / evening：114 intervals	Morning：129 intervals /afternoon：184 intervals / evening：117 intervals	Morning：456 intervals /afternoon：327 intervals / evening：231 intervals
Weather	Clear：429 intervals/Cloudy：155 intervals	Clear：192 intervals/Cloudy：238 intervals	Clear：621 intervals/Cloudy：393 intervals

* Of this total, 4 people participated both before and after the WS

Table 3 Summary of video observation results

Video data	No. of people observed	27
	Observation time	573 min(Average of 24.9 min per Person)
	Travel distance (non-intersection intervals)	160.5 km (Average of 7.0 km per Person)
	No. of non-intersection intervals on arterial/non-arterial roads	594/420 (Total 1014)
	Average non-intersection interval distance	0.160 km
	Average non-intersection interval passage time	29.6 s
Driving behavior	Driving behaviors indicating driving conditions	Lane changing (no. of times)
		Passing a motorcycle (no. of times)
		Being passed by a motorcycle (no. of times)
	Driving behaviors in common with questionnaire	Q2 Driving motorcycle on sidewalk for a few meters (no. of times)
		Q4 Weaving between cars on a congested road (no. of times)
		Q6 Passing when cars turning right/left ahead are stopped (no. of times)
		Q8 Turning directly in front of an oncoming car when turning left at an intersection (no. of times)
		Q3 Driving in the wrong direction on a one-way road (no. of times)
		Q5 Driving off sooner than other cars after waiting for a traffic light at an intersection
		Q10 Not paying attention to doors opening when passing stationary cars (no. of times)
		Q21 Driving closer to the car in front when it seems as though other cars might try to cut in (no. of times)

3.3 Summary of traffic safety workshop

The traffic safety workshop held at the Royal University of Phnom Penh on July 16, 2017 consisted of 2 hours of classroom learning and 2 hours of driving learning. In classroom learning, after explaining the situation of traffic accidents in Cambodia, hazard prediction training was carried out using dangerous driving scenarios extracted from the video observation of driving behavior. Observed cased of near-misses were used as the dangerous driving scenarios, for example, entering the blind spot of a four-wheeled vehicle when weaving between cars, another vehicle suddenly appearing from a blind spot. The training method took the form of stopping the video before the dangerous driving scenario and having the participants anticipate the potential hazards, before explaining the actual dangerous driving scenario. In driving learning, approximately two hours of basic riding skills, such as riding a figure of eight and braking were given by a motorcycle instructor.

3.4 Introduction of vehicle area occupation ratio around a subject

Although driving behavior on non-intersection intervals of arterial roads is thought to be influenced by surrounding traffic conditions, measuring the traffic conditions for each road thought to be difficult. So the observable relationship between average interval speed and average vehicle density was employed in this study instead of the relationship between speed and density for each road in traffic flow theory.

First, to define the unit distance of motorcycle use on roads, a non-intersection interval between intersections was used. The boundary of intersection was set as the extension of a straight line from the end of the corner cut-off at the intersection. The width and length of the intervals were measured using Google Earth. Measurement errors may occur in the passage times because the interval start and end positions were reliant on visual estimates. As a rough guide, assuming that the error in average interval passage time is ±1 s for both intersections, the error in average interval speed will be approximately -1.23 to 1.41 (km/h).

Next, with regard to vehicle density, average vehicle density around the observed vehicle was used. To calculate this, a range with road width in front of the motorcycle was defined using traffic lane markings, and the number of vehicles in the range was counted according to the type of vehicle as shown in FIGURE 1. Area parameters shown in TABLE 3 for each type of vehicle were used to convert the number of vehicles into the total vehicle area in the range. Using Equation (1), the instantaneous vehicle density for every five seconds was averaged over the number of observations within the same interval. The coefficients used were a, b, c: number of motorcycles, four-wheeled vehicles, auto rickshaws and others; α, β, γ: area parameters; A: area by which the total vehicle area is divided; n: number of observations within interval.

$$\left(\sum_{K=1}^{n}(\alpha a_{mn}+\beta b_{mn}+\gamma c_{mn})\right)/An \quad (1)$$

Excluding 136 intervals for which it was not possible to accurately count all of the vehicles inside the angle of view owing to the effect of camera shaking and road congestion, etc., data for a total of 878 intervals was obtained from the video analysis. The number of observations of instantaneous vehicle density found every five seconds averaged 4.86 per interval, with a standard deviation of ±4.42.

Using the calculated results, when correlation coefficients of average interval speed and average interval vehicle density according to road conditions were compared, excluding the small number of one-way intervals, correlation was highest for "intervals with median strip, and 2 or more lanes in each direction" (TABLE 4). Median strip is defined as a paved or planted strip dividing an arterial road into lanes according to direction of travel. And the scatter diagram of vehicle density and speed confirmed that, as average interval vehicle density increases, average interval speed decreases (FIGURES 2, 3). Reasons for different correlation coefficients depending on road conditions include the fact that, in addition to road conditions such as road surface, the situation concerning crossing the centerline, reckless right/left turning, driving in the wrong direction on the road shoulder, etc. also varies according to road conditions. The conditions on "intervals with median strip, and 2 or more lanes in each direction" are such that driving behavior is less affected by the road and other people, and a detailed analysis of the 542 "intervals with median strip, and 2 or more lanes in each direction" was conducted.

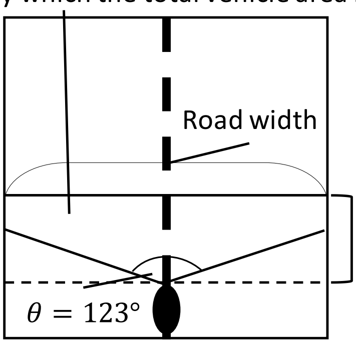


FIGURE 1 Defined range in front of motorcycle

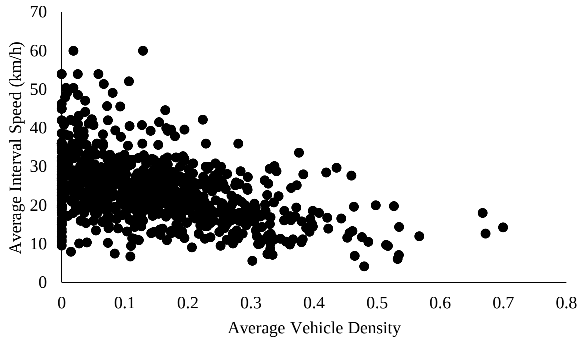


FIGURE 2 Relationship between average vehicle density and average interval speed (all intervals)

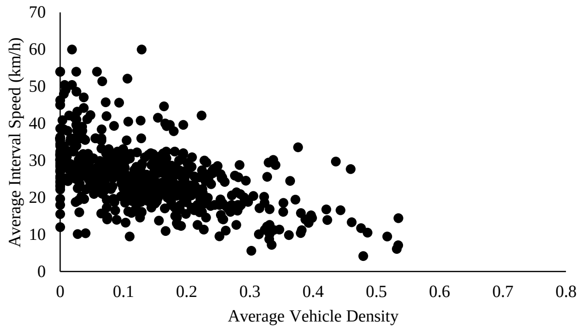


FIGURE 3 Relationship between average vehicle density and average interval speed (intervals with median strip, and 2 or more lanes in each direction)

Table 4 Area parameters

	Sample size	Average vehicle area (m^2)	standard deviation (m^2)
Motorcycle	6	1.22	0.14
Four-wheeler	6	8.51	0.51
Auto rickshaw	10	4.59	0.17

Table 5 Correlation between speed and average vehicle density for each traffic lane scenario

Traffic lane scenario	No. of intervals	Correlation coefficient, R
Interval without median strip, and 1 or 1.5 lanes in both direction (total 2 or 3 lane)	165	-0.27
Interval without median strip, and 2 or more lanes in both direction (total 4 or more lane)	126	-0.37
Interval with median strip, and 1 or 1.5 lanes in each direction	33	-0.48
Interval with median strip, and 2 or more lanes in each direction	542	-0.54
One-way interval	12	-0.65
All intervals	878	-0.43

4. Results

4.1 Difference in risk perception between individual attributes

Table 6 shows aggregate results by question on risk perception in driving behavior. The results showed that the level of risk perception differs depending on the item, with a difference of approximately one point in the average values between top items, such as "driving under the influence of alcohol" and "driving at night without switching lights on," and the bottom items, such as "driving while listening to music through headphones" and "riding a motorcycle with more than one persons on board". Next, scoring the responses to all of the questions and comparing the average values determined for each individual attribute showed that the risk perception level is higher in females and university students, while there is hardly any difference in risk perception level between the attribute of possessing and not possessing a driver licenses (Figure 4). Furthermore, as a result of multiple regression analysis by taking the total score for risk perception levels as the response variable and individual attributes as explanatory variables confirmed that, although the coefficient of determination is low at 0.05 with significant F-value and there is large variation among individuals, there is a significant difference between gender and student categories while there is no significant difference in type of driving license (Table 7). It is noted that unofficial driving license means that have acquired a driver's license in unofficial procedure, such as purchasing a driver's license without any education or training. From this result, in terms of risk perception, danger tend to be underestimated more by males than females, and more by high-school students than university students.

Table 6 Aggregate results for risk perception in driving behavior

Question no.	Questionnaire item	-2	-1	1	2	Mean	Standard deviation
Q.13	Driving under the influence of alcohol.	28	18	54	457	1.61	1.02
Q.14	Driving at night without switching lights on.	40	26	99	392	1.39	1.18
Q.8	Turning directly in front of an oncoming car when turning left at an intersection.	33	51	84	389	1.34	1.22
Q.22	Occasionally driving as fast as you can.	37	35	135	350	1.30	1.18
Q.21	Driving closer to the car in front when it seems as though other cars might try to cut in.	31	55	123	348	1.26	1.21
Q.3	Driving in the wrong direction on a one-way road.	22	64	141	330	1.24	1.16
Q.6	Passing when cars turning left/right ahead are stopped.	34	55	127	341	1.23	1.23
Q.1	Not wearing a helmet when riding a motorcycle.	29	64	155	309	1.17	1.21
Q.15	Driving while operating a cell phone.	31	57	199	270	1.11	1.18
Q.7	Increasing your speed when you think you will be late for an appointment or class.	26	85	179	267	1.03	1.23
Q.9	Not signaling when turning right/left.	33	57	242	225	1.02	1.16
Q.5	Driving off sooner than other cars after waiting for a traffic light at an intersection.	35	110	178	234	0.84	1.32
Q.12	Acting first, and frequently putting safety checks aside.	28	112	197	220	0.84	1.28
Q.10	Not paying attention to sudden opening of doors when passing stationary cars.	42	94	219	202	0.80	1.29
Q.4	Weaving between cars on a congested road.	27	130	212	188	0.73	1.28
Q.18	Stacking bulky luggage on the rear rack of a motorcycle.	31	129	246	151	0.64	1.25
Q.20	Driving with damaged mirrors or lights.	42	130	211	174	0.62	1.33
Q.11	Not reducing speed at places where there are strong crosswinds, such as elevated bridges.	51	128	205	173	0.58	1.37
Q.2	Driving motorcycle on sidewalk for a few meters.	37	151	245	124	0.48	1.28
Q.19	Driving with one hand.	41	163	209	144	0.45	1.34
Q.16	Driving while listening to music through headphones.	61	163	229	104	0.27	1.35
Q.17	Riding a motorcycle with more than one persons on board.	64	176	240	77	0.16	1.32

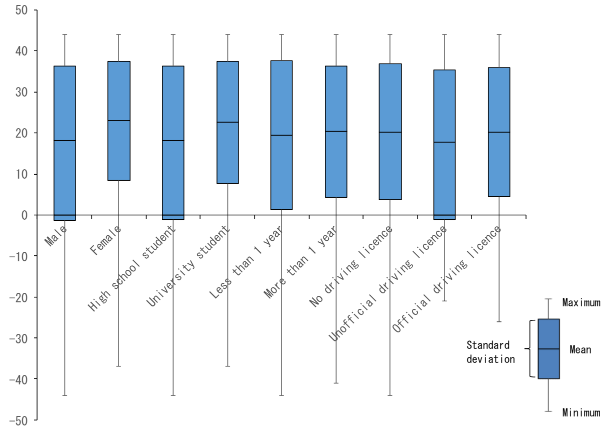


Fig. 4 Comparison of risk perception score by individual attribute

Table 7 Multiple regression analysis with the average value of responses per person in the total question total of the questionnaire as the objective variable

	coefficient	t-value
Constant term	13.71	8.23 **
Female dummy	6.04	4.37 **
University student dummy	5.43	3.89 **
More than one year dummy	0.39	0.24
Possessing official driving license dummy	-0.11	-0.05
Possessing unofficial driving license dummy	-2.53	-0.80
Coefficient of determination	0.05	
f-value	7.40 **	
Samples size	557	

*p < 0.05, **p < 0.01

4.2 Relationship between risk perception and driving behavior

Table 8 lists risk perception rate for individual questions in the questionnaire survey, and number of observations and frequency of driving behavior in 542 intervals on arterial roads with a median strip and 2 lanes in each direction before and after the workshop, as well as three items indicating driving conditions- lane changing, passing a motorcycle, and being passed by a motorcycle. Comprising risk perception rate and number of video observations, little relationship is found between the two, and despite the high proportion of responses stating that "Q.10 Not paying attention to sudden opening of doors when passing stationary cars " and " Q.21 Driving closer to the car in front when it seems as though other cars might try to cut in" are dangerous these driving behaviors were in fact observed. This result shows that assessment of risk perception level differs between oneself and others, and there was no consistency between risk perception level and actual driving behaviors that minimize risk.

Table 8 Risk perception rate for driving items in common with questionnaire and number of observations of corresponding driving behavior

Item	Risk percep-tion rate	No. of video observations		Average interval frequency	
		Before WS	After WS	Before WS (267)	After WS (275)
Q.10	71.8%	51	29	0.191	0.105
Q.21	81.3%	45	25	0.169	0.091
Q.4	68.4%	15	12	0.056	0.044
Q.6	81.0%	5	5	0.019	0.018
Q.2	62.7%	3	2	0.011	0.007
Q.8	82.6%	0	1	0	0.004
Q.3	80.0%	0	0	0	0.000
Q.5.	71.8%	0	1	0	0.004
Average interval speed (km/h)				26.67	25.44
Lane chan-ging		53	132	0.199	0.480
Passi-ng a moto-rcycle		355	386	1.330	1.404
Being passed by a moto-rcycle		565	436	2.116	1.585

4.3 Comparison of driving behavior before and after workshop by attribute

In order to examine the influence of the workshop on driving behavior, the average number of occurrences of the three driving behaviors indicating driving conditions were compared before and after the workshop according to gender and student category. The results (Figures 5-7) show a change before and after workshop in the attribute groups other than female high school students, and the average number of occurrences of "lane changing" and "passing a motorcycle" increased greatly among the male high school students and female university students. However, in the male university student group, although there was little change in "lane changing", the average number of occurrences of "passing motorcycle" was roughly halved. These changes are considered to be effects of the traffic safety workshop, and especially, driving skill learning is thought to have had an effect on aggressive behavior side and the risk perception training on defensive behavior side.

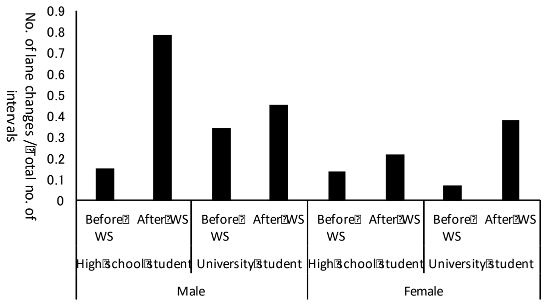


Fig. 5 Comparison of the average number of occurrences of lane changing by individual attribute

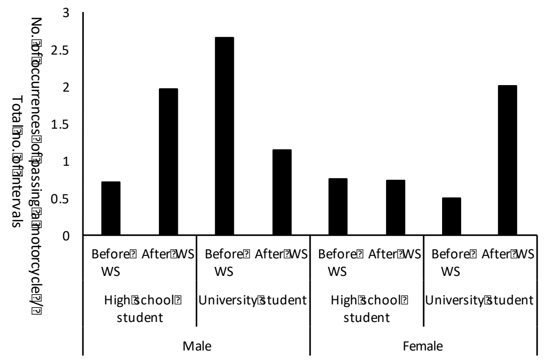


Fig. 6 Comparison of the average number of occurrences of passing a motorcycle by individual attribute

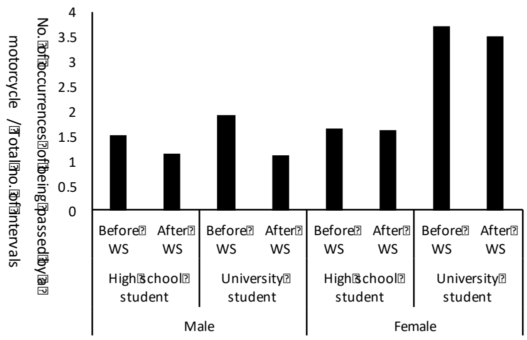


Fig. 7 Comparison of the average number of occurrences of being passed by a motorcycle by individual attribute

5. Conclusion

In this study, comparative analysis of the effect of a motorcycle traffic safety workshop for high school and university students in Phnom Penh, Cambodia, based on the results of a local observation survey were conducted. Comparing driving behavior on arterial roads before and after the workshop, which comprised driving skill learning and classroom learning aimed at improving the ability to minimize behavioral risks and acquiring basic driving skills, showed that average interval speed decreased, and the three driving behaviors indicating driving conditions changed towards defensive driving behavior in some individual attributes. However, as a result of participating in the workshop, inexperienced male high school students driving on non-intersection intervals of arterial roads tended to change from the slow lane towards the center of the road, and to pass motorcycles etc. and in particular, tended to go faster when the average vehicle density was low. One could argue that this is because the student had become able to adapt their driving behavior to the traffic conditions owing to improving driving skills; however, taking a comprehensive view that includes travel speed, this change could be connected to so-called risk-taking associated with overconfidence. In light of the above, the current situation of motorcycle traffic safety education in Cambodia can be said to offer insufficient educational opportunities for driving skills and capabilities in a form that is close to practical training, and in addition to this kind of basic content, providing opportunities for more advanced driver education, such as hazard anticipation, can be expected to improve driving behavior. In terms of risk perception among young people, as there was no significant difference in risk perception by the type of driving license, it is considered that social norms were not developed in the procedure of official driving license.

