PROCEEDINGS OF

14th ATRANS ANNUAL CONFERENCE

TRANSPORTATION FOR A BETTER LIFE:
"FUTURE POTENTIAL OF TRANSPORTATION
AND URBAN MODEL POST COVID ERA"

ATRANS YOUNG RESEARCHERS' FORUM 2021

SPECIAL SESSION

17 DECEMBER 2021
MILLENNIUM HILTON HOTEL, BANGKOK, THAILAND,

ORGANIZED BY ASIANTRANSPORTATION RESEARCH SOCIETY (ATRANS) AND INTERNATIONAL ASSOCIATION OF TRAFFIC AND SAFETY SCIENCES (IATSS)

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

Dear ATRANS Young Researcher's Forum 2021 Special Session Participants,

It is a pleasure to welcome you to the 14th ATRANS Annual Conference: Young Researcher's Forum 2021 Special Session.

In this fourteenth year, ATRANS organized 2 days event in which AYRF 2021, a special session of paper presentation took place on 17 December and the annual conference, our main event took place on 18 December 2021. We received 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 during these 2 days virtual meeting event.

Every aspect of our lives has been affected by the pandemic of COVID-19. And it has been two years since the pandemic, large parts of the world are emerging from lockdown and slowly restarting the economy. It is obvious that things are far from being back to normal. The experience of lockdown has brought the limitations to urban mobility which has underlined a new important aspect of the issue of proximity applied to urban everyday life. These are among other reasons why this year conference's theme is upon "Transportation for a Better Life: Future Potential of Transportation and Urban Model Post Covid Era."

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 2021 Special Session 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 2021.

Tuenjai Fukuda, Dr. Eng.

ATRANS Secretary-General, and

Chair of ATRANS Conference & Activity Committee

December 2021

Welcome Message from ATRANS Young Researcher's Forum

Advisory Committee 2019

Dear ATRANS Young Researcher's Forum (AYRF) 2021 Special Session Participants

Asian Transportation Research Society (ATRANS) is a non-profit organization established in 2008. The main purpose of ATRANS is to encourage scholars and researchers on conducting researches associated with traffic safety, energy and environment, and other transportation-related problems. ATRANS also provides grant and funding for its members to conduct the research.

Every year, ATRANS holds international conferences to allow students, researchers, and scholars to present their research findings and exchange research knowledge in relation to transportation, traffic management, and road safety. In 2021, the 14th ATRANS Annual Conference is hosted at the Millennium Hilton Hotel Bangkok during December 17-18, 2021.

This ATRANS Young Researcher's Forum is opened for students to present their paper so they can have a good chance to exchange views and ideas with transportation experts as well as other students from different universities not only from Thailand but also from abroad.

I hope that the conference and AYRF 2021 will be in the best interests of the participants, and hopefully this event will be successful to enhance nationally and internationally network among transportation scholars in the future.

Thank you.

Asst.Prof.Pol.Lt.Col. Waiphot Kulachai, Ph.D.

Vice-Chair of ATRANS Conference & Activity Committee

Suan Sunandha Rajabhat University

December 2021

List of ATRANS Young Researcher's Forum 2021 Organizing and Scientific Committee

AYRF Organizing and Scientific Committee		
1	Ms. Kanjana Saengkham	Rangsit University
2	Ms. Sutthikarn Weluwanarak	Burapha University
3	Ms. Boonyaporn Thuraphan	Kasetsart University

List of Mentors of ATRANS Young Researcher's Forum 2021 Committee

AYRF 2021 Mentors		
4	Mr. Naruphol Niyom (AYRF Alumni and Mentor of ATRANS Young Researcher's Forum Committee 2017-2021)	PlanPro Corp., Ltd., (Transportation Consultant)
5	Ms. Suwishada Fukuda	ATRANS Secretariat officer for In-House Management
6	Ms. Narisara Pongpakdeeboribhan	ATRANS Secretariat officer for Academic Affairs

List of Advisory Committee of ATRANS Young Researcher's Forum 2021 Committee

International Advisory Committee		
1	Dr. Tuenjai Fukuda	Nihon University, Japan
Local Advisory committee		
2	Asst.Prof. Pol.Lt.Col.Dr. Waiphot Kulachai	Suan Sunandha Rajabhat University
3	Asst.Prof.Dr. Sittha Jaensirisak	Ubonratchathani University
4	Asst.Prof.Dr.Paramet Luathep	Prince of Songkla University

List of the Paper Reviewers of ATRANS Young Researcher's Forum 2021

NO.	Name	Organization
1	Prof. Dr. Atsushi Fukuda	Nihon University, Japan
2	Assoc. Prof. Dr. Sorawit Narupiti	Chulalongkorn University, Thailand
3	Assoc. Prof. Dr. Varameth Vichiensan	Kasetsart University, Thailand
4	Assoc. Prof. Dr. Pawinee Iamtrakul	Thammasat University, Thailand
5	Assoc. Prof. Dr. Viroat Srisurapanon	King Mongkut's University of Technology Thonburi
6	Assoc. Prof. Dr. Apiwat Ratanawaraha	Chulalongkorn University, Thailand
7	Asst. Prof. Dr. Sittha Jaensirisak	Ubonratchathani University, Thailand
8	Asst. Prof. Dr. Waiphot Kulachai	Suan Sunandha Rajabhat University
8	Asst. Prof. Dr. Paramet Luathep	Prince of Songkla University
9	Asst. Prof.Dr. Saroch Boonsiripant	Kasetsart University
10	Asst. Prof. Dr. PhongPhan Tankasem	Mahasarakham University
11	Dr. Passakon Prathombutr	Digital Economy Promotion Agency (DEPA)
12	Dr. Tuenjai Fukuda	Nihon University, Japan
13	Dr. Nuwong Chollacoop	National Metal and Materials Technology (MTEC)
14	Dr. Pattarathep Sillapacharn	Department of Highways, Thailand
15	Dr. Bhanitiz Aursudkij	Department of Highways, Thailand

AYRF 2021 Special Session of Research Paper Presentation

Live stream

สมาคมวิจัยวิทยาการขนส่งแห่งเอเชีย
Asian Transportation Research Society

SCAN ME
For registration

Page | 1

14TH ATRANS ANNUAL CONFERENCE

TRANSPORTATION FOR A BETTER LIFE: "FUTURE POTENTIAL OF TRANSPORTATION AND URBAN MODEL POST COVID ERA"

ATRANS YOUNG RESEARCHER'S FORUM 2021 SPECIAL SESSION

Friday, 17 December 2021 during 10:00 – 12:05 Facebook Live broadcast from Meeting Room: Ballroom A: Level 2, Millennium Hilton Hotel Bangkok

zoom The presenters will make presentation via Zoom Meeting only.