Hereafter, conducting analysis of detailed travel speed on workshop effects are required at first. In addition, to clearly demonstrate the relationship between the content of this kind of traffic safety workshop and behavioral changes, it is also necessary to increase the sample size of the analysis and to refine the experimental design, as in a panel survey with reference case. Furthermore, based on these results, it is necessary to develop a traffic safety workshop program that includes advanced driving skills training, such as speed awareness and hazard prediction to minimize behavioral risk.

6. Acknowledgement

The questionnaire and video surveys in this study were conducted with substantial cooperation from the Faculty of Education of the Royal University of Phnom Penh. We would like to take this opportunity to express our gratitude.

References

[1] International Transport Forum (2017): *Road Safety Annual Report*, OECD Publishing.

[2] Hongsranagon,P. Khompratya,T. Hongpukdee,S. Havanond,P. Deelertyuenyong,N. (2011) Traffic risk behavior and perceptions of Thai motorcyclists: A case study, *IATSS Research*, Volume 35, Issue 1, Pages 30-33.

[3] Priyantha, D.M. WEDAGAMA. (2009), THE INFLUENCE OF YOUNG AND MALE MOTORISTS ACCIDENT: Factors on Motorcycle Injuries in Bali, *IATSS Research*, Volume 33, Issue 2, Pages 64-75.

[4] Muhammad Marizwan Abdul Manan, András Várhelyi (2012) Motorcycle fatalities in Malaysia, *IATSS Research*, Volume 36, Issue 1, Pages 30-39.

[5] Sutanto SOEHODHO (2007) MOTORIZATION IN INDONESIA AND ITS IMPACT TO TRAFFIC ACCIDENTS, *IATSS Research*, Volume 31, Issue 2, Pages 27-33.

[6] Mau-Roung Lin, Jess F. Kraus (2009) A review of risk factors and patterns of motorcycle injuries, *Accident Analysis & Prevention*, Volume 41, Issue 4, Pages 710-722.

[7] Michon J.A. (1976) The Mutual Impacts of Transportation and Human Behaviour. In: Stringer P., Wenzel H. (eds) Transportation Planning for a Better Environment. *Nato Conference Series*, Vol 1. Springer, Boston, MA.

[8] M. Hatakka, E. Keskinen, N.P. Gregersen, A. Glad, K. Hernetkoski (2002) From control of the vehicle to personal self-control: broadening the perspectives to driver education, *Transportation Research Part F: Traffic Psychology and Behaviour*, 5, pp. 201-215.

[9] Esko Keskinen (2014): Education for older drivers in the future, *IATSS Research*, Volume 38, Issue 1, Pages 14-21.

[10] Hiroshi Nakai, Shinnosuke Usui (2012) Comparing the self-assessed and examiner-assessed driving skills of Japanese driving school students, *IATSS Research*, Volume 35, Issue 2, Pages 90-97.

[11] Patarawan Woratanarat, Atiporn Ingsathit, Pornthip Chatchaipan, Paibul Suriyawongpaisal (2013) Safety riding program and motorcycle-related injuries in Thailand, *Accident Analysis & Prevention*, Volume 58, Pages 115-121.

[12] Khuat Viet Hung, Le Thu Huyen (2011) Education influence in traffic safety: A case study in Vietnam, *IATSS Research*, Volume 34, Issue 2, Pages 87-93.

[13] Barry Watson, Deborah Tunnicliff, Katy White, Cynthia Schonfeld, Darren Wishart (2007) Psychological and social factors influencing motorcycle rider intentions and behavior, *Australian Transport Safety Bureau*.

[14] Nina Dragutinovic, Divera Twisk (2006) The effectiveness of road safety education, a literature review, *R-2006-6, SWOV Institute for Road Safety Research*.

[15] Divera Twisk (1994) Improving Safety of Young Drivers: In Search of Possible Solutions, D-93-2, *SWOV Institute for Road Safety Research*.

[16] Sudip Barua, Bhzad Sidawi, Shamsul Hoque (2014) Assessment of the Role of Training and Licensing Systems in Changing the Young Driver's Behavior, *International Journal of Transportation Science and Technology*, Volume 3, Issue 1, Pages 63-78.

[17] Stéphane Espié, Abderrahmane Boubezoul, Samuel Aupetit, Samir Bouaziz (2013) Data collection and processing tools for naturalistic study of powered two-wheelers users' behaviours, *Accident Analysis & Prevention*, Volume 58, Pages 330-339.

[18] Atthapol Seedam, Thaned Satiennam, Thana Radpukdee, Wichuda Satiennam (2015) Development of an onboard system to measure the on-road driving pattern for developing motorcycle driving cycle in Khon Kaen city, Thailand, *IATSS Research*, Volume 39, Issue 1 , Pages 79-85.

[19] Fred Wegman, Hans-Yngve Berg, Iain Cameron, Claire Thompson, Stefan Siegrist, Wendy Weijermars (2015) Evidence-based and data-driven road safety management, *IATSS Research*, Volume 39, Issue 1, Pages 19-25.

[20]Mark A. Wetton, Andrew Hill, Mark S. Horswill (2011) The development and validation of a

hazard perception test for use in driver licensing, *Accident Analysis & Prevention*, Volume 43, Issue 5, Pages 1759-1770.

[21] Tova Rosenbloom, Amotz Perlman, Avihu Pereg (2011) Hazard perception of motorcyclists and car drivers, Accident Analysis & Prevention, Volume 43, Issue 3.

ผลของโปรแกรมสุขศึกษาร่วมกับสื่อวีซีดีหนังสั้น เพื่อการเสริมสร้างความรอบรู้ทางสุขภาพในการป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ของผู้สูงอายุ อายุ 60-69 ปี อำเภอเกษตรสมบูรณ์ จังหวัดชัยภูมิ

Effects Of Health Literacy Program With Shot Film Multimedia On VCD For Creating Health Literacy Skill In The Prevention Of Traffic Accidents Frome Motocycles In 60-69 Years Old 0f The Elderly In Kasetsombun District, Chaiyaphum Province

หมายเลขบทความ: AYRF18-031

ณัฏฐา ชำนาญยา[1], ดร.จุฬาภรณ์ โสตะ[2]

Nuttha Chumnanya, Dr. Chulaporn Sota

[1] นักศึกษา หลักสูตรสาธารณสุขศาสตรมหาบัณฑิต
สาขาสุขศึกษาและการส่งเสริมสุขภาพ คณะสาธารณสุขศาสตร์ มหาวิทยาลัยขอนแก่น
E-mail: donut_nuttha@hotmail.com

[2] รองศาสตราจารย์ คณะสาธารณสุขศาสตร์
มหาวิทยาลัยขอนแก่น
E-mail: chusot@kku.ac.th

บทคัดย่อ

การวิจัยกึ่งทดลองครั้งนี้ มีวัตถุประสงค์เพื่อศึกษาผลของโปรแกรมสุขศึกษาร่วมกับสื่อวีซีดีหนังสั้นเพื่อการเสริมสร้างความรอบรู้ทางสุขภาพในการป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ของผู้สูงอายุ อายุ 60-69 ปี อำเภอเกษตรสมบูรณ์ จังหวัดชัยภูมิ โดยแบ่งกลุ่มตัวอย่าง ออกเป็น 2 กลุ่ม คือกลุ่มทดลอง จำนวน 39 คน และกลุ่มเปรียบเทียบ จำนวน 39 คน โดยในกลุ่มทดลองได้รับโปรแกรมสุขศึกษาร่วมกับสื่อวีซีดีหนังสั้นเพื่อการเสริมสร้างความรอบรู้ทางสุขภาพในการป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ประกอบด้วย การบรรยาย ประชุมกลุ่มแลกเปลี่ยนความคิดเห็นและเล่า ประสบการณ์ที่เคยพบเจออภิปรายกลุ่ม สาธิตการขับขี่รถจักรยานยนต์ที่ปลอดภัย การสวมหมวกนิรภัย และการตรวจเช็คสภาพรถ การศึกษาหนังสือเพิ่มเติม และชมสื่อวีซีดีหนังสั้นเกี่ยวกับการเสริมสร้างความรอบรู้ทางสุขภาพในการป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ระยะเวลาดำเนินการ 12 สัปดาห์ สัปดาห์ละ 2 ชั่วโมง เก็บรวบรวมข้อมูลจาก แบบสอบถาม วิเคราะห์ข้อมูลทั่วไปด้วย ร้อยละ ค่าเฉลี่ย ส่วนเบี่ยงเบนมาตรฐาน ค่ามัธยฐาน ค่าต่ำสุด สูงสุด และเปรียบเทียบความแตกต่างของค่าเฉลี่ยภายในกลุ่มและระหว่างกลุ่มด้วยสถิติ Paired samples t-test และ Independent t-test กำหนดนัยสำคัญที่ระดับ 0.05

ผลการศึกษา พบว่า หลังทดลองกลุ่มทดลองมี ความรู้ความเข้าใจทางสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ การเข้าถึงและบริการสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ การสื่อสารด้านสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ การตัดสินใจเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ การจัดการตนเองเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ การรู้เท่าทันสื่อและสารสนเทศเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ และการปฏิบัติตนเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ มากกว่าก่อนการทดลองและมากกว่ากลุ่มเปรียบเทียบอย่างมีนัยสำคัญทางสถิติ (p-value <0.001)

คำสำคัญ: ความรอบรู้ด้านสุขภาพ, การป้องกันอุบัติเหตุ, ผู้สูงอายุ

Abstract

This quasi-experimental research aimed to investigate effects of health education program with short film multimedia to develop on health literacy for traffic accidental prevention from motorcycles among the elderly in Chaiyaphum Province, Thailand. The populations were 78 elders who were 60-69 years old and rode the motorcycle in daily life at least 3 times a week. The populations were divided into two groups one was the experimental group and the other was the comparison group. Each group had 39 participants. The experimental group participated in 12-weeks program with many activities such as lecture, group discussion, demonstration on safety for motorcycle riding, helmet using, motorcycle inspection, reading safety information guide book and watching a short movie to enhance health literacy skills for traffic accidental prevention. Data were collected by questionnaire, analyzed by descriptive statistics for general characteristics, inferential statistics; paired-t test and independent-t test were applied for testing specific objectives. Statistical significance was set at 0.05

The results showed that after interventions, the experimental group had higher mean score of health literacy skills for traffic accidental prevention form motorcycles than those before intervention and the comparison group significantly statistical (p<0.001). In addition, the experimental group had higher mean score of accidental prevention practiced than those before intervention and the comparison group significantly statistical (p<0.001).

Keywords: Health Literacy, Accidental prevention, Elderly

1. บทนำ

1.1 ความเป็นมาและความสำคัญของปัญหา

ปัญหาอุบัติเหตุจากการจราจรทางถนนเป็นปัญหาสำคัญที่ทุกประเทศกำลังเผชิญ ซึ่งมีแนวโน้มการบาดเจ็บและเสียชีวิตเพิ่มมากขึ้น โดยองค์การอนามัยโลกระบุว่า วัยรุ่น เยาวชน และกลุ่มเริ่มทำงานเสียชีวิตจากอุบัติเหตุบนถนนเป็นอันดับหนึ่ง ประชากรโลกเสียชีวิตจากอุบัติเหตุบนถนนสูงถึง 1.25 ล้านคนต่อปี และในจำนวนนี้มีผู้เสียชีวิต อยู่ในกลุ่มประเทศรายได้ปานกลางถึงต่ำ ร้อยละ 90 โดยผู้เสียชีวิตเกือบครึ่งร้อยละ 49 เกิดขึ้นกับกลุ่มรถจักรยานยนต์ รถจักรยาน และ คนเดินถนน สำหรับประเทศไทยมีอัตราการเสียชีวิตสูงเป็นอันดับ 2 ของโลก 36.2 คนต่อประชากรแสนคน แต่ประเทศไทยมีอัตราการเสียชีวิตจากรถจักรยานยนต์เป็นอันดับ 1 ของโลก 26.3 คนต่อประชากรแสนคน จากสถานการณ์อุบัติเหตุในกลุ่มประเทศอาเซียนและเอเชียตะวันออกเฉียงใต้ จำนวน 10 ประเทศ พบว่าประเทศไทยมีอัตราการเสียชีวิตจากอุบัติเหตุทางถนนสูงเป็นอันดับ 1 รองลงมา คือ เวียดนาม 24.50 คนต่อแสนประชากร มาเลเซีย 24 คนต่อแสนประชากร พม่า 20.30 คนต่อแสนประชากร และกัมพูชา 17.40 คนต่อแสนประชากร (World Health Organization [WHO], 2015)

ในปี พ.ศ. 2557 – 2559 ประเทศไทยมีจำนวนผู้เสียชีวิตจากการเกิดอุบัติเหตุทางถนน สูงถึง 15,045 ราย 14,504 ราย และ 15,458 ราย ตามลำดับ ซึ่งอัตราการเสียชีวิต เท่ากับ 23.66, 22.30 และ 23.77 คนต่อแสนประชากร ตามลำดับ (สำนักโรคไม่ติดต่อ , 2560) จากรายงานการเกิดอุบัติเหตุจราจรทางบก ของสำนักงานตำรวจแห่งชาติ พบว่า รถจักรยานยนต์เป็นพาหนะ ที่สำคัญในการก่อให้เกิดอุบัติเหตุ ซึ่งมีการเกิดอุบัติเหตุสูงสุดถึง 19,671 ครั้งต่อปี ในการเกิดอุบัติเหตุจะพบว่ามียอดผู้เสียชีวิตมากถึง 7,364 คน และมีผู้บาดเจ็บ จำนวน 20,906 คน ที่ได้พบมากที่สุดคือ เมาสุรา รองลงมา คือ การขับขี่รถด้วยความเร็วเกินอัตราที่กำหนดและการขับขี่รถตัดหน้าอย่างกระชั้นชิด สำหรับการเกิดอุบัติเหตุทางบก ส่วนใหญ่จะเกิดขึ้นบริเวณถนนประเภทถนนกรมทางหลวงถึงร้อยละ 44.74 รองลงมาคือถนนในหมู่บ้าน ร้อยละ 25.51 สำหรับถนนในเมือง พบเพียงร้อยละ 11.52 (มูลนิธิเมาไม่ขับ, 2557) สถานการณ์อุบัติเหตุทางถนนของประเทศไทย ปี พ.ศ. 2557 จากข้อมูลขององค์กรอนามัยโลกรายงานว่าผู้เสียชีวิตจากอุบัติเหตุทางถนนของไทย สูงเป็นอันดับ 2 ของโลก โดยมีจำนวนผู้เสียชีวิต จำนวน 24,237 คน คิดเป็นอัตราตาย 36.2 คนต่อประชากรแสนคน ซึ่งประชากรที่มีความเสี่ยง ได้แก่ เพศชายมีการตายจากอุบัติเหตุทางถนนสูงกว่าเพศหญิง มากถึง 3 เท่าตัว ในเพศชาย กลุ่มอายุที่เสียชีวิตจากอุบัติเหตุทางถนนมากที่สุด คือ กลุ่มอายุ 15-19 ปี รองลงมา คือ กลุ่มอายุ 20-24 ปี ส่วนเพศหญิง กลุ่มอายุที่เสียชีวิตมากที่สุด คือ กลุ่มอายุ 40-44 รองลงมา คือ กลุ่มอายุ 15-19 ปี และกลุ่มที่เสียชีวิตน้อยที่สุดยังเป็นกลุ่มอายุ 85 ปีขึ้นไปทั้งเพศชายและหญิง (สถานการณ์อุบัติเหตุทางถนนของประเทศไทย, 2557)

สถานการณ์อุบัติภัยทางถนนจังหวัดชัยภูมิพบว่า อัตราการเกิดอุบัติเหตุทางบกในปี 2555-2559 คิดเป็นร้อยละ 386 427 429 292 และ 276 ครั้ง ตามลำดับ อัตราการเสียชีวิต 153 142 133 149 และ 79 คน ตามลำดับ โดยเพศชายมากกว่าเพศหญิง 4 เท่า กลุ่มอายุที่มีการบาดเจ็บมากที่สุดอยู่ระหว่าง 15-25 ปี รองลงมาคือกลุ่มอายุระหว่าง 52-62 ปี รถจักรยานยนต์เป็นสาเหตุการเกิดอุบัติภัยสูงสุด พฤติกรรมเสี่ยงพบว่า ไม่สวมหมวกนิรภัยร้อยละ 87.57 ใช้แอลกอฮอล์ขณะขับรถร้อยละ 55.82 ไม่คาดเข็ม

คัดนิรภัยร้อยละ 75 และจากการสำรวจโครงการชุมชนปลอดภัย ระหว่าง ปี 2554-2555 พบว่าทัศนะคติและพฤติกรรมการใช้

รถจักรยานยนต์ของประชาชน ร้อยละ 73.13 ประชาชนคิดว่า การสวมหมวกนิรภัยไม่สะดวกในการขับขี่รถ ร้อยละ 60.63 ประชาชน คิดว่าคนจะสวมหมวกนิรภัยเมื่อถูกตำรวจจับเท่านั้น และร้อยละ 43.54 ประชาชนคิดว่าการขับขี่รถระยะใกล้ไม่ต้องสวมหมวกนิรภัย ส่วนด้าน พฤติกรรมการขับขี่ พบว่า ประชาชนนิยมใช้รถจักรยานยนต์เป็นพาหนะ (สำนักงานสาธารณสุขจังหวัดชัยภูมิ, 2559)

จากสถานการณ์ในข้างต้นแสดงให้เห็นว่าอุบัติเหตุจราจร สามารถเกิดขึ้นได้กับประชากรทุกเพศและทุกวัยรวมไปถึงผู้สูงอายุ สำหรับประเทศไทย พบว่าผู้สูงอายุประสบอุบัติเหตุทางการจราจร ซึ่งพบ ได้มากถึงร้อยละ 22.1 ของอุบัติเหตุในผู้สูงอายุ สาเหตุของอุบัติเหตุ จราจรที่พบมากเกิดจากการเดินถนนแล้วถูกรถชน ซึ่งรถที่ชนผู้สูงอายุ มากที่สุดคือ รถจักรยานยนต์ และรถยนต์ โดยส่วนใหญ่เกิดจากสายตา ไม่ดีและการรับเสียงไม่ดี กรณีที่เป็นผู้โดยสารแล้วเกิดอุบัติเหตุมักเกิดใน ช่วงเวลาขึ้นและลงรถ และรถเกิดเคลื่อนที่ไปก่อน หรือรายที่อยู่ในรถก็ เกิดจากผู้ขับรถหยุดรถอย่างกะทันหันหรือออกรถอย่างกระโชกกระชาก หากเมื่อผู้สูงอายุเกิดอุบัติเหตุแล้ว ผลของอุบัติเหตุนั้นยังนำไปสู่ความ พิการทางด้านร่างกาย และผลเสียทางด้านจิตใจ ทำให้ขาดความมั่นใจ ก่อให้เกิดปัญหาต่อผู้สูงอายุเองและยังเป็นภาระต่อญาติพี่น้อง ผู้ดูแล ครอบครัวและสังคม ดังนั้นการป้องกันไม่ให้เกิดอุบัติเหตุในผู้สูงอายุ จึง เป็นเรื่องสำคัญอย่างยิ่ง (ธนวรรษน์ สำกำปัง และกาญจนา นาถะพินธุ, 2554)

สำหรับอำเภอเกษตรสมบูรณ์พบว่าค่าเฉลี่ยของอายุผู้ที่เกิด อุบัติเหตุจราจรทางบก พบว่าค่าเฉลี่ยช่วงอายุที่เกิดอุบัติเหตุจราจรมาก ที่สุดอยู่ในกลุ่มอายุ 49-69 ปี คิดเป็นร้อยละ 36.87 และพบว่าเพศชาย มี อัตราการเกิดอุบัติเหตุจราจรมากกว่า เพศหญิง คิดเป็นร้อยละ 14.73 ซึ่ง จะมีกลุ่มผู้สูงอายุรวมอยู่ด้วยทั้งนี้อาจเป็นเพราะ สภาพเศรษฐกิจและ สังคมที่เปลี่ยนแปลงไปทำให้สมาชิกในครอบครัวมีเวลาดูแลเอาใจใส่กัน น้อยลง รถจักรยานยนต์จึงเป็นส่วนหนึ่งที่ถูกชดเชยแก่ผู้สูงอายุ ทำให้ กลุ่มผู้สูงอายุเป็นกลุ่มที่มีความเสี่ยงต่อการเกิดอุบัติภัยจากการจราจร แต่ อย่างไรก็ตาม อุบัติภัยเป็นเพียงโรคระบาดชนิดหนึ่งซึ่งจัดอยู่ในประเภท โรคระบาดที่ไม่ติดต่อ ซึ่งจะสามารถใช้วิทยาการสมัยใหม่รวมทั้ง วิทยาการควบคุมได้เช่นเดียวกับโรคระบาดอื่นๆ เพื่อการเสริมสร้างความ ปลอดภัยทางถนนอย่างยั่งยืนคือ การปลูกฝังผู้ใช้รถใช้ถนน และการ เปลี่ยนแปลงพฤติกรรมการใช้ถนนโดยการประสานการปฏิบัติการ ระหว่างทุกภาคส่วนที่เกี่ยวข้อง (โรงพยาบาลเกษตรสมบูรณ์, 2559)

นอกจากนี้การใช้สื่อประกอบการให้ความรู้จะทำให้ผู้เรียนมี ความรู้และความเข้าใจได้มากขึ้น นำไปสู่การปฏิบัติตามที่ดี ซึ่งองค์กร อนามัยโลก (1996) ได้เสนอแนะ "การสื่อสารเพื่อสุขภาพ" ซึ่งเป็นกล ยุทธ์หลักในการบอกกล่าวหรือแจ้งให้ประชาชนทราบเกี่ยวกับสุขภาพ ด้วยการให้การสื่อสารมวลชนและการใช้สื่อประเภทต่างๆ รวมทั้ง นวัตกรรมด้านเทคโนโลยีสารสนเทศต่างๆ โดยมุ่งเผยแพร่เนื้อหา ข้อมูล ด้านสุขภาพที่เป็นประโยชน์ต่อสาธารณชน เพื่อให้เกิดการตระหนักใน ประเด็นดังกล่าว ทั้งในระดับปัจเจกบุคคลและในระดับสังคม รวมถึงการ ให้ความสำคัญเกี่ยวกับการพัฒนาสุขภาพด้วย นอกจากนี้องค์กรอนามัย โลกได้อธิบายเพิ่มเติมว่า "การสื่อสารเพื่อสุขภาพ" ประกอบด้วยศาสตร์ หลายสาขา เช่น สาระบันเทิง การสื่อสาร ระหว่างบุคคล การชี้นำด้านสื่อ การสื่อสารในองค์กร การสื่อสารเพื่อสังคม ฯลฯ ซึ่งประเด็นเนื้อหาด้าน สุขภาพต่างๆ จะถูกนำเสนอโดยใช้สื่อที่มีความหลากหลายรูปแบบ เช่น การเล่าเรื่อง การแสดงละครหุ่นเชิด การนำเสนอด้วยเพลงฯลฯ รวมทั้ง การใช้สื่อประสมประเภทวีซีดี /ดีวีดี ซึ่งเป็นเทคโนโลยีสารสนเทศที่ ทันสมัยในยุคปัจจุบัน เพื่อให้สามารถเข้าถึงข้อมูลข่าวสารด้านสุขภาพแก่ กลุ่มเป้าหมายให้ได้มากขึ้น และมีประสิทธิภาพยิ่งขึ้น ดังนั้นสื่อจึงถือว่า เป็นอีกบทบาทหนึ่งที่จะถ่ายทอดความรู้ในด้านสุขภาพให้บุคคล หน่วยงานและสถาบันต่างๆ (พรรณี บัญชรหัตถกิจ , 2541) ดังผล การศึกษาการวิจัยแบบกึ่งทดลอง ผลการสอนสุขศึกษาโดยใช้สื่อประสม เรื่อง "โภชนาการ" ในนักเรียนมัธยมศึกษาปีที่ 1 โรงเรียนขอนแก่น วิทยายน จังหวัดขอนแก่น ซึ่งกลุ่มทดลองได้รับความรู้จากวีซีดีสุขศึกษา เรื่องโภชนาการ ผลการวิจัยสรุปได้ว่าการผลิตสื่อประสมสุขศึกษาเรื่อง โภชนาการสำหรับนักเรียนมัธยมศึกษาชั้นปีที่1ในจังหวัดขอนแก่นมี ประสิทธิภาพเหมาะสมและสามารถนำไปใช้ในการเรียนการสอน ได้กลุ่ม ทดลองมีค่าเฉลี่ยความรู้และทัศนคติ เรื่องโภชนาการสูงกว่าก่อนการ ทดลองและสูงกว่ากลุ่มเปรียบเทียบอย่างมีนัยสำคัญทางสถิติ (ปุญญโชค ลิ้มศิริเรืองไร , 2549) อย่างไรก็ดีการใช้สื่อวีซีดีหนังสั้นมาประกอบการ สอน ถือเป็นเทคนิคการสอนแบบใหม่ ซึ่งเทคนิคการสอนโดยใช้หนังสั้น เป็นวิธีการที่มุ่งช่วยให้ผู้เรียนเห็นภาพของเรื่องราวที่ต้องการเรียนรู้ ประจักษ์ชัดด้วยตาตนเอง ทำให้เรื่องราวนั้นมีชีวิตขึ้นมา จึงช่วยให้ผู้เรียน เกิดการเรียนรู้ที่ชัดเจนและจดจำได้นาน หนังสั้นที่ยึดถือตามธรรมเนียม ปฏิบัติคือ มีการเล่าเรื่องด้วยภาพและเสียงที่มีประเด็นเดียวสั้นๆ แต่ได้ ใจความ หนังสั้นมักมีความยาวตั้งแต่ 1 – 30 นาที มีรูปแบบหรือสไตล์ หลากหลาย ทั้งที่ใช้การแสดงสด (Live action film) หรือ แอนนิเมชั่น (animited film) และมีศิลปะในการเล่าเรื่อง ไม่ว่าจะเป็นนิทาน นิยาย ละคร หรือภาพยนตร์ ล้วนแล้วแต่มีรากฐานแบบเดียวกัน นั่นคือ การเล่า เรื่องราวที่เกิดขึ้นของมนุษย์หรือสัตว์ หรือแม้แต่อะไรก็ตามที่เกิดขึ้น ช่วงเวลาหนึ่งเวลาใด ณ สถานที่ใดที่หนึ่งเสมอ ฉะนั้น องค์ประกอบที่ สำคัญที่ขาดไม่ได้คือ ตัวละคร สถานที่ และเวลา (รักศานต์ วิวัฒน์สิน อุดม, 2546)

จากแนวคิดหลักของความรอบรู้ด้านสุขภาพจะทำให้ผู้สูงอายุ มีความสามารถในการเข้าถึงข่าวสารความรู้ด้านสุขภาพจากแหล่งความรู้ ที่หลากหลาย มีความเข้าใจในเนื้อหาต่างๆ สามารถประเมินความ น่าเชื่อถือและความเหมาะสมของเนื้อหากับตนเอง ใช้ความคิดอย่างเป็น

เหตุเป็นผลในการให้ความสำคัญกับข่าวสารความรู้นั้ น ตลอดจนนำไปสู่การตัดสินใจนำมาลองปฏิบัติและประเมินผลการทดลองจนสามารถเกิดการนำมาใช้ในชีวิตประจำวันได้ ซึ่งจะส่งผลให้ผู้สูงอายุมีคุณภาพชีวิตที่ดีขึ้น จากงานวิจัยที่ผ่านมาพบว่า อายุที่เพิ่มขึ้น ปัญหาในการฟังและ อ่าน ล้วนเป็นปัจจัยที่มีผลต่อการรับและใช้ข้อมูลข่าวสารความรู้ด้านสุขภาพ ทำให้มีการปฏิบัติหรือมีพฤติกรรมสุขภาพที่ไม่ถูกต้อง ก่อให้เกิดปัญหาทางสุขภาพทั้งทางตรงและทางอ้อม กล่าวได้ว่าระดับ ความสามารถในการอ่าน การรับรู้ทางสายตา การได้ยินเสียง การประมวลผล การทำความเข้าใจข้อมูลข่าวสาร ความรู้ด้านสุขภาพที่ลดลงส่งผลทำให้ Health literacy อยู่ในระดับต่ำ บุคคลที่มีระดับ Health Literacy ต่ำจะส่งผลต่อการเข้าถึง (access) ทำความเข้าใจ (understand) และใช้ข้อมูลข่าวสาร (use information) หากประชากรส่วนใหญ่ของประเทศมีระดับ Health Literacy ต่ำ ย่อมจะส่งผลต่อการปฏิบัติตัวและสุขภาวะในภาพรวม กล่าวคือ ประชาชนขาดความสามารถในการดูแลสุขภาพของตนเอง (ขวัญเมือง แก้วดำเกิง และ ดวงเนตร ธรรมกุล , 2558) ซึ่งหากได้นำแนวคิดทฤษฎีความรอบรู้ด้านสุขภาพมาประยุกต์ ร่วมกับการใช้สื่อประเภทวีซีดีหนังสั้น ซึ่งถือเป็นสื่อการให้ความรู้แบบใหม่ ที่น่าสนใจ สนุกสนานไม่น่าเบื่อ และมีภาพเคลื่อนไหว เพื่อให้สามารถเข้าถึงข้อมูลข่าวสารในการเสริมสร้างพฤติกรรมของประชาชนกลุ่มเสี่ยงต่อการเกิดอุบัติภัยจราจร เพื่อให้มีสุขภาพที่ดี ด้วยเหตุนี้ผู้วิจัยจึงมีความจำเป็นอย่างเร่งด่วนที่จะต้องพัฒนานวัตกรรมสื่อวีซีดีหนังสั้น มาประยุกต์ใช้กับทฤษฎีความรอบรู้ด้านสุขภาพเพื่อเสริมสร้างพฤติกรรมของประชาชน ในกลุ่มเสี่ยงต่อการเกิดอุบัติภัยจราจรจากรถจักรยานยนต์ของผู้สูงอายุ อายุ 60-69 ปี อำเภอเกษตรสมบูรณ์ จังหวัดชัยภูมิได้

1.2 วัตถุประสงค์ของการวิจัย

1.2.1 วัตถุประสงค์ทั่วไป

เพื่อศึกษาผลของ โปรแกรมสุขศึกษาร่วมกับสื่อวีซีดีหนังสั้น เพื่อการ เสริมสร้างความรอบรู้ทางสุขภาพในการป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ของผู้สูงอายุ อายุ 60-69 ปี อำเภอเกษตรสมบูรณ์ จังหวัดชัยภูมิ

1.2.2 วัตถุประสงค์เฉพาะ

1. เพื่อ ศึกษาเปรียบเทียบ การเสริมสร้างความรอบรู้ทางสุขภาพในการป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ของผู้สูงอายุ อายุ 60-69 ปี อำเภอเกษตรสมบูรณ์ จังหวัดชัยภูมิ ทั้งก่อนและหลังการทดลอง ภายในกลุ่มทดลองและกลุ่มเปรียบเทียบ

2. เพื่อเปรียบเทียบการเสริมสร้างความรอบรู้ทางสุขภาพในการป้องกันอุบัติภัยจราจร จากรถจักรยานยนต์ ของผู้สูงอายุ อายุ 60-69 ปี อำเภอเกษตรสมบูรณ์ จังหวัดชัยภูมิ ทั้งก่อนและหลังการทดลอง ระหว่างกลุ่มทดลองและกลุ่มเปรียบเทียบ

2. ระเบียบวิธีวิจัย

2.1 รูปแบบการวิจัย

การศึกษาครั้งนี้เป็นการวิจัยกึ่งการทดลอง (Quasi-experimental design) แบบสองกลุ่ม คือกลุ่มทดลองและกลุ่มเปรียบเทียบวัดก่อนและหลังการทดลอง (two-group pretest-posttest design with comparison group) แบ่งเป็นกลุ่มทดลอง (Experimental group) และกลุ่มเปรียบเทียบ (comparison group) โดยกลุ่มทดลองได้รับโปรแกรมการเสริมสร้างความรอบรู้ทางสุขภาพในการป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ของผู้สูงอายุ ดำเนินการทั้งสิ้น 12 สัปดาห์ ส่วนกลุ่มเปรียบเทียบไม่ได้รับโปรแกรมฯ จากผู้วิจัยแต่ได้รับการเรียนการสอนเรื่องการป้องกันอุบัติภัยจากเจ้าหน้าที่สาธารณสุขในโรงพยาบาลส่งเสริมสุขภาพตำบลในพื้นที่ตามปกติ

2.2 กลุ่มตัวอย่าง

กลุ่มตัวอย่างที่ใช้ในการวิจัยครั้งนี้เป็นประชาชนอายุ 60-69 ปี อำเภอเกษตรสมบูรณ์ จังหวัดชัยภูมิ ที่มีพฤติกรรมเสี่ยงต่อการใช้รถจักรยานยนต์ จำนวน 78 คน จำแนกเป็นกลุ่มทดลอง 39 คน และกลุ่มเปรียบเทียบ 39 คน ใช้วิธีการคำนวณขนาดตัวอย่าง โดยมีเกณฑ์ในการคัดเลือกดังนี้

1. เป็นผู้สูงอายุที่มีช่วงอายุระหว่าง 60-69 ปี
2. เป็นผู้ที่สามารถปฏิบัติกิจวัตรประจำวันและสามารถเคลื่อนไหวได้อย่างอิสระ
3. เป็นผู้สูงอายุที่ใช้รถจักรยานยนต์เป็นประจำ อย่างน้อยสัปดาห์ละ 3 ครั้ง
4. เป็นผู้สูงอายุที่มีความสามารถในการอ่านออกเขียนได้ปกติ
5. เป็นผู้ที่สมัครใจเข้าร่วมการศึกษา

2.3 เครื่องมือที่ใช้ในการวิจัย

เครื่องมือที่ใช้ในการวิจัยประกอบด้วย 2 ส่วน ที่สำคัญคือ เครื่องมือที่ใช้ในการทดลอง และเครื่องมือที่ใช้ในการรวบรวมข้อมูล ซึ่งมีรายละเอียดดังต่อไปนี้

2.3.1 เครื่องมือที่ใช้ในการทดลอง ได้แก่ โปรแกรมสุขศึกษาร่วมกับสื่อวีซีดีหนังสั้น เพื่อการเสริมสร้างความรอบรู้ทางสุขภาพ ในการป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ โดยจัดกิจกรรมสัปดาห์ละ 1 ครั้ง เป็นเวลา 12 สัปดาห์

2.3.2 เครื่องมือที่ใช้ในการเก็บรวบรวมข้อมูล ได้แก่ แบบสอบถามเกี่ยวกับข้อมูลทั่วไปของผู้สูงอายุ แบบสอบถามเพื่อศึกษาผลของโปรแกรมการเสริมสร้างความรอบรู้ทางสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ และแบบสอบถามพฤติกรรมการ

ป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ที่ผู้วิจัยสร้างขึ้น ซึ่งแบ่งออกเป็น 2 ตอน

ตอนที่ 1 ข้อมูลทั่วไป ได้แก่ เพศ อายุ สถานภาพ ระดับการศึกษา อาชีพ โรคประจำตัว รายได้ สิทธิการรักษาพยาบาล ระยะทางจากบ้านถึงสถานบริการสุขภาพ ใบอนุญาตขับขี่รถจักรยานยนต์ การใช้รถจักรยานยนต์ และการเกิดอุบัติเหตุ เป็นคำถามแบบมีตัวเลือกให้ตอบและแบบระบุคำตอบ

ตอนที่ 2 แบบสอบถามความรอบรู้ทางสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ประกอบด้วย

1. แบบสอบถามทักษะด้านความรู้ความเข้าใจทางสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์

2. แบบสอบถาม ทักษะด้าน การเข้าถึงข้อมูลสุขภาพและบริการสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์

3. แบบสอบถาม ทักษะด้าน การสื่อสารด้านสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์