Please follow the link below to join our special session.
https://us02web.zoom.us/j/82049390859?pwd=TXE4ejBoM3F1YnlxY0t2T0ljVHAwZz09

Special Session for ATRANS Young Researcher's Forum 2021 Paper Presentations

10:00 – 11:00 Session 1, Chaired by Assoc.Prof.Dr. Varameth Vichiensan, Kasetsart University

10:00 -10:09 Presenter 1 001-2021 "An evaluation of accuracy autonomous driving in parking application by using Jetbot comparing ResNet-18 and AlexNet model" Presents by Mr.Nutchanan PETCHARAT Suranaree University of Technology, Thailand 10:09 – 10:12 Q&A	10:12 – 10:21 Presenter 2 002-2021 "Bangkok's Crazy Footpath: Demands from Young Generation" Presents by Ms.Sansanee MUAKSANG Rajabhat Suan Sunandha University, Thailand 10:21 – 10:24 Q&A	10:24 – 10:33 Presenter 3 003-2021 "Factors Affecting the Intention to Use MRT" Presents by Ms.Thaneeda HOMNGARM Rajabhat Suan Sunandha University, Thailand 10:33 – 10:36 Q&A	10:36 – 10:45 Presenter 4 004-2021 "Evaluating Impacts of Teleworking Policy in Jakarta Metropolitan Area by The Analysis of Activity Pattern" Presents by Mr.Rizky WAHYULINATA Nihon University, Japan 10:45 – 10:48 Q&A	10:48 – 10:57 Presenter 5 005-2021 "Dynamic Simulation Analysis of Impact on Teleworking Policy for After COVID-19 Using Land-Use and Transport Model: Case Study of Japanese City within Population Decline" Presents by Dr.Hiroki KIKUCHI Nihon University, Japan 10:57 – 11:00 Q&A

11:05 – 12:05 Session 2, Chaired by Asst.Prof.Pol.Lt.Col.Dr. Waiphot Kulachai, Rajabhat Suan Sunandha University

11:05 – 11:14 Presenter 1 006-2021 "Study on Improvement of Star Rating Approach to Extract Traffic Hazardous Location in Nakhon Ratchasima Province, Thailand" Presents by Mr.Takeru MIYOKAWA Nihon University, Japan 11:14 – 11:17 Q&A	11:17 – 11:26 Presenter 2 007-2021 "The impact of COVID-19 on the travel behavior of carsharing users in Bangkok" Presents by Ms.Monthira PHAMORNMONGKHONCHAI Kasetsart University, Thailand 11:26 – 11:29 Q&A	11:29 – 11:38 Presenter 3 008-2021 "Supply Analysis of an Access Mode for Local Travel: The Case of Tricycles in the Philippines" Presents by Prof.Dr.Alexis M. Fillone De la Salle University, The Philippines 11:38 – 11:41 Q&A	11:41 – 11:50 Presenter 4 009-2021 "Attitudes and traveling behavior of the people living along the Mass Rapid Transit (MRT) station" Presents by Ms.Saratsawadee Rotjanagusol Thailand cycling and walking institute foundation 11:50 – 11:53 Q&A	11:53 – 12:02 Presenter 5 010-2021 "The Strengths and Weaknesses of NGOs' Roles in Promoting SDGs for Road Safety and Sustainable Transport Systems: A case of Bangkok" Presents by Ms.Nontanee Wiboonkul Thailand cycling and walking institute foundation 12:02 – 12:05 Q&A

Remarks: Please be noted that Special Session for AYRF 2021 Paper Presentations will be conducted in English language only. Each presenter will have 9 minutes for presentation and 3 minutes for questions and answers.

SESSION 1: AYRF 2021 SPECIAL SESSION OF RESEARCH PAPER PRESENTATION
From Paper ID: 001-2021 To Paper ID: 004-2021

An Evaluation of Accuracy in Autonomous Parking Application by Using Jetbot Comparing ResNet-18 and AlexNet Model

Paper Identification number: AYRF-001

Nutchanan PETCHARAT[1],Chalinda LAWONGKERD[1], Romteera PUKAEW[1], Thapanee SAENGTHONGS[1], Atthaphon ARIYARIT[1] Rattanaporn KASEMSRI[2], Narucha TANAIUTCHAWOOT[3], Wannida SAE-TANG[4]

[1]School of Mechanical Engineering, Institute of Engineering
Suranaree University of Technology
Telephone 0-4422-3561, Fax. 0-4422-4613
E-mail: ariyarit@sut.ac.th

[2] School of Civil Engineering, Institute of Engineering
Suranaree University of Technology
Telephone 0-4422-3561, Fax. 044-224613
E-mail: Kasemsri@sut.ac.th

[3] School of Industrial Engineering, Institute of Engineering
Suranaree University of Technology
E-mail: narucha@sut.ac.th

[4] The Sirindhorn International Thai-German Graduate School of Engineering,
King Mongkut's University of Technology North Bangkok, Bangkok, Thailand
E-mail: wannida.s@tggs.kmutnb.ac.th

Abstract

The purposes of this study are to examine and train autonomous vehicle control systems to park in the parking lot. The basis for the development of autonomous vehicle control systems uses the method of investigating the autonomous vehicle control systems tested by AI, Racing Robot Powered by Jetson Nano. The scope of the study is autonomous vehicle control using one front camera for entering the parking lot in the form of angle parking and perpendicular parking. Tested by applying the knowledge of the collision avoidance function which collects data that can be used to control the Jetbot car to park. There are two parking types in the experiment design. Firstly, the angle parking determines that the green sign is to turn right and the blue sign is to turn left. Secondly, the perpendicular parking determines that the green sign is to turn left and the blue sign is to turn right. Pre-trained models from ResNet-18 and AlexNet are used to evaluate the accuracy, in which the test was collected for 1 parking pattern per 100 tests. The results are first, the angle parking using ResNet-18 model had an accuracy of 99%. Second, the angle parking using the AlexNet model had an accuracy of 96%. Third, the perpendicular parking using the ResNet-18 model had an accuracy of 93%, and finally, the perpendicular parking using the AlexNet model had an accuracy of 76%. The findings indicated that the ResNet-18 model is more accurate than the AlexNet model in both angle parking and perpendicular parking. In terms of safety, the test was carried out using a Pre-trained model from ResNet-18, which collected data by simulating 3 obstacles such as trees, cars, and humans, setting the Jetbot to stop when encountering an obstacle and the accuracy was 82%.

Keywords: *Collision avoidance, Perpendicular parking, Angle parking, Autonomous vehicle*

1. Introduction

The advancement of the technology of artificial intelligence or Artificial Intelligence (AI) has made today's human life more convenient. There are technologies that help humans to be healthier. and are safe in life, especially technology. The developers of self-driving cars believe that its greatest benefit is to reduce road accidents. which is often caused by humans.