4. แบบสอบถามทักษะการตัดสินใจเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์

5. แบบสอบถาม ทักษะ การจัดการตนเองเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์

6. แบบสอบถาม ทักษะ การรู้เท่าทันสื่อและสารสนเทศเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์

7. แบบสอบถาม พฤติกรรมการปฏิบัติตัวเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์

2.4 การเก็บรวบรวมข้อมูล

1. ขั้นตอนก่อนดำเนินการวิจัย

1.1 ทำหนังสือราชการจากบัณฑิตวิทยาลัย มหาวิทยาลัยขอนแก่น ถึงหัวหน้าหน่วยงานราชการในพื้นที่ ได้แก่ นายกเทศบาลตำบลบ้านยางและนายกเทศบาลตำบลหนองโพนงาม เพื่อขอความอนุเคราะห์ในการดำเนินการทดลอง และเก็บรวบรวมข้อมูลในผู้สูงอายุ อายุ 60-69 ปี

1.2 นำเอกสารที่ได้รับการอนุมัติแล้วจากนายกเทศบาลตำบลบ้านยางและนายกเทศบาลตำบลหนองโพนงาม ติดต่อประสานงานกับผู้นำชุมชน อาสาสมัครสาธารณสุขประจำหมู่บ้าน และผู้ที่มีส่วนเกี่ยวข้องในการวิจัยโดยชี้แจงวัตถุประสงค์ของการวิจัย ขั้นตอนในการวิจัย การวัด การประเมินผล เพื่อกำหนดตารางเวลาในการจัดโปรแกรมสุขศึกษาร่วมกับสื่อวีซีดีหนังสั้น เพื่อการ เสริมสร้างความรอบรู้ทางสุขภาพในการป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์

1.3 เตรียมกิจกรรมในโปรแกรมสุขศึกษา รวมถึงสื่อการสอนในแต่ละกิจกรรม อาทิ ซีดีหนังสั้น Power Point วีดิทัศน์ ใบความรู้ต่างๆ ที่ใช้กับผู้สูงอายุในกลุ่มทดลอง

1.4 ประสานงานและแจ้งวัตถุประสงค์ของการวิจัย และระยะเวลาในการดำเนินการวิจัยให้กับผู้สูงอายุกลุ่มทดลองและกลุ่มเปรียบเทียบให้มีความเข้าใจ

2. ขั้นตอนระหว่างดำเนินการวิจัย

2.1 ประเมินความรอบรู้ ทาง สุขภาพเกี่ยวกับการป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ โดยใช้แบบสอบถาม ในกลุ่มทดลองและในกลุ่มเปรียบเทียบ ในสัปดาห์แรกก่อนการทดลอง (Pre-test)

2.3 นำผลการวัดก่อนการดำเนินการวิจัยมาทดสอบความแตกต่างของค่าเฉลี่ยโดยการทดสอบค่าที (t-test) เพื่อทดสอบว่าผู้สูงอายุในกลุ่มทดลองและกลุ่มเปรียบเทียบมีความรอบรู้ทางสุขภาพเกี่ยวกับการป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์มีความแตกต่างกันหรือไม่

2.4 จัดกิจกรรมสุขศึกษา ร่วมกับสื่อวีซีดีหนังสั้น เพื่อการเสริมสร้างความรอบรู้ทางสุขภาพ ในการป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ กับกลุ่มทดลอง ตามกิจกรรมที่ได้กำหนดไว้ทั้ง 12 กิจกรรม จัดโปรแกรมสุขศึกษาสัปดาห์ละ 1 ครั้ง ครั้งละ 2 ชั่วโมง รวมทั้งสิ้น 12 สัปดาห์ ส่วนกลุ่มเปรียบเทียบ ไม่ได้รับโปรแกรมฯ จากผู้วิจัย แต่ได้รับการเรียนการสอน เรื่องการป้องกันอุบัติภัยจราจรจากเจ้าหน้าที่สาธารณสุขในโรงพยาบาลส่งเสริมสุขภาพตำบลในพื้นที่ตามปกติ

3. ขั้นตอนหลังดำเนินการวิจัย

3.1 เมื่อกลุ่มทดลองได้เข้าร่วมโปรแกรมสุขศึกษาเพื่อเสริมสร้างความรอบรู้ทางสุขภาพเป็นที่เรียบร้อยแล้ว ก็จะทำการทดสอบหลังการทดลองอีกครั้งด้วยแบบสอบถามความรอบรู้ทางสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ทั้งในกลุ่มทดลองและกลุ่มเปรียบเทียบ ภายหลังการทดลองสิ้นสุดลง

2.5 การวิเคราะห์ข้อมูล

สถิติเชิงพรรณนา (Descriptive statistics) วิเคราะห์ข้อมูลทั่วไป โดยใช้การแจกแจงความถี่ ค่าเฉลี่ย ร้อยละ และส่วนเบี่ยงเบนมาตรฐาน

สถิติอนุมาน (Inferential statistics) วิเคราะห์เปรียบเทียบคะแนนเฉลี่ย ในเรื่องของ ความรอบรู้ ทางสุขภาพ ทดสอบความแตกต่างของคะแนนเฉลี่ยทั้งก่อนการทดลองและหลังการทดลอง ระหว่างกลุ่มทดลองและกลุ่มเปรียบเทียบ ด้วยสถิติ Independent t-test ภายในกลุ่ม ทั้งกลุ่มทดลองและกลุ่มเปรียบเทียบระหว่างก่อนและหลังการทดลอง ด้วยสถิติ Paired t-test

3. ผลการวิจัย

1. ข้อมูลทั่วไปของกลุ่มทดลอง พบว่า ส่วนใหญ่เป็นเพศชาย ร้อยละ 71.8 เพศหญิง ร้อยละ 28.2 ส่วนใหญ่อายุเฉลี่ย 64.36 ปี ส่วนใหญ่อายุเฉลี่ย 64.36 ปี ส่วนใหญ่มีสถานภาพ สมรส ร้อยละ 69.2 ส่วน

ใหญ่มีการศึกษาอยู่ในระดับประถมศึกษา ร้อยละ 84.6 ส่วนใหญ่มีอาชีพเกษตรกร ร้อยละ 61.5 ส่วนใหญ่ไม่มีโรคประจำตัว ร้อยละ 46.2 ส่วนใหญ่มีรายได้อยู่ในช่วง 1,500 – 10,000 บาท ร้อยละ 87.2 ส่วนใหญ่ใช้สิทธิบัตรทอง 30 บาท ร้อยละ 74.4 ส่วนใหญ่ไม่มี ใบอนุญาตขับขี่รถจักรยานยนต์ ร้อยละ 74.4 ส่วนใหญ่ระยะทางจากบ้านถึงสถานบริการเฉลี่ย 3.59 กิโลเมตร ส่วนใหญ่มีการใช้รถจักรยานยนต์ต่อสัปดาห์เฉลี่ย 5.28 วัน ส่วนใหญ่ไม่เคยได้รับอุบัติเหตุจากการขับขี่รถจักรยานยนต์ ใน 1 ปีที่ผ่านมา ร้อยละ 79.5 รองลงมาเคยได้รับอุบัติเหตุจากการขับขี่รถจักรยานยนต์ ใน 1 ปีที่ผ่านมา ร้อยละ 20.5

2. ผลการเปรียบเทียบค่าเฉลี่ยคะแนนความรู้ความเข้าใจทางสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ภายในกลุ่มทดลองและกลุ่มเปรียบเทียบ ก่อนและหลังการทดลอง กลุ่มทดลอง พบว่า ก่อนการทดลอง มีคะแนนความรู้ความเข้าใจทางสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 5.79 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 1.00 คะแนน หลังการทดลอง มีคะแนนความรู้ความเข้าใจทางสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 10.82 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 0.39 คะแนน เมื่อเปรียบเทียบค่าเฉลี่ยคะแนนความรู้ความเข้าใจทางสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ภายในกลุ่มทดลอง พบว่า หลังการทดลองมีค่าเฉลี่ยคะแนนสูงกว่าก่อนการทดลองอย่างมีนัยสำคัญทางสถิติ $p<0.0001$ กลุ่มเปรียบเทียบ พบว่าก่อนการทดลอง มีคะแนนความรู้ความเข้าใจทางสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 6.08 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 1.13 คะแนน หลังการทดลอง มีคะแนนความรู้ความเข้าใจทางสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 6.13 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 0.86 คะแนน เมื่อเปรียบเทียบค่าเฉลี่ยคะแนนความรู้ความเข้าใจทางสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์กลุ่มเปรียบเทียบ พบว่า หลังการทดลองมีค่าเฉลี่ยคะแนนสูงกว่าก่อนการทดลองอย่างไม่มีนัยสำคัญทางสถิติ $p=0.083$

ผลการเปรียบเทียบค่าเฉลี่ยคะแนนความรู้ความเข้าใจทางสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ระหว่างกลุ่มทดลองและกลุ่มเปรียบเทียบ ก่อนและหลังการทดลอง พบว่า ก่อนการทดลอง กลุ่มทดลองมีคะแนนความรู้ความเข้าใจทางสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 5.80 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 1.00 คะแนน และกลุ่มเปรียบเทียบมีคะแนนเฉลี่ย 6.08 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 1.13 คะแนน เมื่อเปรียบเทียบความแตกต่างของค่าเฉลี่ยคะแนนความรู้ความเข้าใจทางสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ระหว่างกลุ่มทดลองและกลุ่มเปรียบเทียบ พบว่ากลุ่มเปรียบเทียบมีค่าเฉลี่ยคะแนนสูงกว่ากลุ่มทดลองอย่างไม่มีนัยสำคัญทางสถิติ p-value = 0.248 หลังการทดลอง กลุ่มทดลองมีคะแนนความรู้ความเข้าใจทางสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 10.82 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 0.39 คะแนน และกลุ่มเปรียบเทียบมีคะแนนเฉลี่ย 6.15 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 1.04 คะแนน เมื่อเปรียบเทียบความแตกต่างของค่าเฉลี่ยคะแนนความรู้ความเข้าใจทางสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ระหว่างกลุ่มทดลองและกลุ่มเปรียบเทียบ พบว่ากลุ่มทดลองมีค่าเฉลี่ยคะแนนสูงกว่ากลุ่มเปรียบเทียบอย่างมีนัยสำคัญทางสถิติ p-value <0.0001

3. ผลการเปรียบเทียบค่าเฉลี่ยคะแนนการเข้าถึงข้อมูลและบริการสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ภายในกลุ่มทดลอง และกลุ่มเปรียบเทียบ ก่อนและหลังการทดลอง กลุ่มทดลอง พบว่า ก่อนการทดลอง มีคะแนนการเข้าถึงข้อมูลและบริการสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 9.44 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 12.21 คะแนน หลังการทดลอง มีคะแนนการเข้าถึงข้อมูลและบริการสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 14.00 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 0.76 คะแนน เมื่อเปรียบเทียบค่าเฉลี่ยคะแนนการเข้าถึงข้อมูลและบริการสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ภายในกลุ่มทดลอง พบว่า หลังการทดลองมีค่าเฉลี่ยคะแนนสูงกว่าก่อนการทดลองอย่างมีนัยสำคัญทางสถิติ $p<0.0001$ กลุ่มเปรียบเทียบ พบว่า ก่อนการทดลอง มีคะแนนการเข้าถึงข้อมูลและบริการสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 9.10 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 2.09 คะแนน หลังการทดลอง มีคะแนนการเข้าถึงข้อมูลและบริการสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์เฉลี่ย 9.28 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 1.75 คะแนน เมื่อเปรียบเทียบค่าเฉลี่ยคะแนนการเข้าถึงข้อมูลและบริการสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ภายในกลุ่มเปรียบเทียบ พบว่า หลังการทดลองมีค่าเฉลี่ยคะแนนสูงกว่าก่อนการทดลองอย่างไม่มีนัยสำคัญทางสถิติ $p=0.164$

ผลการเปรียบเทียบค่าเฉลี่ยคะแนนการเข้าถึงข้อมูลและบริการสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ระหว่างกลุ่มทดลองและกลุ่มเปรียบเทียบ ก่อนและหลังการทดลอง พบว่า ก่อนการทดลอง กลุ่มทดลองมีคะแนนการเข้าถึงข้อมูลและบริการสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 9.44 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 1.21 คะแนน และกลุ่มเปรียบเทียบมีคะแนนเฉลี่ย 9.10 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 2.09 คะแนน เมื่อเปรียบเทียบความแตกต่างของค่าเฉลี่ยคะแนนการเข้าถึงข้อมูลและบริการสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ระหว่างกลุ่มทดลองและกลุ่มเปรียบเทียบ พบว่ากลุ่มทดลองมีค่าเฉลี่ยคะแนนสูงกว่ากลุ่มเปรียบเทียบอย่างไม่มีนัยสำคัญทางสถิติ p-value = 0.391 หลังการทดลอง กลุ่มทดลองมีคะแนนการเข้าถึงข้อมูลและบริการสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 14.00 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 0.76 คะแนน และกลุ่มเปรียบเทียบมีคะแนนเฉลี่ย 9.28 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 1.75 คะแนน เมื่อเปรียบเทียบความแตกต่างของค่าเฉลี่ยคะแนนการเข้าถึงข้อมูลและบริการสุขภาพเพื่อป้องกันอุบัติภัย

จราจรจากรถจักรยานยนต์ ระหว่างกลุ่มทดลองและกลุ่มเปรียบเทียบ พบว่ากลุ่มทดลองมีค่าเฉลี่ยคะแนนสูงกว่ากลุ่มเปรียบเทียบอย่างมีนัยสำคัญทางสถิติ p-value <0.0001

4. ผลการเปรียบเทียบค่าเฉลี่ยคะแนนการสื่อสารด้านสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ภายในกลุ่มทดลอง และกลุ่มเปรียบเทียบ ก่อนและหลังการทดลอง กลุ่มทดลอง พบว่า ก่อนการทดลอง มีคะแนนการสื่อสารด้านสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 9.62 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 1.04 คะแนน หลังการทดลอง มีคะแนนการสื่อสารด้านสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 14.62 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 1.04 คะแนน เมื่อเปรียบเทียบค่าเฉลี่ยคะแนนการสื่อสารด้านสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ภายในกลุ่มทดลอง พบว่า หลังการทดลองมีค่าเฉลี่ยคะแนนสูงกว่าก่อนการทดลองอย่างมีนัยสำคัญทางสถิติ p<0.0001 กลุ่มเปรียบเทียบ พบว่า ก่อนการทดลอง มีคะแนนการสื่อสารด้านสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 9.51 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 1.91 คะแนน หลังการทดลอง มีคะแนนการสื่อสารด้านสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 9.77 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 1.84 คะแนน เมื่อเปรียบเทียบค่าเฉลี่ยคะแนนการสื่อสารด้านสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ภายในกลุ่มเปรียบเทียบ พบว่า หลังการทดลองมีค่าเฉลี่ยคะแนนสูงกว่าก่อนการทดลองอย่างไม่มีนัยสำคัญทางสถิติ p=0.058

ผลการเปรียบเทียบค่าเฉลี่ยคะแนนการสื่อสารด้านสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ระหว่างกลุ่มทดลองและกลุ่มเปรียบเทียบ ก่อนและหลังการทดลอง พบว่า ก่อนการทดลอง กลุ่มทดลองมีคะแนนการสื่อสารด้านสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 9.62 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 1.04 คะแนน และกลุ่มเปรียบเทียบมีคะแนนเฉลี่ย 9.51 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 1.92 คะแนน เมื่อเปรียบเทียบความแตกต่างของค่าเฉลี่ยคะแนนการสื่อสารด้านสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ระหว่างกลุ่มทดลองและกลุ่มเปรียบเทียบ พบว่ากลุ่มทดลองมีค่าเฉลี่ยคะแนนสูงกว่ากลุ่มเปรียบเทียบอย่างไม่มีนัยสำคัญทางสถิติ p-value = 0.770 หลังการทดลอง กลุ่มทดลองมีคะแนนการสื่อสารด้านสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 14.61 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 1.04 คะแนน และกลุ่มเปรียบเทียบมีคะแนนเฉลี่ย 9.77 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 1.84 คะแนน เมื่อเปรียบเทียบความแตกต่างของค่าเฉลี่ยคะแนนการสื่อสารด้านสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ระหว่างกลุ่มทดลองและกลุ่มเปรียบเทียบ พบว่ากลุ่มทดลองมีค่าเฉลี่ยคะแนนสูงกว่ากลุ่มเปรียบเทียบอย่างมีนัยสำคัญทางสถิติ p-value <0.0001

5. ผลการเปรียบเทียบค่าเฉลี่ยคะแนนการตัดสินใจเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ภายในกลุ่มทดลอง และกลุ่มเปรียบเทียบ ก่อนและหลังการทดลอง กลุ่มทดลอง พบว่า ก่อนการทดลอง มีคะแนนการตัดสินใจเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 6.23 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 0.74 คะแนน หลังการทดลอง มีคะแนนการตัดสินใจเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 9.36 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 0.74 คะแนน เมื่อเปรียบเทียบค่าเฉลี่ยคะแนนการตัดสินใจเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ภายในกลุ่มทดลอง พบว่า หลังการทดลองมีค่าเฉลี่ยคะแนนสูงกว่าก่อนการทดลองอย่างมีนัยสำคัญทางสถิติ p<0.0001 กลุ่มเปรียบเทียบ พบว่า ก่อนการทดลอง มีคะแนนการตัดสินใจเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 6.59 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 1.02 คะแนน หลังการทดลอง มีคะแนนการตัดสินใจเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์เฉลี่ย 6.77 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 0.71 คะแนน เมื่อเปรียบเทียบค่าเฉลี่ยคะแนนการตัดสินใจเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ภายในกลุ่มเปรียบเทียบ พบว่า หลังการทดลองมีค่าเฉลี่ยคะแนนสูงกว่าก่อนการทดลองอย่างไม่มีนัยสำคัญทางสถิติ p=0.070