In the case of car parking, the autonomous parking system also plays an important role for providing convenience and also safety for the drivers.

This research is aimed for learning and development of autonomous car parking system by using Jetbot which is the car robot powered by Jetson nano and applying basic function from Robot Operating System Framework (ROS framework) using technique of transfer learning for design car parking system in two patterns of parking (Angle and Perpendicular parking) with the basic knowledge of Real time object detection

2. Literature review

2.1 Real time Object detection

Real time object detection is a computer vision technique that help users to detect, locate, and trace the object from a trained image or video in real time. It can also be trained to identify the class of objects (car, obstacle, tree, etc.). It can be trained to remember or identify the object by drawing the boundary box around the coordinate of the object through the supported tool or software.

In autonomous parking design, Real time object detection is important to identify the sign or a line for training the control of a demonstrated car for parking and also to identify an obstacle in case of providing safety for human or public property.

There is a research of real time object detection applied on vehicles since 1999, [1] has presented experimental results on the real-time detection of traffic signs and pedestrians from a moving vehicle.

2.2 Jetbot by Jetson nano

Jetbot is the actual smart robot powered by Jetson Nano. In this research the robot kit using Jetson nano with 4 cores of CPU, 128 cores of GPU and 4 GB of RAM is used. The robot also consisted of one front camera and basic components of a car.

The article [2] has explained the Robot Operating System framework (ROS framework) that it is a flexible framework for writing robot software. ROS framework contains the tools, code and the libraries which provides the simple way to learn the operation of the robot.

Jetbot is very useful for basic artificial intelligent learning with its front camera and supported ROS framework, it is ready for learning many of intelligent function e.g. Basic motion of the robot, Road following, Collision avoidance etc.

The Figure 1 example of auto collision avoidance function is shown.

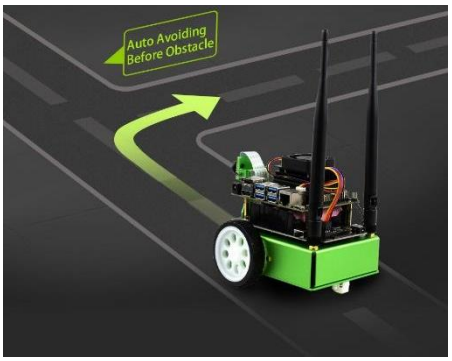


Figure 1 Example auto collision avoidance [3]

Jetbot was used for many of application, in [4] Jetbot was used for delivering Items at agricultural workplace by applied the Object-Finding and avoidance functions

2.3 Transfer learning and Pre-trained model

Transfer learning is the technique which reduces the training time of deep learning models by reusing some of the already trained models. with similar jobs to be used as part of the new model. The models that are already trained are called Pre-trained model.

In this research, there are two pre-trained models are used as follows

2.3.1 ResNet-18 model

ResNet (Deep Residual Network) is one of the architectures from ResNet that was used as a pre-trained model and There are multiple versions of ResNet where '18' denotes the number of layers. The Convolutional Neural Network (CNN) started to get deeper, since ResNet has presented the solution for the vanishing gradient problem by putting Shortcut in the network. The

Structural details of ResNet 18 are shown in figure.2

ResNet has presented comprehensive experiments in [5] and show that deep residual nets has ability to keep accuracy gains from greatly increased depth of network.

ResNet18 - Structural Details

#	Input Image			output			Layer	Stride	Pad	Kernel		in	out	Param
1	227	227	3	112	112	64	conv1	2	1	7	7	3	64	9472
	112	112	64	56	56	64	maxpool	2	0.5	3	3	64	64	0
2	56	56	64	56	56	64	conv2-1	1	1	3	3	64	64	36928
3	56	56	64	56	56	64	conv2-2	1	1	3	3	64	64	36928
4	56	56	64	56	56	64	conv2-3	1	1	3	3	64	64	36928
5	56	56	64	56	56	64	conv2-4	1	1	3	3	64	64	36928
6	56	56	64	28	28	128	conv3-1	2	0.5	3	3	64	128	73856
7	28	28	128	28	28	128	conv3-2	1	1	3	3	128	128	147584
8	28	28	128	28	28	128	conv3-3	1	1	3	3	128	128	147584
9	28	28	128	28	28	128	conv3-4	1	1	3	3	128	128	147584
10	28	28	128	14	14	256	conv4-1	2	0.5	3	3	128	256	295168
11	14	14	256	14	14	256	conv4-2	1	1	3	3	256	256	590080
12	14	14	256	14	14	256	conv4-3	1	1	3	3	256	256	590080
13	14	14	256	14	14	256	conv4-4	1	1	3	3	256	256	590080
14	14	14	256	7	7	512	conv5-1	2	0.5	3	3	256	512	1180160
15	7	7	512	7	7	512	conv5-2	1	1	3	3	512	512	2359808
16	7	7	512	7	7	512	conv5-3	1	1	3	3	512	512	2359808
17	7	7	512	7	7	512	conv5-4	1	1	3	3	512	512	2359808
	7	7	512	1	1	512	avg pool	7	0	7	7	512	512	0
18	1	1	512	1	1	1000	fc					512	1000	513000
Total														11,511,784

Figure 2 Structural details of ResNet-18 [6]

2.3.2 AlexNet model

AlexNet is the convolutional neural network architecture that was designed by Alex Krizhevsky. This architecture contains 8 layers with 5 convolutional layers that the first, the second and the fifth layer are followed by max pooling layers and the last 3 layers are fully connected layers as shown in the structural details of AlexNet model in the figure 3.

AlexNet is the first model which used max pooling layers [7] in 2012 instead of average pooling layer that was used in LeNet.

AlexNet Network - Structural Details

Input			Output			Layer	Stride	Pad	Kernel size		in	out	# of Parar
227	227	3	55	55	96	conv1	4	0	11	11	3	96	34944
55	55	96	27	27	96	maxpool1	2	0	3	3	96	96	0
27	27	96	27	27	256	conv2	1	2	5	5	96	256	614656
27	27	256	13	13	256	maxpool2	2	0	3	3	256	256	0
13	13	256	13	13	384	conv3	1	1	3	3	256	384	885120
13	13	384	13	13	384	conv4	1	1	3	3	384	384	1327488
13	13	384	13	13	256	conv5	1	1	3	3	384	256	884992
13	13	256	6	6	256	maxpool5	2	0	3	3	256	256	0
						fc6			1	1	9216	4096	37752832
						fc7			1	1	4096	4096	16781312
						fc8			1	1	4096	1000	4097000
Total													62,378,34

Figure 3 Structural details of AlexNet [6]

3. Design Method

The design method of this research is shown in figure 4.

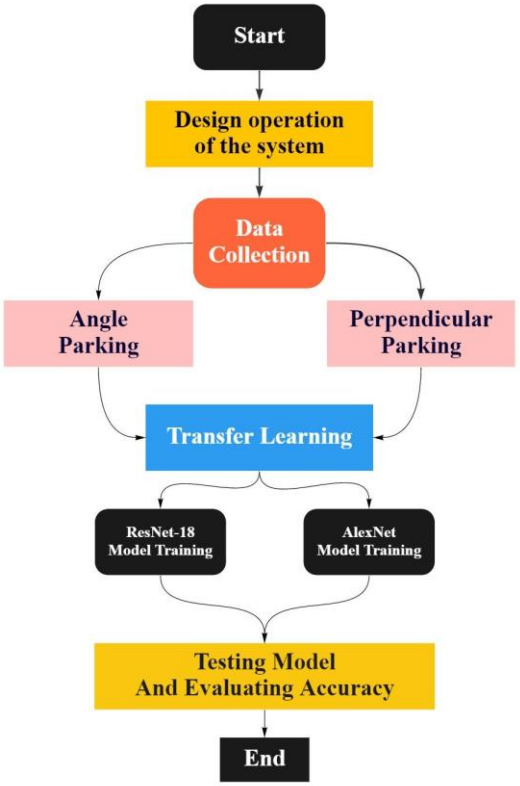


Figure4 The Flow Chart of Design method

3.1 Design the operation of the system

The collision avoidance function is the basic function of the Jetbot that can train the Jetbot to avoid obstacles or run in the boundary space. The collision avoidance function was trained in this research as shown in figure 5.

The road following function is the function that can train the Jetbot to stay in the middle of the road by training it to detect the line in the middle of the road. The road following function was trained in this research as shown in figure 6.

The model is trained to give jetbot commands for using collision avoidance and road following function in order to consider for the design of the system operation.

Pursuant to the most appropriate function for demonstrating the car parking behavior, Jetbot car control system is designed to enter the parking lot in the pattern of Angle parking and Perpendicular parking by applying the knowledge of the collision avoidance function.

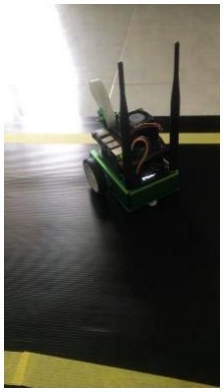


Figure5 collision avoidance function test

Figure6 Road following function test

3.2 Data collection

Data is collected to control the Jetbot car to park. In order to do the angle parking, the system is designed by setting when Jetbot encounters the green sign for turning right and the blue sign for turning left. In order to do the perpendicular parking , the system is designed by setting when Jetbot encounters the green sign for turning left and the blue sign for turning right as shown in figure 7. However, the safety system is designed by commanding Jetbot to stop when it encounters the three given examples of obstacles (trees, cars, humans).

In both angle parking and perpendicular parking, the 700 images of the signs are used by taking 200 images in order to train to let the Jetbot go forward when it is too far away from the parking lot and taking 500 images of the sign in appropriate distance in order to train the Jetbot to do the method of angle parking or perpendicular parking.

In the safety test, the 675 images of obstacles which assumed that could incurs the accident are used. In figure 8, the car which assumed to be the obstacle was in the appropriate distance to stop the Jetbot are shown.

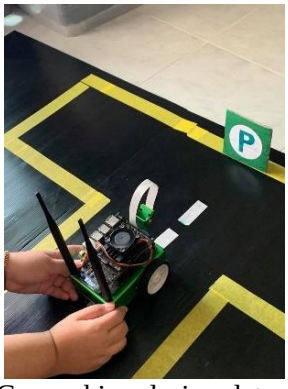


Figure7 Car parking design data collecting

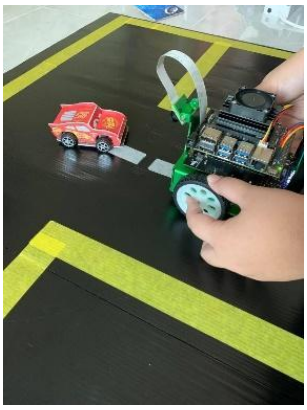


Figure8 Safety test data collecting

3.3 Parking and Safety test

Parking system is tested by letting the Jetbot run on the designed road until it encounters the parking sign at an appropriate distance that the Jetbot has to do the parking method by turning itself in the designated direction then moving forward and stopping itself. When Jetbot is in the angle parking test it has to turn itself 45° degrees to stop properly in the parking lot as shown in figure 9. and when Jetbot is in the perpendicular parking test it has to turn itself 90° degrees to stop properly in the parking lot as shown in figure 10.

Safety system is tested by letting the Jetbot run on the designed road until it encounters the obstacles then the Jetbot has to stop itself suddenly in the appropriate distance as shown in figure 11.

The function of the system is tested to control the Jetbot to enter the parking lot in the form of Angle parking and Perpendicular parking by using a pre-trained model from ResNet-18 and AlexNet to test and to evaluate the accuracy. And in terms of safety, it was performed by using only ResNet-18 pre-trained model.

Figure 9 Jetbot after finished the Angle parking

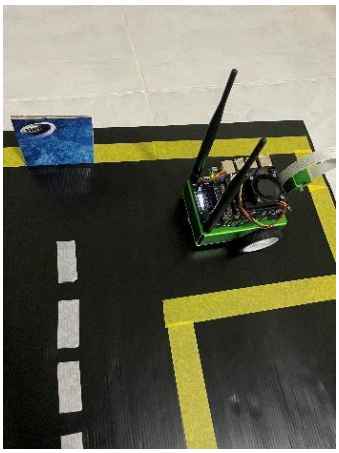


Figure 10 Jetbot after finished the Perpendicular parking

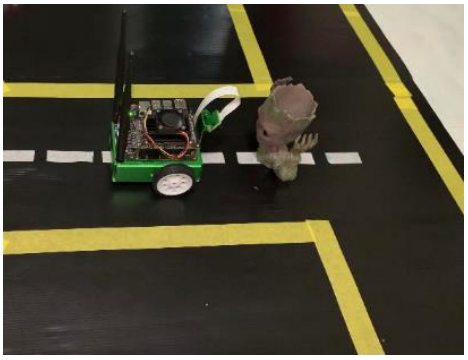


Figure 11 Jetbot when it found the obstacle

3.4 Accuracy evaluation

Angle parking and perpendicular parking are tested by using the ResNet-18 model and the AlexNet model, which collected 1 parking pattern per 100 tests, divided into 4 test models.