ผลการเปรียบเทียบค่าเฉลี่ยคะแนนการตัดสินใจเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ระหว่างกลุ่มทดลองและกลุ่มเปรียบเทียบ ก่อนและหลังการทดลอง พบว่า ก่อนการทดลอง กลุ่มทดลองมีคะแนนการตัดสินใจเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 6.23 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 0.74 คะแนน และกลุ่มเปรียบเทียบมีคะแนนเฉลี่ย 6.59 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 1.02 คะแนน เมื่อเปรียบเทียบความแตกต่างของค่าเฉลี่ยคะแนนการตัดสินใจเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ระหว่างกลุ่มทดลองและกลุ่มเปรียบเทียบ พบว่ากลุ่มเปรียบเทียบมีค่าเฉลี่ยคะแนนสูงกว่ากลุ่มทดลองอย่างไม่มีนัยสำคัญทางสถิติ p-value = 0.079 หลังการทดลอง กลุ่มทดลองมีคะแนนการตัดสินใจเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 9.36 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 0.74 คะแนน และกลุ่มเปรียบเทียบมีคะแนนเฉลี่ย 6.78 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 0.71 คะแนน เมื่อเปรียบเทียบความแตกต่างของค่าเฉลี่ยคะแนนการตัดสินใจเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ระหว่างกลุ่มทดลองและกลุ่มเปรียบเทียบ พบว่ากลุ่มทดลองมีค่าเฉลี่ยคะแนนสูงกว่ากลุ่มเปรียบเทียบอย่างมีนัยสำคัญทางสถิติ p-value <0.0001

6. ผลการเปรียบเทียบค่าเฉลี่ยคะแนนการจัดการตนเองเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ภายในกลุ่มทดลอง และกลุ่มเปรียบเทียบ ก่อนและหลังการทดลอง กลุ่มทดลอง พบว่า ก่อนการทดลอง มีคะแนนการจัดการตนเองเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 10.44 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 0.98

คะแนน หลังการทดลอง มีคะแนนการจัดการตนเองเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 14.64 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 1.04 คะแนน เมื่อเปรียบเทียบค่าเฉลี่ยคะแนนการจัดการตนเองเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ภายในกลุ่มทดลอง พบว่า หลังการทดลองมีค่าเฉลี่ยคะแนนสูงกว่าก่อนการทดลองอย่างมีนัยสำคัญทางสถิติ p<0.0001 กลุ่มเปรียบเทียบ พบว่า ก่อนการทดลอง มีคะแนนการจัดการตนเองเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 9.77 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 1.94 คะแนน หลังการทดลอง มีคะแนนการจัดการตนเองเพื่อป้องกัน โรคอ้วน เฉลี่ย 9.82 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 1.90 คะแนน เมื่อเปรียบเทียบค่าเฉลี่ยคะแนนการจัดการตนเองเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ภายในกลุ่มเปรียบเทียบ พบว่า หลังการทดลองมีค่าเฉลี่ยคะแนนสูงกว่าก่อนการทดลองอย่างไม่มีนัยสำคัญทางสถิติ p=0.160

ผลการเปรียบเทียบค่าเฉลี่ยคะแนนการจัดการตนเองเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ระหว่างกลุ่มทดลองและกลุ่มเปรียบเทียบ ก่อนและหลังการทดลอง พบว่า ก่อนการทดลอง กลุ่มทดลองมีคะแนนการจัดการตนเองเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 10.44 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 0.97 คะแนน และกลุ่มเปรียบเทียบมีคะแนนเฉลี่ย 9.78 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 1.94 คะแนน เมื่อเปรียบเทียบความแตกต่างของค่าเฉลี่ยคะแนนการจัดการตนเองเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ระหว่างกลุ่มทดลองและกลุ่มเปรียบเทียบ พบว่ากลุ่มทดลองมีค่าเฉลี่ยคะแนนสูงกว่ากลุ่มเปรียบเทียบอย่างไม่มีนัยสำคัญทางสถิติ p-value = 0.058 หลังการทดลอง กลุ่มทดลองมีคะแนนการจัดการตนเองเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 14.64 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 1.04 คะแนน และกลุ่มเปรียบเทียบมีคะแนนเฉลี่ย 9.82 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 1.90 คะแนน เมื่อเปรียบเทียบความแตกต่างของค่าเฉลี่ยคะแนนการจัดการตนเองเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ระหว่างกลุ่มทดลองและกลุ่มเปรียบเทียบ พบว่ากลุ่มทดลองมีค่าเฉลี่ยคะแนนสูงกว่ากลุ่มเปรียบเทียบอย่างมีนัยสำคัญทางสถิติ p-value <0.0001

7. ผลการเปรียบเทียบค่าเฉลี่ยคะแนนการรู้เท่าทันสื่อและสารสนเทศเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ภายในกลุ่มทดลอง และกลุ่มเปรียบเทียบ ก่อนและหลังการทดลอง กลุ่มทดลอง พบว่า ก่อนการทดลอง มีคะแนนการรู้เท่าทันสื่อและสารสนเทศเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 8.18 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 0.85 คะแนน หลังการทดลอง มีคะแนนการรู้เท่าทันสื่อและสารสนเทศเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 12.33 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 0.93 คะแนน เมื่อเปรียบเทียบค่าเฉลี่ยคะแนนการรู้เท่าทันสื่อและสารสนเทศเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ภายในกลุ่มทดลอง พบว่า หลังการทดลองมีค่าเฉลี่ยคะแนนสูงกว่าก่อนการทดลองอย่างมีนัยสำคัญทางสถิติ p<0.0001 กลุ่มเปรียบเทียบ พบว่า ก่อนการทดลอง มีคะแนนการรู้เท่าทันสื่อและสารสนเทศเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 7.64 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 1.71 คะแนน หลังการทดลอง มีคะแนนการรู้เท่าทันสื่อและสารสนเทศเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 7.74 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 1.67 คะแนน เมื่อเปรียบเทียบค่าเฉลี่ยคะแนนการรู้เท่าทันสื่อและสารสนเทศเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ภายในกลุ่มเปรียบเทียบ พบว่าหลังการทดลองมีค่าเฉลี่ยคะแนนสูงกว่าก่อนการทดลองอย่างไม่มีนัยสำคัญทางสถิติ p=0.291

ผลการเปรียบเทียบค่าเฉลี่ยคะแนนการรู้เท่าทันสื่อและสารสนเทศเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ระหว่างกลุ่มทดลองและกลุ่มเปรียบเทียบ ก่อนและหลังการทดลอง พบว่า ก่อนการทดลอง กลุ่มทดลองมีคะแนนการรู้เท่าทันสื่อและสารสนเทศเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 8.18 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 0.85 คะแนน และกลุ่มเปรียบเทียบมีคะแนนเฉลี่ย 7.64 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 1.71 คะแนน เมื่อเปรียบเทียบความแตกต่างของค่าเฉลี่ยคะแนนการรู้เท่าทันสื่อและสารสนเทศเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ระหว่างกลุ่มทดลองและกลุ่มเปรียบเทียบ พบว่ากลุ่มทดลองมีค่าเฉลี่ยคะแนนสูงกว่ากลุ่มเปรียบเทียบอย่างไม่มีนัยสำคัญทางสถิติ p-value = 0.082 หลังการทดลอง กลุ่มทดลองมีคะแนนการรู้เท่าทันสื่อและสารสนเทศเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 12.23 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 0.93 คะแนน และกลุ่มเปรียบเทียบมีคะแนนเฉลี่ย 7.74 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 1.67 คะแนน เมื่อเปรียบเทียบความแตกต่างของค่าเฉลี่ยคะแนนการรู้เท่าทันสื่อและสารสนเทศเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ระหว่างกลุ่มทดลองและกลุ่มเปรียบเทียบ พบว่ากลุ่มทดลองมีค่าเฉลี่ยคะแนนสูงกว่ากลุ่มเปรียบเทียบอย่างมีนัยสำคัญทางสถิติ p-value <0.0001

8. ผลการเปรียบเทียบค่าเฉลี่ยคะแนนพฤติกรรมการปฏิบัติตนเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ภายในกลุ่มทดลอง และกลุ่มเปรียบเทียบ ก่อนและหลังการทดลอง กลุ่มทดลอง พบว่า ก่อนการทดลอง มีคะแนนพฤติกรรมการปฏิบัติตนเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 16.51 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 0.69 คะแนน หลังการทดลอง มีคะแนนพฤติกรรมการปฏิบัติตนเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 24.95 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 0.88 คะแนน เมื่อเปรียบเทียบค่าเฉลี่ยคะแนนพฤติกรรมการปฏิบัติตนเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ภายในกลุ่มทดลอง พบว่า หลังการทดลองมีค่าเฉลี่ยคะแนนสูงกว่าก่อนการทดลองอย่างมีนัยสำคัญทางสถิติ p<0.0001 กลุ่มเปรียบเทียบ พบว่า ก่อนการทดลอง มีคะแนนพฤติกรรมการปฏิบัติตนเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 16.36 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 1.40

คะแนน หลังการทดลอง มีคะแนนพฤติกรรมการปฏิบัติตนเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 16.44 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 1.35 คะแนน เมื่อเปรียบเทียบค่าเฉลี่ยคะแนนพฤติกรรมการปฏิบัติตนเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ภายในกลุ่มเปรียบเทียบ พบว่า หลังการทดลองมีค่าเฉลี่ยคะแนนสูงกว่าก่อนการทดลองอย่างไม่มีนัยสำคัญทางสถิติ p=0.083

ผลการเปรียบเทียบค่าเฉลี่ยคะแนนพฤติกรรมการการปฏิบัติตนเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ระหว่างกลุ่มทดลองและกลุ่มเปรียบเทียบ ก่อนและหลังการทดลอง พบว่า ก่อนการทดลองกลุ่มทดลองมีคะแนนพฤติกรรมการการปฏิบัติตนเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 16.51 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 0.88 คะแนน และกลุ่มเปรียบเทียบมีคะแนนเฉลี่ย 16.36 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 1.40 คะแนน เมื่อเปรียบเทียบความแตกต่างของค่าเฉลี่ยคะแนนพฤติกรรมการการปฏิบัติตนเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ระหว่างกลุ่มทดลองและกลุ่มเปรียบเทียบ พบว่ากลุ่มทดลองมีค่าเฉลี่ยคะแนนสูงกว่ากลุ่มเปรียบเทียบอย่างไม่มีนัยสำคัญทางสถิติ p-value = 0.564 หลังการทดลอง กลุ่มทดลองมีคะแนนพฤติกรรมการการปฏิบัติตนเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เฉลี่ย 24.95 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 0.69 คะแนน และกลุ่มเปรียบเทียบมีคะแนนเฉลี่ย 16.44 คะแนน ส่วนเบี่ยงเบนมาตรฐาน 1.35 คะแนน เมื่อเปรียบเทียบความแตกต่างของค่าเฉลี่ยคะแนนพฤติกรรมการการปฏิบัติตนเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ระหว่างกลุ่มทดลองและกลุ่มเปรียบเทียบ พบว่ากลุ่มทดลองมีค่าเฉลี่ยคะแนนสูงกว่ากลุ่มเปรียบเทียบอย่างมีนัยสำคัญทางสถิติ p-value <0.0001

4. สรุปและอภิปรายผล

1. ข้อมูลทั่วไปของกลุ่มทดลอง พบว่า กลุ่มทดลองส่วนใหญ่เป็นเพศชาย ร้อยละ 71.8 อายุเฉลี่ยของกลุ่มทดลอง 64.36 ปี กลุ่มทดลองส่วนใหญ่มีสถานภาพสมรส ร้อยละ 69.2 กลุ่มทดลองส่วนใหญ่มีการศึกษาอยู่ในระดับประถมศึกษา ร้อยละ 84.6 กลุ่มทดลองส่วนใหญ่มีอาชีพเกษตรกร ร้อยละ 61.5 กลุ่มทดลองส่วนใหญ่ไม่มีโรคประจำตัว ร้อยละ 46.2 รายได้เฉลี่ยต่อเดือนของครอบครัวกลุ่มทดลองส่วนใหญ่มีรายได้เฉลี่ยต่อเดือนอยู่ในช่วง 1,500 – 10,000 ร้อยละ 87.2 สิทธิการรักษาพยาบาลกลุ่มทดลองส่วนใหญ่ใช้สิทธิบัตรทอง 30 บาท ร้อยละ 74.4 ระยะทางจากบ้านถึงสถานบริการสุขภาพเฉลี่ยของกลุ่มทดลอง 3.59 กิโลเมตร กลุ่มทดลองส่วนใหญ่ไม่มีใบอนุญาตขับขี่รถจักรยานยนต์ ร้อยละ 74.4 กลุ่มทดลองส่วนใหญ่มีการใช้รถจักรยานยนต์ต่อสัปดาห์เฉลี่ย 5.28 วัน ระยะ 1 ปีที่ผ่านมากลุ่มทดลองส่วนใหญ่ ไม่เคยได้รับอุบัติเหตุจากการขับขี่รถจักรยานยนต์ ร้อยละ 79.5

2. ความรู้ความเข้าใจทางสุขภาพเพื่อป้องกัน อุบัติภัยจราจรจากรถจักรยานยนต์ ผลการศึกษาพบว่า ก่อนการทดลองกลุ่มทดลองส่วนใหญ่มีคะแนนความรู้ความเข้าใจทางสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์อยู่ในระดับพอใช้ ร้อยละ 71.8 หลังการทดลองส่วนใหญ่มีคะแนนความรู้ความเข้าใจทางสุขภาพเพื่อป้องกันเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ระดับดีมาก ร้อยละ 100.0 ผลการเปรียบเทียบค่าเฉลี่ยคะแนนพบว่า หลังการทดลอง กลุ่มทดลองมีค่าเฉลี่ยคะแนนความรู้ความเข้าใจทางสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์สูงกว่าก่อนการทดลอง อย่างมีนัยสำคัญทางสถิติ p-value<0.0001

3. การเข้าถึงข้อมูลและบริการสุขภาพเพื่อป้องกัน อุบัติภัยจราจรจากรถจักรยานยนต์ ผลการศึกษาพบว่า ก่อนการทดลองกลุ่มทดลองส่วนใหญ่มีคะแนนการเข้าถึงข้อมูลและบริการสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์อยู่ในระดับพอใช้ ร้อยละ 23.1 หลังการทดลองอยู่ในระดับดีมาก ร้อยละ 20.5 ผลการเปรียบเทียบค่าเฉลี่ยคะแนนพบว่า หลังการทดลอง กลุ่มทดลองมีค่าเฉลี่ยคะแนนการเข้าถึงข้อมูลและบริการสุขภาพสูงกว่าก่อนการทดลอง อย่างมีนัยสำคัญทางสถิติ p-value<0.0001

4. การสื่อสารด้านสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ผลการศึกษาพบว่า ก่อนการทดลอง กลุ่มทดลองส่วนใหญ่มีคะแนนการสื่อสารด้านสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์อยู่ในระดับไม่ดี ร้อยละ 79.5 หลังการทดลองอยู่ในระดับดีมาก ร้อยละ 56.4 ผลการเปรียบเทียบค่าเฉลี่ยคะแนนพบว่า หลังการทดลอง กลุ่มทดลองมีค่าเฉลี่ยคะแนนการสื่อสารด้านสุขภาพเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์สูงกว่าก่อนการทดลอง อย่างมีนัยสำคัญทางสถิติ p-value<0.0001

5. การตัดสินใจเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ผลการศึกษาพบว่า ก่อนการทดลอง กลุ่มทดลองส่วนใหญ่มีคะแนนการตัดสินใจเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์อยู่ในระดับไม่ดี ร้อยละ 69.2 หลังการทดลองอยู่ในระดับดีมาก ร้อยละ 46.2 ผลการเปรียบเทียบค่าเฉลี่ยคะแนนพบว่า หลังการทดลอง กลุ่มทดลองมีค่าเฉลี่ยคะแนนการตัดสินใจเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์สูงกว่าก่อนการทดลอง อย่างมีนัยสำคัญทางสถิติ p-value <0.0001

6. การจัดการตนเองเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ผลการศึกษาพบว่า ก่อนการทดลอง กลุ่มทดลองส่วนใหญ่มีคะแนนการจัดการตนเองเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์อยู่ในระดับพอใช้ ร้อยละ 69.2 หลังการทดลองอยู่ในระดับดีมาก ร้อยละ 53.8 ผลการเปรียบเทียบค่าเฉลี่ยคะแนนพบว่า หลังการทดลอง กลุ่มทดลองมีค่าเฉลี่ยคะแนนการจัดการตนเองเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์สูงกว่าก่อนการทดลอง อย่างมีนัยสำคัญทางสถิติ p-value <0.0001

7. การรู้เท่าทันสื่อและสารสนเทศเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ผลการศึกษาพบว่า ก่อนการทดลอง กลุ่มทดลอง

ส่วนใหญ่มีคะแนนการรู้เท่าทันสื่อและสารสนเทศเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์อยู่ในระดับไม่ดี ร้อยละ 53.8 หลังการทดลองอยู่ในระดับดีมาก ร้อยละ 82.1 ผลการเปรียบเทียบค่าเฉลี่ยคะแนนพบว่า หลังการทดลอง กลุ่มทดลองมีค่าเฉลี่ยคะแนนการรู้เท่าทันสื่อและสารสนเทศเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์สูงกว่าก่อนการทดลอง p-value<0.0001

8. พฤติกรรมการปฏิบัติตนเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ผลการศึกษาพบว่า ก่อนการทดลอง กลุ่มทดลองส่วนใหญ่มีคะแนนพฤติกรรมการปฏิบัติตนเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์อยู่ในระดับไม่ดี ร้อยละ 84.6 หลังการทดลองอยู่ในระดับดีมาก ร้อยละ 97.4 ผลการเปรียบเทียบค่าเฉลี่ยคะแนนพบกว่า หลังการทดลอง กลุ่มทดลองมีค่าเฉลี่ยพฤติกรรมการปฏิบัติตนเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์สูงกว่าก่อนการ อย่างมีนัยสำคัญทางสถิติ p-value <0.0001

ข้อเสนอแนะจากงานวิจัย

1. การศึกษาครั้งนี้เป็นการประยุกต์แนวคิดการส่งเสริมความรอบรู้ด้านสุขภาพร่วมกับการใช้สื่อวีซีดีหนังสั้น มีผลต่อการเสริมสร้างความรอบรู้ทางสุขภาพในการป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ของผู้สูงอายุ อายุ 60-69 ปี อำเภอเกษตรสมบูรณ์จังหวัดชัยภูมิ สามารถนำไปใช้ในพื้นที่ใกล้เคียงกันได้

2. สื่อวีซีดีหนังสั้น ในการเสริมสร้างความรอบรู้ทางสุขภาพในการป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ เป็นการใช้ภาพแล้เสียงเล่าเรื่องราวการเสริมสร้างความรอบรู้ทางสุขภาพและการปฏิบัติตนเพื่อป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ ซึ่งสะท้อนให้เห็นการใช้รถจักรยานยนต์ พร้อมสื่อให้เห็นผลเสียของการใช้รถจักรยานยนต์แบบประมาทที่เข้าใจง่ายเพื่อประกอบกับการให้สุขศึกษา ในการศึกษาวิจัยนี้ได้เปิดสื่อวีซีดีหนังสั้นร่วมกับการทำกิจกรรมวิจัยทุกครั้งและแจกวีซีดีหนังสั้นให้กับผู้เข้าร่วมทุกคน เพื่อช่วยกระตุ้นในการเสริมสร้างพฤติกรรมการป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ได้อย่างมีประสิทธิภาพ

ข้อเสนอแนะการศึกษาครั้งต่อไป

1. ในการศึกษาครั้งต่อไปควรทำการทดลองนำสื่อวีซีดีหนังสั้น ไปประยุกต์ใช้ในการเสริมสร้างพฤติกรรมการป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์กับกลุ่มเป้าหมายอื่นๆ เช่น กลุ่มนักเรียน กลุ่มนักศึกษา และกลุ่มวัยแรงงาน เป็นต้น

2. การศึกษาครั้งต่อไปควรใช้ระยะเวลาการศึกษาเพิ่มขึ้นเพื่อให้เห็นผลการเปลี่ยนแปลงด้านพฤติกรรมการป้องกันอุบัติภัยจราจรจากรถจักรยานยนต์ที่ชัดเจน

5. กิตติกรรมประกาศ

งานวิจัยฉบับนี้สำเร็จลงได้ด้วยดี ผู้วิจัยจึงขอขอบพระคุณคณาจารย์คณะสาธารณสุขศาสตร์ทุกท่าน ขอบคุณศูนย์วิจัยและฝึกอบรมเพื่อส่งเสริมคุณภาพชีวิตคนวัยแรงงาน คณะพยาบาลศาสตร์ มหาวิทยาลัยขอนแก่นที่สนับสนุนทุนทำวิทยานิพนธ์ ขอบคุณผู้สูงอายุอำเภอเกษตรสมบูรณ์ จังหวัดชัยภูมิ ขอบคุณผู้เข้าร่วมกิจกรรมทุกท่านที่ได้ให้ความอนุเคราะห์ในการเข้าร่วมกิจกรรมเป็นอย่างดีและขอขอบคุณหน่วยงานต่างๆ ที่มีส่วนให้งานวิจัยนี้สำเร็จลุล่วงด้วยดี

เอกสารอ้างอิง

[1] เกรียงศักดิ์ เจริญวงศ์ศักดิ์. (2552). จัดสวัสดิการอย่างไรให้ผู้สูงอายุไทยอยู่ดีมีสุข. รัฐสภาสาร; ปีที่ 57 ฉบับที่ 11 เลขหน้า 167-171 ปี 2552.

[2] ธนวรรษน์ สำกำปัง และกาญจนา นาถะพินธุ .(2554). ปัจจัยที่มีความสัมพันธ์กับการเกิดอุบัติเหตุในผู้สูงอายุ ตำบลขามป้อม อำเภอพระยืน จังหวัดขอนแก่น.วารสารสำนักงานป้องกันควบคุมโรคที่ 6 ขอนแก่น, 17(3), 40-52.

[3] มูลนิธิเมาไม่ขับ .(2557). สถิติอุบัติเหตุในประเทศไทย . ค้นเมื่อ 10 กันยายน 2560, จาก http://www.ddd.or.th.

[4] โรงพยาบาลเกษตรสมบูรณ์ .(2559). ข้อมูลการเกิดอุบัติเหตุจราจรของโรงพยาบาลเกษตรสมบูรณ์ ปี 2559. เกษตรสมบูรณ์: (เอกสารอัดสำเนา).

[5] วีรศักดิ์ เมืองไพศาล .(2556). ผู้สูงอายุกับการขับรถ . ค้นเมื่อ 1 กันยายน 2560, จาก http://www.si.mahidol.ac.th/sidoctor/e-pl/articledetail.asp?id=417.

[6] สำนักงานสาธารณสุขจังหวัดชัยภูมิ .(2559). ข้อมูลสถิติการเกิดอุบัติเหตุจราจรของจังหวัดชัยภูมิ ปี 2559. ชัยภูมิ : (เอกสารอัดสำเนา).

[7] สำนักงานขนส่งจังหวัดชัยภูมิ .(2559). สถิติจำนวนรถจักรยานยนต์ที่จดทะเบียนของจังหวัดชัยภูมิ ปี 2559. ชัยภูมิ : (เอกสารอัดสำเนา).

[8] Knodel J and Chayovan N, (2008). Population ageing and the well-being of older persons in Thailand: Past Trends, Current Situation, and Future Challengs. Papers in Population Ageing Series, Number 5. Bangkok: UNFPA Thailand and Asia and the Pacific Regional office. [4]

[9] United Nation, Department of Internation Economic and Social Affair. (1981). Popular Participation as a Strategy for Promoting Community Level Action and Nation Development. Report of The Meeting for The Adhoc Group of Expert. New York: United Nation. [3]

[10] World Health Organization. Global Statusreport on Road Safety 2015. Geneva:WHO;2015. [1]

Assessment on-street parking demand depend on land use in downtown, case study; Kahramanmaras City, Turkey

Paper Identification number: AYRF18-032
Ahmet Basid DOGRU [1], Ahmet YILDIRIM [2], Sayana SER [3]

[3]Department of Transportation,
Kahramanmaras Metropolitan Municipality, from Turkey
Telephone mobile: +90-553-9190950,
E-mail: abasitdogru@gmail.com

[2]Department of Urban Planning, Faculty of Architecture,
Istanbul Technical University, from Turkey
Telephone +90-553-218 8811,
E-mail: ahmetyildirim89@gmail.com

[3]Research Associate, Leisure, Tourism and Environment,
Wegeningen University, from Cambodia
Telephone +855-10-922 232,
E-mail: sayana.ser@googlemail.com

Abstract

On-street parking is one of the major mobility issues to address in many developing countries' cities that grown by rapid urbanization and car-oriented. However, there are only a few studies related this subject due to limited access to data the on-street parking. At that study 65 on-street parking location's parking data were collected in the city central district of the Kahramanmaras city to analyze the on-street parking demand components depend on land use characteristics. The objective of this study is to analyze on-street parking detail and managing the parking demand depend on the land use characteristics in downtown. The study analyses the on-parking data by multi linear regression in order to set up an on-street parking demand model to identify the on-street parking daily parking frequency volume, duration time is correlated with some commercial (retail and shopping) type of land use in the downtown. On-street parking indicators have been specified for each land use in downtown. The results of this study can be used by the local government in order to manage the parking demand.

Keywords: On-street parking, land use, parking demand.

1. General Introduction

Kahramanmaras is a largely populated city of Turkey with around half a million people living in the city center. The city urban area developed rapidly during the last decade. Even though the city urbanization area developed the downtown area still the same size, while the mobility and travel demand have been increased more times. Private car is the main modes of road transportation in Kahramanmaras so that the numbers of registered cars increased during the last years. There are approximately 80.000 cars in the center districts of the city. The car increasing rate is 5 times of the population growth and the city is totally car-oriented city. This subsequently resulted in a high demand for parking spaces. However, due to a lack of off-street parking lots and easy access to final destinations,

most vehicles park on the streets. Afterward, on-street parking became overloaded, and it became one is big reason for traffic junction at main-busy streets.

Although recently some parking lots have been provided in the city center, the high demand for on-street parking still is not under control. Because most of the drivers still willing to park on the streets due to for short stops. As the result of this consequences, too much car parking on streets caused reduction of the road capacity. Local authority has to answer this issue and it is more necessary to manage both on-street parking and off-street parking. Parking space is required depend on the trip purpose. When the destination required long break, driver need to park for long time at the accessible parking lot. However, if driver need a couple of stops at different destinations for short time the on-street parking would be more necessary. These short trips are related with short duration parking and it is mostly caused stuck of on street mobility. The issue is highly related with land use characteristic. Some land usage such as retail, shopping, refreshment zones need short time stop and driver need to have a short break at on-street parking. This subject is related on-street parking optimization management. This system required short time and high frequency parking. Land use characteristic should be determined in terms the requirement of on-street parking spaces and the parking duration period for each land use types in the downtown. This subject required to put more focus on the relation of on-street parking demand and urban land use characteristics.

There are several studies which identified the relationship between land use and parking demand. These dimensions are land use characteristics and structure density as well as user-population density. The other components are related the accessibility, such as, parking space accessibility to different sort of land usages (retail, offices, residential, hospital and other relevant land use in the city center). Most of research's results offer parking requirement at building or more knowledge about off-street parking and parking lot. There are only a few outcomes related on-street parking. On the other hand, parking demands management is a holistic system which required focus on the both off-street and on-street parking demand structure. Therefore, land use characteristics should be identified depend on requirement of on-street parking and to define how the land usage effect the parking behavior choices in the downtown. These outcomes can guide the local government for appropriate parking spaces.

This study wiling to figure out to analyze the characteristics of on-street parking in order to resolve the parking issue. Some measurements were identified in order to analyze the correlation between on-street parking characteristics and the land use characteristic. These are; parking duration, parking usage frequency, parking occupy rate, parking demand, land use characteristic such as building density, parking accessibility measurements for land use function.

2. Literature review

Generally parking demand and especially on-street parking demand related land use characteristic literatures were revived by considering the main idea of some research, some approaches which developed from different cities and sources of data. There are several studies related land use and the effect of transportation and on travel behavior. Some of them such as Badoe and Miller (2000); Crane (2000); Ewing and Cervero (2001); are mostly focused on the land use impact on mode choice. [1] [2] As the result of these studies are land use characteristics have a significant impact on mode choice decisions. Some other while found out that the significant influence of land use attributes. Crane and Crepeau (1998) and Hess (2001) found no relationship between land use and mode choice decisions.
trips.

Hess (2001) studied the effect of free parking on mode choice and parking demand. A multinomial logit model was used to evaluate the probabilities of commuters with or without free parking at work for the trip to work in the central business district (CBD) of Portland, Oregon. His research found out that parking fee effected the driver usage rate of cars.
Some studies have been conducted related to estimation of demand, particularly in mixed-use areas. Hensher (Hensher and King, 2001) investigates the role of parking pricing and supply by time of day in whether to drive and park in the Central Business District (CBD). [3]

There are also a few studies related to the design of parking facilities that cover parking demand as an important factor (Zhao and Tseng, 2003). [4] For estimation of parking demand, many studies focus on average and peak trip generation rates by land-use or use simple forecast models (Hensher and King, 2001, Chen et al., 2014). [3]

One study introduced a methodology to estimate the effect of parking prices on car drivers' choice between street and garage parking. (Kobus M., Puigarnau E. and others, 2012) They figure out that the marginal benefit of parking duration does not depend on this choice. The endogeneity of parking duration is acknowledged in the estimation procedure. They applied the methodology to an area where traveling for parking is absent, street parking is allover and garage parking is discretely located over space. So, in this area, the average distance to the final destination is longer for garage parking than for street parking. They found out that drivers are willing to pay a premium for street parking, it was found out that the demand for street parking is extremely price elastic. [6]

Ajeng C., Tommy Gim T. studied on-street parking duration and demand. They analyzed Yogyakarta (Indonesia) city center on-street parking data in terms of the parking duration and demand and how differentiated by street and land use characteristics. In that study identified that parking duration is affected by the street length, parking volume, and commercial type of land use, while the street length also differentiates the parking demand. Regarding the street length, it is found to be the only significant variable in the demand model, but it becomes the weakest among those significant in the duration model, where the land use type has the highest magnitude. [7]

3. Methodology and Data collection

Kahramanmaras Metropolitan Municipality administration is currently beginning efforts to improve management of parking, and Transportation Department worked with Akbel Company to conduct a detailed analysis of parking supply and demand, looking at the impacts of current parking management strategies on utilization. Akbel is city parking operator company works under municipality administration. The city downtown contains a diverse mix of land uses, including several financial institutions, a large retail and entertainment district, a government district, and several distinct residential districts. Transportation Department worked closely with Akbel Co. to explore how parking utilization varies relative to these contexts, and to determine a potential set of management strategies that can meaningfully improve parking operations.

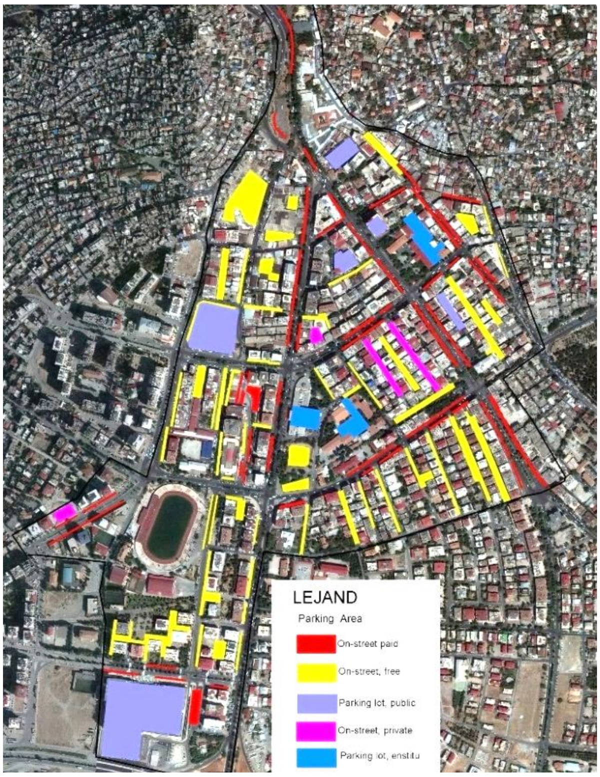


Fig.1; Type of parking in Kahramanmaras downtown

The map above shows how parking occupancy varies in downtown. The high on-street parking demand throughout the central business district.

Table 1 Different Types of Parking and capacities

Parking types	capacity	% rate
Off-street parking (parking lot)	1,987	31.8
On-street parking	1,173	18.8
Private off-street parking	275	4.4
Institution parking	360	5.8
Free on-street parking	2,445	39.2
Total	6,240	100.0

3.1- Questionnaire survey

The questionnaire survey was set in order to understand the user's on-street parking characteristic as well as their parking choice behavior. The result used to set up the research theory and the methodology regarding defining the general concept of the subject and the study targets. From the questionnaire survey these findings below were identified;

1-There is very strong relation between off-street parking, on-street parking user and land use characteristics.

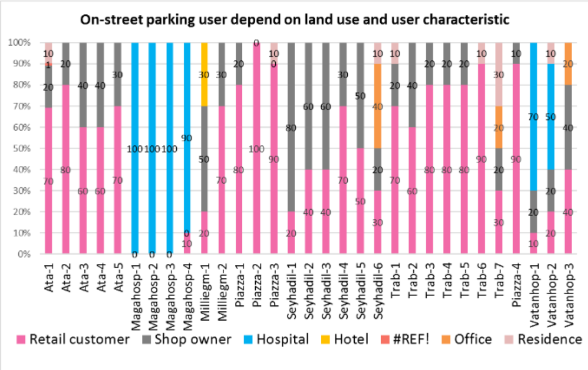


Fig.2; On-street parking user depend on land use and user characteristic

2-Parking user use different type of parking for some reasons and these are explained as mentioned below;

a-Off-street parking (garage parking) space; mostly used by shop owner from morning till evening and they use the garages by subscription system and they pay monthly. These user groups are middle and well income group, it is necessary to provide parking space at 10 minutes walking distance and secured parking lot during week days including Saturday. The parking location is middle accessible which only preferred by shop owner in terms of they used only one times per day. 90% of parking space occupied by this type of users. The off-street parking is operated by local government (by Akbel Co.)

b-Private off-street parking space; 80% used by shop owner from morning till evening. Some user park as by subscription system and they pay monthly the others use and pay daily. This user group is middle income group, it is necessary to provide parking space at 10 minutes walking distance and secured off-street parking during week days including Saturday. These parking locations are good accessible and operated by some private companies. Parking spaces occupied from 10.00 AM. Usually it is hard to provide available parking spaces during day time, it is mostly used by commuters and shop owner during day time and however they are used by residence owner during night time. Daily commuters prefer to use when they need to park for long time in terms of the pricing is cheaper than the paid on-street park.

c-Free (uneducated) on-street parking space; these parking space approximately 100-150 meter far 10-15 minutes walking distance from the main center of the downtown. The user groups are who have low income profile who willing to not pay for parking. There are main two group of users, who 60% are shop owner who their shops close to these streets and the other 40% low income customers who commuter to downtown and have middle quality and cheap vehicle, they are not worried to park on street where there are uneducated parking spaces. The owner groups users are start to park from the early morning till the evening time. The commuter group is not regularly user and they use these parking space when they need to come to downtown. They are able to park these locations if only they reached before 10 AM.

d-Institution parking space; these parking spaces are available only for government employees, usually the car parking spaces are enough for staffs. However, the visitors need to park other parking spaces, such as paid on-street parking, or free on-street parking spaces,

Fig.3; On-street parking locations and the accessibility of parking

f-Paid on-street parking space, used by two main groups which 30% shopping owner, office owner and a few users are residence owners, who they have residences at top of mixed used building. 70% customers are commuters who come to downtown for shopping, for getting service from hospital, school and other public service centers. The shop owner group is use parking space during whole day time, the customer group uses short time depend one land use characteristic. Such that retail, shopping, restaurant customers are usually park during 30 min.-2 hours. The customer group is consisting two subgroups; low income and middle income. The low-income group first of all checks the availability of parking space at free parking and if they did not able to park there then they have to park at the paid on-street parking. The middle-income group regularly parks at on-street parking, they prefer the paid on-street parking space due to good accessible location from busy retail and shopping streets.