1. Angle parking with Resnet-18 model
2. Angle parking with Alexnet model
3. Perpendicular parking with Resnet-18 model
4. Perpendicular parking with Alexnet model

In the parking system testing, the output view of the Jetbot is shown in figure 14. If the Jetbot parks itself properly in the parking lot when there is no wheel which steps on the yellow line and Jetbot is in the designated direction as shown in figure 12, it is recorded that the Jetbot has the enough accuracy of the parking system in that parking system test. but if the wheel of Jetbot steps on the yellow line as example in figure 13 or turn itself in the wrong direction, it will be considered that the Jetbot is not accurate in that parking system test.

Figure 12 Jetbot when it is perfectly parked

Figure 13 Jetbot when it is not perfectly parked

For the safety testing, the data is collected from the Jetbot car, it was trained to stop when it encounters the obstacles. And test the accuracy for 100 times using only the ResNet-18 model.

If the Jetbot is perfectly stopped when encounters the obstacle as shown in figure 15, it is recorded that the Jetbot is accurate in that safety test, but if the Jetbot cannot perfectly stops itself in the appropriate distance as shown in figure 16, it is recorded that the Jetbot is not accurate in that safety test.

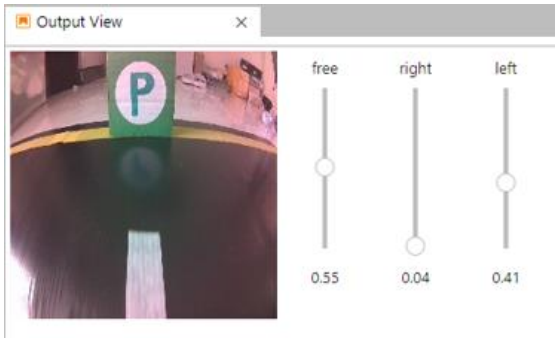


Figure 14 The View from Jetbot's camera when it perfectly parked

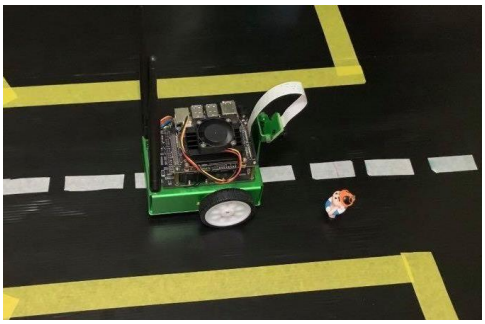


Figure 15 Jetbot that had perfectly stop when encounter the obstacle

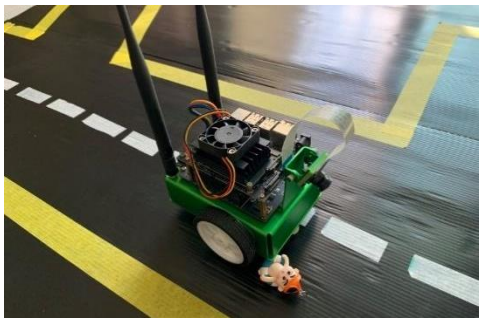


Figure 16 Jetbot that had not the perfectly stop when encounter the obstacle

4. Result and suggestion

Comparing the result from the parking test between the ResNet-18 model and the AlexNet model to control the Jetbot car, enter the parking lot in the pattern of Angle parking and Perpendicular parking and the result obtained from the ResNet-18 model used in the safety test The results are shown in the chart in figure 18.

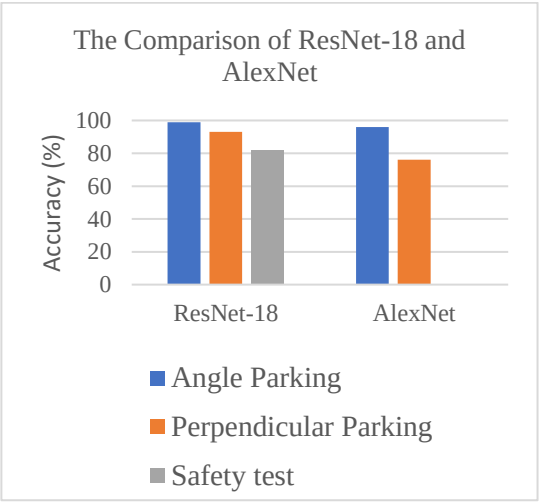


Figure 18 ResNet-18 model vs. AlexNet model and safety testing of Resnet-18 model comparison chart

According to the chart, it concluded that to control the Jetbot car to enter the parking lot in all 4 forms, the two pre-trained models are giving different accuracy as follows

1. Angle parking using the ResNet-18 model has an accuracy of 99%.
2. Angle parking using the AlexNet model has an accuracy of 96%.
3. Perpendicular parking using the ResNet-18 model has an accuracy of 93%.
4. Perpendicular parking using the AlexNet model has an accuracy of 76%.

As for the safety aspect of testing using the ResNet-18 model, the accuracy was 82%.

5. Conclusion

Pursuant to the result of testing the control of self-driving cars by using 1 front camera for entering the parking lot in the pattern of an angle parking and perpendicular parking and was tested by applying knowledge of collision avoidance using a pre-trained model from ResNet-18 and AlexNet in order to evaluate the accuracy. which collecting 1 parking pattern per 100 tests, it can be concluded that the ResNet-18 model is more accurate than the AlexNet model in both Angle parking and Perpendicular parking. And in terms of safety testing, the test was performed using a pre-trained model from ResNet-18 with an accuracy of 82%. The concept of autonomous driving which has been considered by the

proposed method is useful to apply in the actual situation to support human life.

There are some limitations of using Jetbot for parking simulation in this study as following

1.The Jetbot has only one front camera that causes the limitation of parking pattern design and cannot simulate the situation that the drivers need to reverse their vehicle into the parking lot.

2.The battery of the Jetbot that causes the inaccuracy of the test because when Jetbot's battery is low, the output view shows that the camera cannot detect the object in the right time. This problem can be solved by connecting Jetbot directly to power supply devices e.g. the computer notebook.

3.The hardware limitation of Jetbot due to the Jetbot is powered by Jetson nano that the others pre-trained model are too complicated to use in Jetbot and the Jetbot only has the 4 Gigabyte of Random Access Memory (RAM) that causes the transfer learning on the Jetbot takes a very long time but this problem can be solved by do the transfer learning on the other computer instead of the Jetson nano on the Jetbot.

References

[1] Gavrila, D. M., & Philomin, V. (1999, September). Real-time object detection for" smart" vehicles. In Proceedings of the Seventh IEEE International Conference on Computer Vision (Vol. 1, pp. 87-93). IEEE.