3-It is significant that there is some different parking user depend user profile and the purpose for committing to downtown and these reasons are managed their parking behavior choices, shop owners, office owners and residence owners are park whole day and they start to parking from early day till evening time,

4-Retail customers and some office owner and customers mostly prefer paid on-street parking space because of good accessible and the parking fee is affordable when they only need to park for short time.

5-Parking accessibility is one is most necessary factor paid on-street parking places, the distance for accessibility is 30-50 meter. The accessibility of parking perron (parking space) is depend on some factors such as closeness to main shopping center, availability of easy walkable pavement, closeness to core of business and retail land use. Free on-street parking space accessibility distance longer than paid on-street parking for low in-come users.

4. On-street Parking Data Analyses

The questionnaire results used to set up a comprehensive the study methodology of analyze of on-street parking and relation with land use characteristic. The analysis of supply and occupancy data established a baseline for comparative analysis to evaluate how the relationship between parking supply, demand, land use characteristic. By analyzing a complete parking data set of parking inventory, occupancy, turnover, the region and for all times of day, days of week, and seasons. From this view the busiest month was chosen as July for parking analyses. Information for all parking both private and public supplies would allow a full supply and demand analysis.

In this study, it was targeted to assessment the parking occupancy analysis of both off-Street parking and on on-Street parking data collected on supply, occupancy, public parking facilities 65 locations on-street parking perron analyzed in detail. This information is location-specific so that demand by area is correlated with land use characteristics that makes each area unique. In addition to analyzing occupancy by region, GIS is used to map findings spatially and looked at which parking conditions are common throughout the downtown.

In that part of the study developed by 3 subtitles;

1- Analyze of daily parking occupancy, by hours and by duration time,

2-On-street parking locations occupancy rate distribution by hours,

3-assessment of on-street parking demand and supply

The on-street parking data collected from 65 on-street parking locations in the city central district of the Kahramanmaras city. The parking occupancy data provided from on-street parking hand-park meter, this parking occupancy inventory data consist the on-street parking location name, the parking capacity, parking start and end time, the duration time.

One month on-street parking data is collected and this date consists about 150.000 parking during July in 2017. The data analyzed in order to figure out the on-street parking demand components depend on land use characteristics.

Parking data was determined by two measurements such as;

a-Daily parking occupancy, by hours,

b-Daily parking occupancy, by duration time

There are 11 parking zones which consist 65 on-street parking locations and the parking data was analyzed by these two measurements, some different characteristic zones explained at below in order to assessment in detail.

4.1. Analyze of on-street parking characteristics depend on zones occupancy and land use characteristic:

1.a- Daily parking occupancy, by hours, Ata Zone; this zone consists 6 on-street parking locations, the main land use characteristic is retail and shopping, daily parking occupancy analyses figure shows that these on-street parking the high occupied rate start from 9:00 AM, then the occupancy rate usually go on till 5:00 PM. This zone is the second busiest street of the downtown. The big rate of users are retail and shopping customers. Ata-1 is the busiest on-street parking location due to close to historical bazaar. The rate of users is high for this location. Fig.4

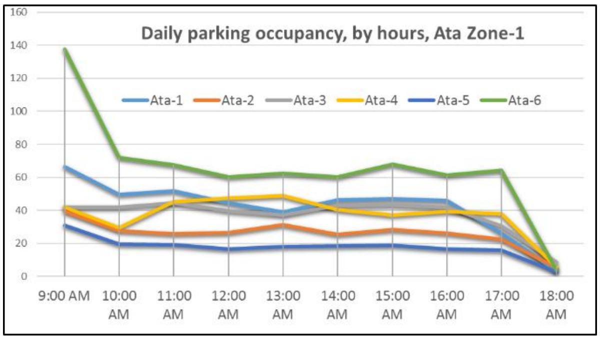


Fig.4; Daily parking occupancy, by hours, Ata Zone

1.b- Daily parking occupancy, by duration time Ata Zone; parking occupancy depend on duration time figure shows that some on-street parking (Ata-1, Ata-6) location have high short time (5-20 min and 20-40 min) parking and the frequency of parking occupancy is high there. Ata-1 parking location accessible zone cower the historical bazaar and the most of users are customers who come to this location. 40 min-60 min. and 1-2-hour parking duration is mostly similar for all locations. The distribution of long time parking duration (3-5 hour) parking is similar too. Fig.5

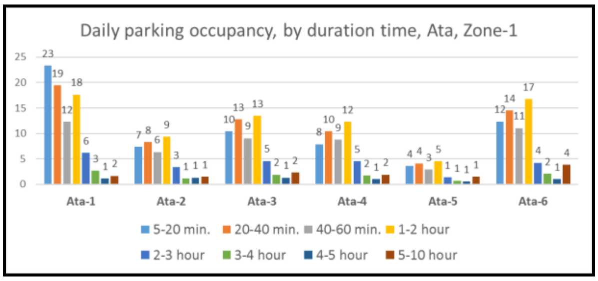


Fig.5; Daily parking occupancy, by duration time, Ata Zone

2.a- Daily parking occupancy, by hours, 1BTrab Zone; this zone consists 6 on-street parking locations, this zone is the highest busy street where located in the core of the downtown. The main land use characteristic is retail and shopping, daily parking occupancy analyses figure shows that these on-street parking the highest occupied rate start from 9:00 AM, and someone reached to top at 11:00 AM. then the occupancy rate usually goes on till 5:00 PM. The big rate of users are retail and shopping customers. 1BTrab-5 is the busiest on-street parking location due to close to retails and shopping buildings. The rate of users is high for this location. Fig.6

2.b- Daily parking occupancy, by duration time 1BTrab Zone; parking occupancy depend on duration time figure shows that some on-street parking (1BTrab-1, 1BTrab-5) location have high short time (5-20 min and 20-40 min) parking and the frequency of parking occupancy is high there.

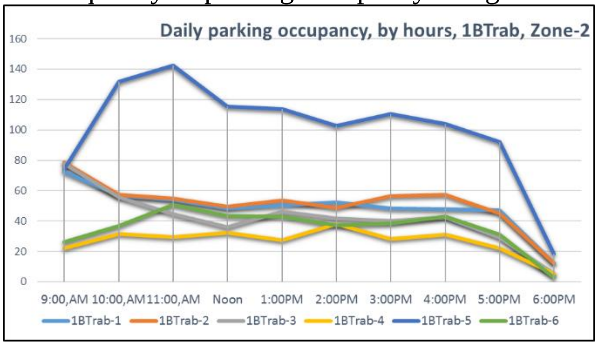


Fig.6; Daily parking occupancy, by hours, 1BTrab Zone

The most of users are customers who come to this location. 40 min-60 min. and 1-2-hour parking duration is mostly similar for all locations. The distribution of long time parking duration (3-5 hour) parking is similar too. Fig.7

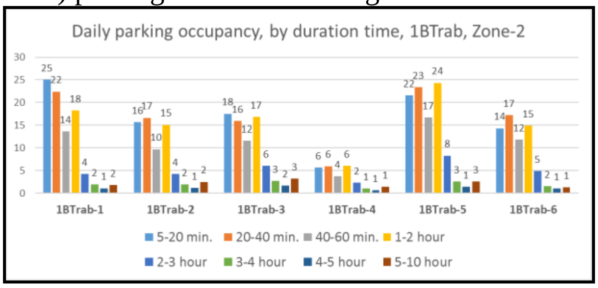


Fig.7; Daily parking occupancy, by duration time, 1BTrab Zone

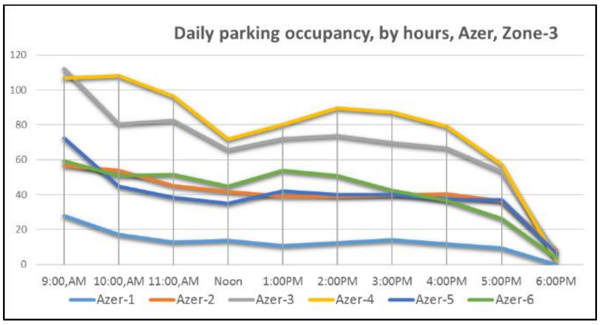


Fig.8; Daily parking occupancy, by hours, Azer Zone

3.a- Daily parking occupancy, by hours, Azer Zone; this zone consists 6 on-street parking location, this zone is the middle busy street where located near the core of the downtown. The main land use characteristic is home staff shopping and office and upstairs are residence, daily parking occupancy analyses figure shows that these on-street parking the highest occupied rate start from 9:00 AM, and most of parking locations rate goes down at noon, then goes up afternoon. The occupancy rate usually goes on till 5:00 PM. The big rate of users is home staff shopping customers. Azer-4 is the busiest on-street parking location due to close to retails and shopping buildings. The rate of users is high for this location. Fig.8

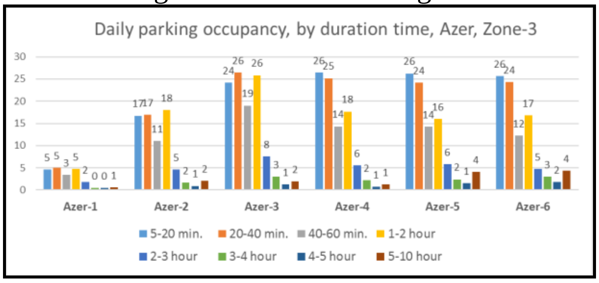


Fig.9; Daily parking occupancy, by duration time, Azer Zone

3.b- Daily parking occupancy, by duration time Azer Zone; parking occupancy depend on duration time figure shows that some on-street parking (Azer-3, Azer-4, Azer-5, Azer-6) location have high short time (5-20 min, 20-40 min and 40 min-60 min) parking and the frequency of parking occupancy is high there, 1-2-hour parking duration is high in Azer-3, The distribution of long time parking duration (3-5 hour) parking is similar too. Fig.9

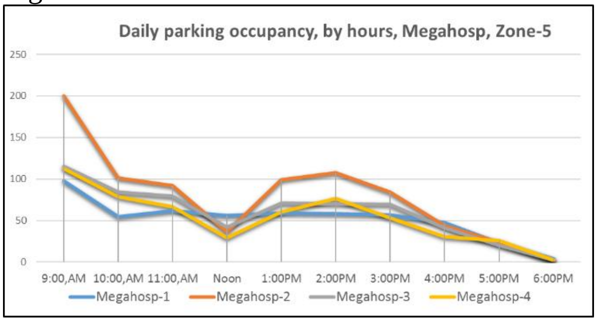


Fig.10; Daily parking occupancy, by hours, Megahosp Zone

4.a- Daily parking occupancy, by hours, Megahosp Zone; this zone consists 4 on-street parking location, this zone is the middle busy street where located near the core of the downtown. The main land use characteristics are hospital, hotel, retail and office. The main part of these users are hospital visitors. Daily parking occupancy analyses figure shows that these on-street parking the highest occupied rate start from 9:00 AM, and most of parking locations rate goes down at noon, then goes up afternoon. It is significant that the hospital visitors are mostly affected the profile of the parking occupy form. The occupancy rate goes down after 3:00 PM due to doctors leave from hospital and the health examination process end at 3:00 PM. Fig.10

4.b- Daily parking occupancy, by duration time Megahosp Zone; parking occupancy depend on duration time figure shows that most of on-street parking locations illustrate high short time (5-20 min, 20-40 min and 40 min-60 min) parking.

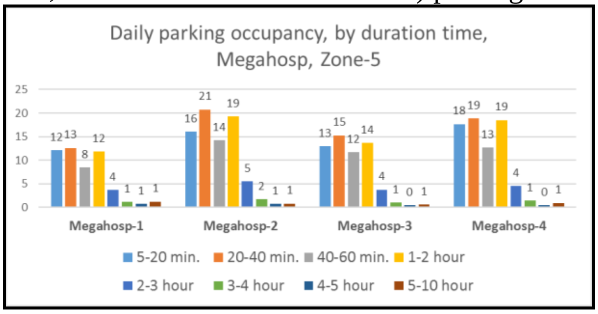


Fig.11; Daily parking occupancy, by duration time, Megahosp Zone

The frequency of parking occupancy is high there, 1-2-hour parking duration is high in Megahosp-2 and Megahosp-4, The distribution of long time parking duration (3-5 hour) parking is similar too. Fig.11

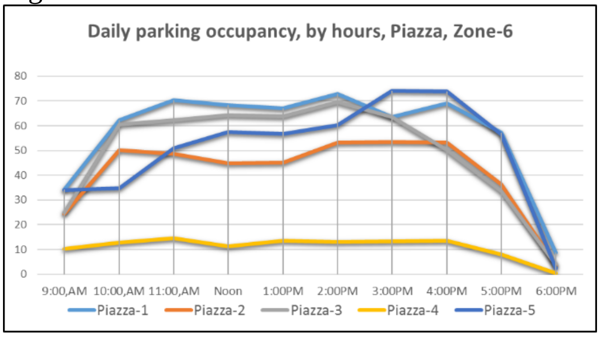


Fig.12; Daily parking occupancy, by hours, Piazza Zone

5.a-Daily parking occupancy, by hours, Piazza Zone; this zone consists 5 on-street parking locations, this zone one is the highest busy street where located in the biggest Shopping Mall.

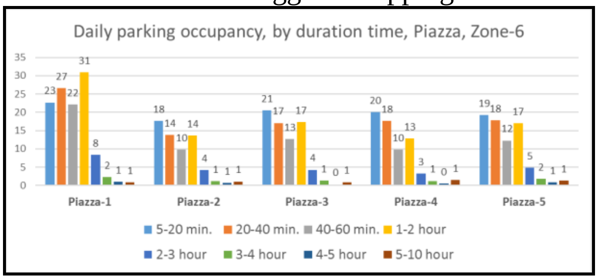


Fig.13; Daily parking occupancy, by duration time, Piazza Zone

The main land use characteristic is retail shopping mall and banks, daily parking occupancy analyses figure shows that these on-street parking the highest occupied rate reached at 11:00 AM, the occupancy rate goes down after 5:00 PM. The big rate of users are retail and shopping customers. Piazza-5 parking location shows a little bit different form since the occupy rate goes up during 3.00-4.00PM, this location users are bank users Fig.12

5.b- Daily parking occupancy, by duration time Piazza Zone; parking occupancy depend on duration time figure shows that all of on-street parking location have high short time (5-20 min and 20-40 min) parking and the frequency of parking occupancy is high there. The most of users are customers who come to this location. 40 min-60 min. and 1-2-hour parking duration is mostly similar for all locations. The distribution of long time parking duration (3-5 hour) parking is similar too. Fig.13

4.2. On-street parking locations occupancy rate distribution by hours;

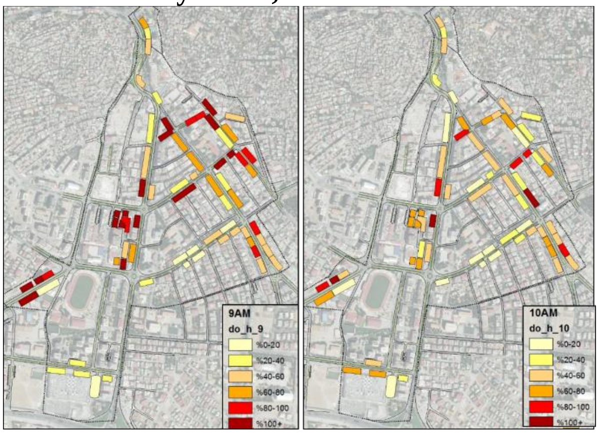


Fig.14; Daily parking occupancy, by hours; 9:00 AM and 10:00 AM

Daily parking occupancy 9:00 AM and 10:00 AM figure shows that; at 9:00 AM; Ata, 1BTrab, Vatanhosp and Megahosp zones are high occupied, at 10:00 AM Trab, Azer and Megahosp zones are high occupied while others are middle and low occupied. Fig.14

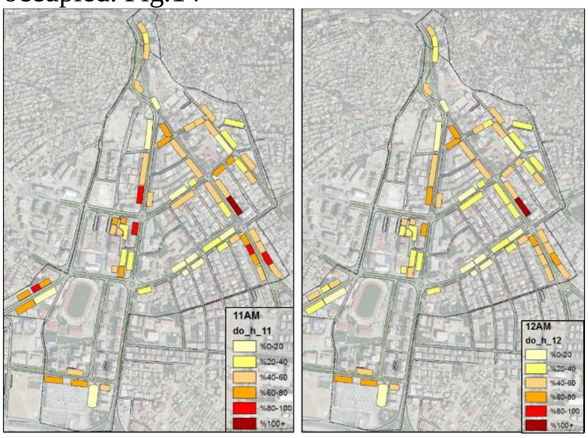


Fig.15; Daily parking occupancy, by hours; 11:00 AM and 12:00 AM

Daily parking occupancy 11:00 AM and 12:00 AM figure shows that; at 11:00 AM; Azer and Trab, are high occupied, at 12:00 AM only 1BTrab is high occupied while others are middle and low occupied. Fig.15

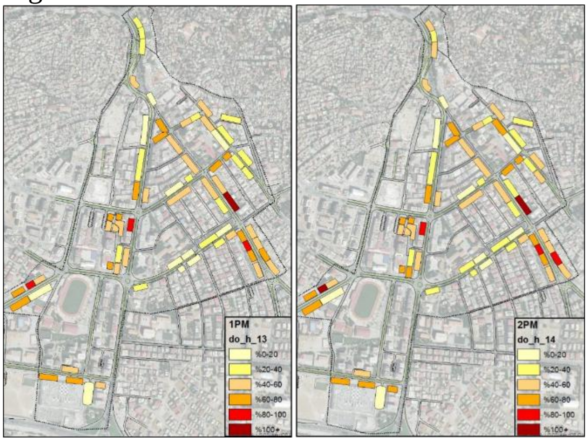


Fig.16; Daily parking occupancy, by hours; 1:00 PM and 2:00 PM

Daily parking occupancy 1:00 PM and 2:00 PM figure shows that; at 1:00 PM; Megahosp, Ata and Trab zones are high occupied, at 2:00 PM Megahosp, 1Bata and Trab zones are high occupied Fig.16

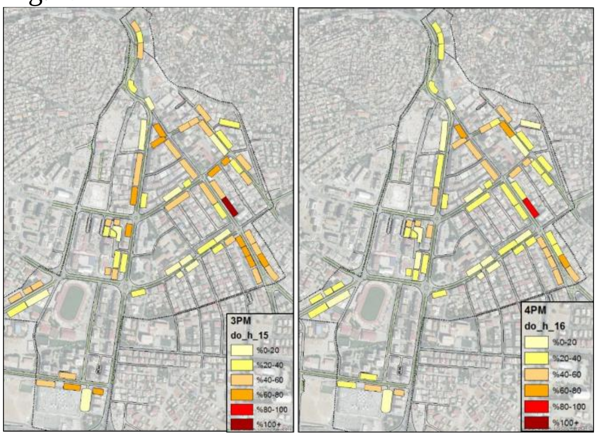


Fig.17; Daily parking occupancy, by hours; 3:00 PM and 4:00 PM

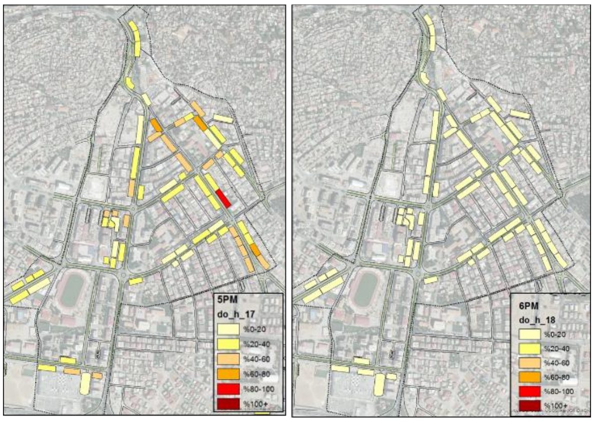


Fig.18; Daily parking occupancy, by hours; 5:00 PM and 6:00 PM

Daily parking occupancy 3:00 PM and 4:00 PM figure shows that; at 3:00 PM; Megahosp, Vatanhosp, Ata and Trab zones are high occupied, at 4:00 PM only 1BTrab zones is high occupied while others are middle and low occupied. Fig.17 Daily parking occupancy, by hours; 5:00 PM and 6:00 PM figure shows that; at 5:00 PM; Ata, 1BTrab, and Trab zones are middle occupied, at 6:00 PM all zones are low occupied Fig.18

4.3 Assessment of on-street parking demand and supply

The questionnaire survey results and the analyses result of parking data which consist daily parking occupancy, by hours and by duration time analyses, on-street parking locations occupancy rate distribution by hours are determined in order to set develop an assessment methodology of on-street parking demand and supply. Generally parking supply and demand is a complex system which combined with some components, questionnaire survey results helped to divide on-street parking demand and supply from other type of parking. Figure Different of parking spaces shows the all type of parking space. Fig.19.

Fig.19; Different type parking

On-street parking accessible zone distance was determined from the questionnaire survey results that it is 30-50 meter. Figure 20, 21

Fig.20; On-street parking and accessible zone

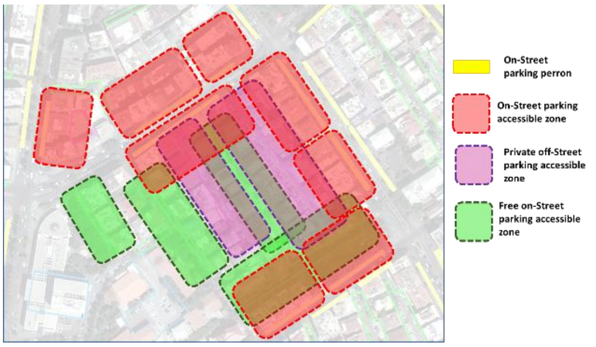


Fig.21; On-street parking and other type of parking accessible zone overlapping

The general description of the on-street parking demand model;

<u>n1; a homogeneous land use,</u>

Bl-n1; (n1) building area is cowered in Zp-on, (m2)
Zp-on; On-street parking accessible zone area, (m2)
Zp-lot; Parking lot (off-Street) parking accessible zone area, (m2)
Zp-free; Free parking accessible zone area, (m2)

P-lot; Parking lot parking spaces in (Zp-on),
P-on; On-street parking spaces in (Zp-on)
P-free; Free parking spaces in (Zp-on),
P-exist; Existing parking spaces in (Zp-on),
t (n1); constant, for per parking space, required n1 land use building area, (m2)
Pd-(n1); Parking demand for land use (n1) in Zp-on,
Pd-on (n1); Parking demand for on-street parking for land use (n1) in Zp-on,

P-exist(n1) = (P-lot) + (P-free) , (1)
Pd-(n1) = Bl-n1 x t (n1), (2)
Pd-on (n1) = Pd-(n1) – P-exist, (3)

<u>n1+n2 is a mixed land use and</u>

Pd (n1+n2); On-street parking demand for (n1+n2) mixed land use,
t (n1); constant, for per parking space, required (n1) land use building area, (m2)
t (n2); constant, for per parking space, required (n2) land use building area, (m2),
Pd-(n1+n2); Parking demand for land use (n1+n2) in Zp-on,
Pd-on (n1+n2); Parking demand for on-street parking for land use (n1+n2) in Zp-on,
Pd-on (n1+n2); On-street parking spaces in (Zp-on)

Pd-(n1+n2)= Bl-(n1) x t(n1)+Bl-(n2) x t(n2) , (4)

P-on2 = Pd-(n1+n2)- P-exist, (5)

<u>n1+n2+n3 is a mixed land use</u>

t (n1); constant, for per parking space, required (n1) land use building area,
t (n2); constant, for per parking space, required (n2) land use building area,
t (n3); constant, for per parking space, required (n3) land use building area,
Pd-(n1+n2+n3); On-street parking demand for (n1+n2+n3) mixed land use,
Pd-on(n1+n2+n3); On-street parking spaces in (Zp-on)
Pd-(n1+n2+n3)= Bl-(n1) x t(n1)+Bl-(n2) x t(n2)+ Bl-(n3) x t(n3)–P-exist, (6)
Pd-on(n1+n2+n3)=Pd-(n1+n2+n3)–P-exist, (7)

The adaptation the on-street parking demand model by Multiple Regression analyses;
Retail land use building area and the existing parking spaces in the on-street parking accessible zone are independent variable and the on-street parking demand is dependent variables were adapted by multiple regression, as the result; Correlation Parking on-Street and Retail Land use building area; positive, 0.354, the correlation is significant (0,12). Correlation Parking on-Street and Parking existing space; negative -0.173, the correlation is significant. (0,14) Table 2

Table 2 Coefficient retail land use and existing parking for on-street parking demand

Coefficients[a]

Model				Standardized Coefficients	t	Sig.	Collinearity Statistics	
				Beta			Tolerance	VIF
1	(Constant)	61.756	7.965		7.754	0.000		
	Bl_retail	0.020	0.004	0.766	4.678	0.000	0.604	1.655
	Pr_existing_parking	-1.067	0.267	-0.655	-3.999	0.000	0.604	1.655

a. Dependent Variable: Pr_On_street_parking

Residence land use building area and the existing parking spaces in the on-street parking accessible zone are independent variable and the on-street parking demand is dependent variable were adapted by multiple regression, as the result; correlation parking on-street and residence land use building area; positive, 0.646, the correlation is significant (0,59). Fig.22 Correlation parking on-street and parking existing space; negative -0.269, the correlation is significant (0,233). Table 3

On-street parking space retail = 61,756 + (0.20 x retail building area)

Table 3 Coefficient residence land use and existing parking for on-street parking demand

Coefficients[a]

Model				Standardized Coefficients	t	Sig.	Collinearity Statistics	
				Beta			Tolerance	VIF
1	(Constant)	52.391	31.858		1.645	0.175		
	Bl_residen	0.011	0.007	0.599	1.548	0.196	0.928	1.078
	Pr_existing_parking	-0.464	1.043	-0.172	-0.445	0.680	0.928	1.078

a. Dependent Variable: Pr_On_street_parking

As a adapting the model result shows that there is highest positive correlation between land use (retail and residence) and there is negative correlation between existing parking.Fig.22
On-street parking space for resident = 52,391 + (0.11 x residence bulding area)

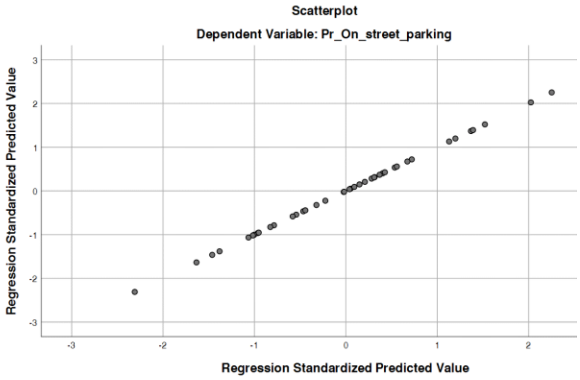


Fig.22; On-street parking demand land use correlation

5. Conclusion

As the target of this study is identified the correlation on-street parking demand depend on land use characteristic. At the result of the on-street parking demand and relation with land use characteristic analyses defined some out comes;
-The land use characteristic elements such as the building size and the user size are the highest factor which effect the on-street parking demand with existing parking space and parking location accessibility factors.
-On-street parking accessibility distance is various for each parking locations. However, it is defined that 30-50-meter distance is the highest preferable for on-street parking where located in the core of downtown,
-Each different land use has own effect on on-street parking demand and it is possible to evaluate the real demand by providing a model. The model can be used by local authority in order to implement for business district -downtown,
-On-street demand model can be used in order to set up general parking demand management and parking pricing optimization model.

-This model can be used to better forecast future on-street parking demand and changing pricing in the business center district depend on changes in land use characteristic at predicting the parking supply side.

References

[1] Badoe, D. and E. Miller. 2000. Transportation—land use interaction: Empirical findings in North America, and their implications for modeling. Transportation Research Part D: Transport and Environment, 5(4):235–263. doi: 10.1016/S1361 -9209(99)00036-X.

[2] Crane, R. and R. Crepeau. 1998. Does neighborhood design influence travel behavior? a behavioral analysis of travel diary and GIS data. Technical Report UCI-ITS-AS-WP- 98-4, University of California, Irvine: Center for Activity Systems Analysis.

[3] Hensher, D. A. and J. King. 2001. Parking demand and responsiveness to supply, pricing and location in the Sydney central business district. Transportation Research Part A: Policy and Practice, 35(3):177–196. doi: 10.1016/ S0965- 8564(99)00054-3.

[4] Zhao, T. and Tseng, C.-L. 2003. Valuing flexibility in infrastructure expansion. Journal of infrastructure systems, 9, 89-97.

[5] The on-street parking premium and car drivers' choice between street and garage parking, Kobus M., Puigarnau E. and others, 2012).

[6] Kobus M., Puigarnau E. and others, 2012. The on-street parking premium and car drivers' choice between street and garage parking.

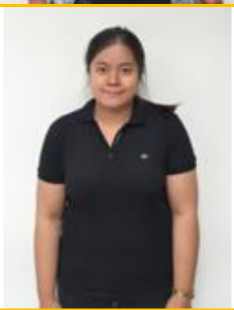
[7] (Ajeng C., Tommy Gim T., 2018) Analyzing on-Street Parking Duration and Demand in a Metropolitan City of a Developing Country: A Case Study of Yogyakarta City, Indonesia

LIST OF ATRANS YOUNG RESEARCHER'S FORUM COMMITTEE AND CONTACT ADDRESS

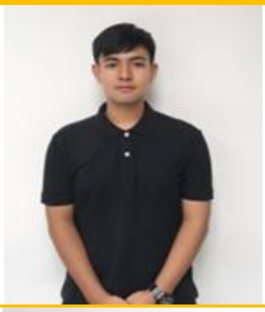
List of ATRANS Young Researcher's Forum Committee 2018

Young Researcher's Forum Committee	ATRANS Affiliation	University/Institute/Advisor
	Ms. Suchada Pongsawat (President of ATRANS Young Researcher's Forum Committee 2018)	Burapha University Call: 086 019 9305 E-mail: Mararai.suchad@gamil.com Advisor: Pol. Lt. Col. Waiphot Kulachai
	Mr. Bethala Aditya (Vice-President of Scientific Committee 2018)	Asian institute of Technology Call: 064 347 5149 E-mail: Bethala.aditya@gmail.com Advisor: Dr. Surachet Pravinvongvut
	Mr. Pattarapon Pupetch (Vice-President of Organizing Committee 2018)	Chiang Mai University Call: 091 738 9614 E-mail: Zomar04@gmail.com Advisor: Asst.Prof.Dr. Preda Pichayapan
	Ms. Bolla Vidya Sundari (Secretariat of ATRANS Young Researcher's Forum Committee 2018)	Asian institute of Technology Call: 061 707 9705 E-mail: vidyachowdaeybolla@gmail.com Advisor: Dr. Surachet Pravinvongvut
	Ms. Kanjana Saengkham (Secretariat of ATRANS Young Researcher's Forum Committee 2018)	Rangsit University Call: 095 171 1147 E-mail: Kanjan.s60@esu.ac.th Advisor: Dr. Tuenjai Fukuda

List of ATRANS Young Researcher's Forum Committee 2018

Young Researcher's Forum Committee	ATRANS Affiliation	University/Institute/Advisor
	Ms. Yatawee Kit-ek (Paper Coordinator of ATRANS Young Researcher's Forum Committee 2018)	Prince of Songkla University Call: 099 486 0787 E-mail: Yatawee3@gmail.com Advisor: Dr. Paramet Luathep
	Ms. Supawan Nuallaong (Paper Coordinator of ATRANS Young Researcher's Forum Committee 2018)	Prince of Songkla University Call: 083 692 3995 E-mail: Supawun.n343@gmail.com Advisor: Dr. Paramet Luathep
	Mr. Kanin Wongyai (Paper Coordinator of ATRANS Young Researcher's Forum Committee 2018)	Burapha University Call: E-mail: kaninwongyai@hotmail.com Advisor: Pol. Lt. Col. Waiphot Kulachai
	Ms. Wanattra Sawangjai (Paper Coordinator of ATRANS Young Researcher's Forum Committee 2018)	Chiang Mai University Call: 095 678 2963 E-mail: U_wanat@hotmail.com Advisor: Asst.Prof.Dr. Preda Pichayapan
	Mr. Navapon Pongpool (Graphic Designer of ATRANS Young Researcher's Forum Committee 2018)	Chiang Mai University Call: 090 321 0449 E-mail: Navaponpongpool@hotmail.com Advisor: Asst.Prof.Dr. Preda Pichayapan

List of ATRANS Young Researcher's Forum Committee 2018

Young Researcher's Forum Committee	ATRANS Affiliation	University/Institute/Advisor
	Mr. Arif Siriwat (Graphic Designer of ATRANS Young Researcher's Forum Committee 2018)	Prince of Songkla University Call: 090 220 1969 E-mail: arifsiriwat@gmail.com Advisor: Dr. Paramet Luathep
	Mr. Nattawat Panyasai (Graphic Designer of ATRANS Young Researcher's Forum Committee 2018)	Khon Kaen University Call: 091 861 6577 E-mail: n-o44@hotmail.com Advisor: Assoc. Prof. Dr. Chulaporn Sota
	Mr. Pasit Wonghabut (Registrar of ATRANS Young Researcher's Forum Committee 2018)	Khon Kaen University Call: 082 115 2585 E-mail: Pasit_w@kkumail.com Pratan_tor@hotmail.com Advisor: Prof. Dr. Chulaporn Sota
	Ms. Nuttha Chumnanya (Registrar of ATRANS Young Researcher's Forum Committee 2018)	Khon Kaen University Call: 097 335 6767 E-mail: Donut_nuttha@hotmail.com Advisor: Dr. Thaned Satiennam
	Ms. Supphakan Sridan (Registrar of ATRANS Young Researcher's Forum Committee 2018)	King Mongkut's University of Thechnology Thonburi Call: 083 060 3929 E-mail: maprangsridan@gmail.com Advisor: Assoc.Prof.Dr.Viroat Srisurapanon

List of ATRANS Young Researcher's Forum Committee 2018

Young Researcher's Forum Committee	ATRANS Affiliation	University/Institute/Advisor
	Mr. Thanapat Poolsawat (Registrar of ATRANS Young Researcher's Forum Committee 2018)	Burapha University Call: 083 060 3929 E-mail: Tnp.tong@gmail.com Advisor: Pol. Lt. Col. Waiphot Kulachai
	Mr. Nopphon Settisakgo (Registrar of ATRANS Young Researcher's Forum Committee 2018)	Burapha University Call: 098 828 0080 E-mail Tnp.tong@gmail.com: Advisor: Pol. Lt. Col. Waiphot Kulachai
	Mr. Pola Rahul (Paper Coordinator of ATRANS Young Researcher's Forum Committee 2018)	Asian institute of Technology Call: 083 246 3696 E-mail: Polarahul194@gmail.com Advisor: Dr. Surachet Pravinvongvut

List of ATRANS Young Researcher's Forum Committee 2018

Young Researcher's Forum Committee	ATRANS Affiliation	University/Institute/Advisor
	Mr. Songkiet Duangsadee (Mentor of ATRANS Young Researcher's Forum Committee 2018)	Khon Kaen University Call: 091 882 8515 E-mail: Duangsadee@gmail.com Advisor: Prof. Dr. Chulaporn Sota
	Mr. Naruphol Niyom (Mentor of ATRANS Young Researcher's Forum Committee 2018)	Prince of Songkla University Call: 097 361 9389 E-mail: naruphol@outlook.com Advisor: Dr. Paramet Luathep
	Mr. Jetsada Kumphong (Mentor of ATRANS Young Researcher's Forum Committee 2018)	Khon Kaen University Call: 087 233 3142 E-mail: Jetsada.kumphong@gmail.com Advisor: Dr. Thaned Satiennam

STATE RAILWAY OF THAILAND

Organized by:
Asian Transportation Research Society (ATRANS)
902/1, 9th Floor, Soi Sukhumvit 25 (Daeng Prasert),
klongtoey-nua, Wattana, Bangkok 10110, Thailand
Tel. +66 (0)2 661 6248, Fax. +66 (0)2 661 6249
www.atransociety.com