[2] E, S. (2021, May 3). Ros: A brief introduction. Medium. Retrieved December 15, 2021, from https://medium.com/dsc-sastra-deemed-to-be-university/ros-a-brief-introduction-17eccbb2043b

[3] Waveshare JetBot AI Kit. (n.d.). Retrieved December 15, 2021, from https://www.sunsky-online.com/th/view/1154312.htm

[4] Kawakura, S., & Shibasaki, R. (2020). Deep Learning-Based Self-Driving Car: JetBot with NVIDIA AI Board to Deliver Items at Agricultural Workplace with Object-Finding and Avoidance Functions. European Journal of Agriculture and Food Sciences, 2(3).

[5] Russakovsky, O., Deng, J., Su, H., Krause, J., Satheesh, S., Ma, S., ... & Fei-Fei, L. (2015). Imagenet large scale visual recognition challenge. *International journal of computer vision*, *115*(3), 211-252

[6] Anwar, A. (2021, April 7). Difference between alexnet, vggnet, ResNet and inception. Medium. Retrieved December 25, 2021, from https://towardsdatascience.com/the-w3h-of-alexnet-vggnet-resnet-and-inception-7baaaecccc96

[7] Krizhevsky, A., Sutskever, I., & Hinton, G. E. (2012). Imagenet classification with deep convolutional neural networks. *Advances in neural information processing systems*, *25*, 1097-1105.

Bangkok's Crazy Footpath: Demands from Young Generation

Paper Identification number: AYRF-002

Sansanee MUAKSANG[1], Thaneeda HOMNGARM[2], Waiphot KULACHAI[3], KeratiwanKALAYANAMITRA[4]

[1]College of Politics and GovernmentSuan Sunandha Rajabhat University
Telephone 098 870 6263
E-mail: S63123472061@ssru.ac.th

[2]College of Politics and GovernmentSuan Sunandha Rajabhat University
Telephone 089 207 8038
E-mail: thang.thaneeda@gmail.com

[3]College of Politics and GovernmentSuan Sunandha Rajabhat University
Mobile: 081 939 1094
E-mail: waiphot.ku@ssru.ac.th

[4]College of Politics and GovernmentSuan Sunandha Rajabhat University
Mobile: 087 559 3351
E-mail: Keratiwan.ka@ssru.ac.th

Abstract

This research is qualitative research. It intended to study problem, and conditions of the footpath in Bangkok, as well as the impact that happened to pedestrians. It also figured out suggestions and guidelines to fix the problem. Key informants in this study included 17 students from 6 educational institutions: Assumption University of Thailand (ABAC), Chulalongkorn University (CU), King Mongkut's Institute of Technology Ladkrabang (KMITL), Suan Sunandha Rajabhat University, Thammasat University (TU), and Kasetsart University (KU), obtained from snowball sampling. The research tools are semi-structural interviews. The researchers analyzed the data with inductive analytical. The results suggest that the conditionof the footpath in Bangkok is rough, bumpy. There are trees, power poles, billboards, and numerous obstacles.There are also street vending stalls, riding a motorcycle on the sidewalk, which is vulnerable to accidents because pedestrians have to go down to the street. Therefore, the relevant authorities must design the footpathto meet the needs of all kinds of pedestrians, especially disabilities. If appropriate, remove obstacles on the sidewalk. Law enforcement against pedestrian drivers should be restricted. Rearranging the sale of goods orfoods on the sidewalk and punishing offenders should be done consistently.

Keywords: MRT, footpath, demand, young generation, Bangkok

1. Introduction

Bangkok is the capital and economic center, a large city with prosperity and many developments, changing and continuously evolving. Hence, there are many problems, such as people's overcrowding, and traffic congestion [1]. One goal of Bangkok's development is to improve the quality of life of its citizens, but today it is found that Bangkok continues to experience many urban development problems, especially those related to traffic and traffic networks in urban areas that cannot be created adequate convenience for the public.

This is especially the case of sidewalks, which are the basic public areas of the city to accommodate commuters and are equal to roads, with developed cities having continuous corridors connecting all public areas of the city, such as markets, shops, and parks. People can use the sidewalks from the residential area, which is conveniently connected to the important areas of the city, but the sidewalks of Bangkok are located trespassing in a variety of ways, especially for commercial activities on sidewalks. Road extension by dismantling sidewalks, leaving, or retaining less pavement space than legally, riding motorcycling on the pavement, and parking on the pavement for example.

Although the pedestrian area in Bangkok is rubbed and regulated by law, in practice it has been found that there is a respite for almost all the stalls on the pavements of the main streets in the city center. Therefore, people cannot use sidewalks effectively and safely [2]. Footpaths in Bangkok are extremely problematic for pedestrian users. The condition of the sidewalk is rough, bumpy. In some areas, the footpaths or sidewalks become the selling point of merchants, causing pedestrians to walk on the surface of traffic. In addition, some areas of the sidewalk have designs that do not meet the needs of pedestrians because of billboards and some obstacles are installed on the pavement everywhere and can affect accidents unexpectedly.

Each day, pedestrians have to walk on the streets because they face a lot of obstacles. When walking on the sidewalk, especially on the rough sidewalks, and during rainy times, pedestrians may accidentally step on potholes, causing water to stain their bodies. Furthermore, they also faced with motorcycles that are often easy to drive back on the pavement, and even honk their horns. These distractions are pedestrian problems in Bangkok. It has happened daily, and this kind of serious problem hasn't been solved.

This study, therefore, would like to examine young generation aspects toward sidewalks in Bangkok, impacts of the problem on people safety, and quality of life. In addition, this study also provides suggestions and recommendations to policy makers in the aspect of young generation demands.

2. Literature Review

2.1 Footpaths Design

Walkway refers to a different form of footpath in conjunction with the road. The sidewalks are clearly separated from the road, and sidewalks shared with commuters in other modes. Sidewalks play an important role in the city, primarily as the city's major commuter routes linking parts of the city together makes it easy to access parts of the city as well as the streets. In a city with good footpath development, there is a corridor system that connects all public areas of the city resulted in people in the community being able to travel from their residences to different parts of the city, such as parks, markets, shops, and even convenient places to work [3]. The way to travel is also what promotes social and economic activity whether it's entertainment, fairs, academic events, and even shopping for services and goods in the pedestrian area.

In urban communities, sidewalks are a type of urban space, especially in residential areas where there is light traffic. In urban areas, footpaths are used as public retreats. In crowded areas, lounge chairs are arranged under the trees, or in front of the store. For this reason, the footpath is like a living room for residents living nearby as well as passers-by. Jacobs [4] added that city environment influences the lifestyle and behavior of the city, and street design encourages a wide range of activities bringing the city to life. Residents feel safe encouraging more people to walk and do activities on the streets and promoting the city's social conditions.

According to the studied by Tanaboriboon and Guyano [5], there are some problematic of sidewalk facility. They concluded that Bangkok pedestrian facility design standards should conform with local standards and authorities should try to refrain from directly adopting Western pedestrian design standards.

2.2 Footpaths Problem

According to a survey of road users in

Bangkok by the Center for Urban Design and Development, pedestrians in Bangkok have to face with the followings problem [6].

1. Security issues: The respondents of the survey reported that they worried about crime (32.5%), accidents (31.5%), and problems of walking at night without lighting (31.5%).
2. Walking comfort issues: The respondentsreport the problems such as absence of bus stations within walking distance (26.9%), there are no pedestrian or intermittent pedestrian areas (21.6%), and bumpy and uneven sidewalk (18.4%).
3. Walking environment problems: They reported vital problems as absence of essential stores in everyday life along the way (44%), unpleasant physical environment problems which does not attracted walking (23.3%), pavement filth, includingthe presence of solid waste (16.8%).

These things are becoming increasingly demanding for both pavement users and commuters.

2.3 Impacts of Crazy Footpaths

2.3.1 Bangkok's Untidyness

Bangkok is the capital of a country known to people around the world who dream of visiting. In the past, street food was one of the "charms" that persuaded tourists to visit. Lifestyle and well-being of Thai citizens attracted foreign tourists to come and see the simple Thai lifestyle, whether it is dress code, food, or consumer goods. These things are easy to find in the way of Habre – stalls (street vending), but later the booms came to a cover. Fierce business competition is increasing. The increase in the population of people migrating to Bangkok in search of employment. As a result, more stalls have been found under extreme business competition conditions. This has changed the layout of the stalls and made the condition of the city simple and beautiful that has been changed completely [7].

2.3.2 Impact on traffic problems

The people of Bangkok have been experiencing traffic problems and the days havebeen intensifying so Bangkok's traffic problem has been raised as a national problem and has had a significant economic impact. An important factor that causes traffic problems is the use of roads among people, driving discipline of among cars andmotorcycle's drivers, insufficient road, increased vehicle volume, and problems with the constructionof state utilities. The problem of poaching on the sidewalks has forced people to come down to the traffic surface to travel around [7].

2.3.3 Accidents

Accidents on the traffic surface due to the poaching of the sidewalks. This causes pedestrian users to go down to the traffic surface. This caused accidents to the public and the loss of both life and property of the pavement users, and there was a noticeable social resistance. There were groups of people who saw the problem and gathered against the pavement users by opening the website, a group that did not take breezy stalls on the sidewalk. Because this group of people has been subjected to violations of their right to use the pavements from the Habre-stall traders, as well as injuries and loss of life and property in car accidents since pedestrians have to come down to the pavement, that is, one of the major consequences of crazy sidewalk problem in Bangkok [7].

3. Methodology

This study is qualitative research. The methodology of this study is detailed as followings:

3.1 Key Informants

The key informants in this study consisted of 17 students from 6 educational institutions: Assumption University of Thailand (ABAC), Chulalongkorn University (CU), King Mongkut's Institute of Technology Ladkrabang (KMITL), Suan Sunandha Rajabhat University, Thammasat University (TU), and Kasetsart University (KU), obtained from snowball sampling.

3.2 Research Tool

The authors employed in-depth interview using semi-structured interview. There were 6 interview questions.

1. What do you think of the footpaths in Bangkok?
2. What are vulnerable groups who are affected by the crazy footpaths?
3. Do you think footpaths in Bangkok affectpedestrian safety? And how?
4. Do you think the footpath conditions in Bangkok affect your lifestyle and quality of life? How?
5. How do you want to change the footpath in Bangkok?
6. What are your suggestions for improvingfootpaths in Bangkok?

3.3 Data Collection

Due to the Covid-19 pandemic, the in-depth interviews were conducted online using google meet and zoom during 1-30 November 2021.

3.4 Data Analysis

The gathered data were analyzed using analytic induction method. The analytic induction is an interpretation of the conclusions of information from concrete or visible phenomena, such as rituals, lifestyles, well-being. When the researcher has seen or observed several events and then proceeded to conclusions, but if the conclusions have not been reviewed, then the result is hypothesis. If confirmed, it is considered conclusive [8].

4. Results

4.1 Footpaths in Bangkok: Aspects from Young Generation

The key informants were asked "What do you think of the footpaths in Bangkok?" They responded that Bankok's footpath is crazy. One of the key informants said that "I think the footpaths in Bangkok are not suitable for pedestrians at all. I feel like walking is not as safe as it seems. There are obstructions, and most of the footpaths are damaged. In some areas, the footpath is very narrow, not the standard width. People can't even walk on the way, so they have to walk down on the street." Another key informant added that "Most footpaths in Bangkok are poor quality sidewalks, including thin bricks or mortar that are not equal or some bricks can be caused by long-lasting and time-consuming breakdowns. Lampposts are installed on the pavement unevenly, and both bicycles and motorbikes driving around the sidewalk." The fourth-year student shared her experience while walking on the sidewalk in Bangkok. She mentioned "Uneven footpath, a drove by motorbike, damaged footpath. When walking, you have to avoid motorcycles, broken corridors, and shops that sell things on the sidewalk. Parking on the sidewalk narrows the existing sidewalks. We need to get out of the way of the other person. There's water coming down from the air ducts, hitting the head a lot when walking on the sidewalk. The sidewalks are dirty, there is a lot of garbage, wet, especially after rain, the sidewalk becomes a puddle of rain, sometimes when you step on a rock, there is unsanitary water rising up your legs." A student from Kasetsart University complained that "Sidewalks in Bangkok do not have the right functionality to operate for both people who are physically fit and disabled. There are many obstacles on the sidewalk, such as advertising board, planted tress as if the sidewalk wasn't designed for pedestrians."

4.2 Who are Vulnerable?

The majority of key informants had the consensus that all pedestrians are the vulnerable group, especially disabled people. The first-year student from Chulalongkorn University mentioned that "Pedestrian footpaths in Bangkok are part of the fault of urban structure. Society in Thailand tends to value motor vehicle travel users more than pedestrians, so it's no surprise that nowadays we don't find footpaths that meet the standard." The key informant from Kasetsart University added that "Person who may have been in an accident and take a wheelchair may be vulnerable groups. It is unfavorable for comfort, safety, and even the blind who need to use the sidewalk. I, as a person who can use normal legs and has eyes that can see the environment of the entrance road, still feels bad why Bangkok's sidewalks are in this bad condition for commuters."

4.3 Impacts of Crazy Footpaths

The key informants reported that crazy footpaths in Bangkok affected their daily activities and quality of life. Some of them stated that the footpaths can result in accident as well. A student from King Mongkut's Institute of Technology Ladkrabang explained that it affects her life "It does not respond to usage, make me feel unwillingly to use the pavement to travel even in proximity because of the risk of many dangers. It makes me feel a terrible quality of life because, as mentioned in terms of safety in pavements, those who use it, are hardly secure at all. When you're walking around, you can be hit by a car, even on the sidewalk." A student from Kasetsart University also talked about safety issue. She added that "It affects the quality of life, especially safety issue. The crazy footpaths can cause accidents at all times to injury and is frequently seen according to social networks. The key informant from ABAC also confirm negative impacts of the crazy footpaths in Bangkok. She said that "The footpath in Bangkok affects life more negatively than positive. Walking on the sidewalk in Bangkok, there's always a sense of fear and paranoia. It makes my journey not as comfortable as it should be. If such feelings occur every day, it will certainly not have a positive effect on the mental health of the people who use the footpath." The first-year student from Thammasat University mentioned that "Bangkok's footpaths in some places are not suitable

for blind people. If you stumble, there can be an accident. It will be serious or light injury depending on the person." A student from Suan Sunandha Rajabhat University shared her experience and mentioned that "The biggest impact on pedestrian safety is motorcycles and lampposts, as you can see, motorcycles tend to ride on footpaths, which is a great thing not to do. In some cases, they ride on the wrong sidewalk also find out why they don't dodge. It's not uncommon to have lampposts on the pavement if the wires are stored in an orderly manner, but as many people have seen, it's not uncommon. Most footpaths are often jammed with hanging wires falling. Some places put wires on the ground and lean on the poles. The worst case is that the power line is high voltage. This one is very unsafe for pedestrians."

4.4 What are Young Generation Demands?

The key informants demand policy makers and responsible agencies and persons on various issues:

1. Smooth the pavements.
2. Increase the width of the sidewalk to meet the standard.
3. Remove various obstacles, includingbillboards.
4. Check and maintain sidewalks regularly.
5. Provision of pedestrian lanes for the blind.
6. Install lampposts and store wires tidily.
7. There should be forbidden to sell products on the sidewalk.

A student from Chulalongkorn University proposed interesting ideas that "I want the sidewalks to be available as Service Zone and Walk-Through Zone. The service zone can be divided into transportlink and bus stops. The Walk-Through Zone allows people walking mixed with other routes and want to be safer in the construction part. The materials used are of greater quality and want to be safe for use."

A student from Kasetsart University asked the government "The government needs to focus on sidewalks rather than road extensions because road expansion doesn't solve traffic jams, but it's getting more traffic jams. What the state should do is expand and develop sidewalks along with the development of public transportation. The third is standardized pavement construction. Pedestrian construction and sewer systems should be done in tandem. But what we often see is that when the pavement is completed, it has to be dismantled to make a drainage system, so the sidewalks are back in the mess."

Another key informant from Chulalongkorn University requested that "I want quality footpaths. It can be used practically for normal and disabled people, and it is a strong footpath so that you don't have to repair it often, because a lot of things come from wearing the footpath, and then actually changing the habit of Thai people using footpaths, such as littering trees or electricity poles, enforcing the law against driving a moped up the pedestrian, and diminishing selfishness. In some areas, people who live on the sidewalk take their own sidewalks, which they shouldn't, Finally, reorganize shopkeepers who sell things on the street."

A student of King Mongkut's Institute of Technology Ladkrabang proposed that "I want the use of pavements to be reorganized, both in terms of cleanliness and safety. I also want to make serious adjustments to the use of pavements that are not the right way to use them. Bringing motorcycles to the pavement should be seriously fined for fear of breaking the rules and wanting to rework the pavement. Improve the subject of power poles located in the middle of the sidewalk. Improve brightness in pavement areas. Improve the sidewalks for people with disabilities to use conveniently. Finally, there should be consistent surfaces and practical slopes, as well as regular and on-the-spot pavement maintenance.

5. Conclusion

Bangkok's footpath is crazy in the perspective of young generation, and it results in various problems that affect people quality of life and safety. Hence, policy makers should pay attention and listen to young generation voices.

References

[1] Boonon, N., & Limpaseni, W. (2020). Sidewalk development for convenient Bangkok Metropolitan: A case study of sidewalk along BTS Light Green Line (Silom Line). Vajira Medical Journal: Journal of Urban Medicine, 64(3), 213-222.

[2] Bejranonda, S., & Attanandana, V. (2017). Economic aspects for pavement management: Case study of Rattanakosin Island area. Built Environment Inquiry Journal (BEI): Faculty of Architecture, Khon Kaen University, 16(2), 13-147.

[3] Kaewkeaw, T. (1993). Studying the patterns and roles of vacancies in Bangkok metropolitan communities. Unpublished master thesis, Chulalongkorn University.

[4] Jacobs, J. (1961). The death and life of Great American cities. New York: The Modern Library

[5] Tanaboriboon, Y., & Guyano, J.A. (1991). Analysis of pedestrian movements in Bangkok. Retrieved 2 December 2021 from https://online pubs.trb.org/Onlinepubs/trr/1991/1294/1294-009.pdf

[6] Center for Urban Design and Development. (2020). GoodWalk database. Retrieved 30 November 2021 from https://urbandata.the urbanis.com/ opendata/gw

[7] Sangprapai, W. (2020). Democratic principle with the arrangement of street vendors of Bangkok Metropolitan. Retrieved 2 December 2021 from http://elibrary.constitutionalcourt. or.th/document/documents/documents/IS4D_59 0432.pdf

[8] Appleton, J. V. (1995). Analysing qualitative interview data: addressing issues of validity and reliability. Journal of Advanced Nursing, 22, 993-997

Factors Affecting the Intention to Use MRT

Paper Identification number: AYRF-003

Thaneeda HOMNGARM[1], Sansanee MUAKSANG[2], Waiphot KULACHAI[3], Keratiwan KALAYANAMITRA[4]

[1]College of Politics and Government
Suan Sunandha Rajabhat University
Telephone 089 207 8038
E-mail: thang.thaneeda@gmail.com

[2]College of Politics and Government
Suan Sunandha Rajabhat University
Telephone 098 870 6263
E-mail: S63123472061@ssru.ac.th

[3]College of Politics and Government
Suan Sunandha Rajabhat University
Mobile: 081 939 1094
E-mail: waiphot.ku@ssru.ac.th

[4]College of Politics and Government
Suan Sunandha Rajabhat University
Mobile: 087 559 3351
E-mail: Keratiwan.ka@ssru.ac.th

Abstract

This article examined factors affecting the intention to use the Mass Rapid Transit (MRT). The sample of this study were 137 students at the College of Politics and Government, Suan Sunandha Rajabhat University. Data were collected via online survey and analyzed using ordinary multiple regression analysis technique. The findings indicated that entertainment, convenience, safety, and time saving were the most influential factors in that order with the beta values of .336, .263, .242, and .184 respectively. However, public transport network did not have an influence on the intention to use MRT at all. To attract people of all age groups to use public transport, especially MRT, executives or policy makers should focus on people's needs of each age group. For a new generation or young people, entertainment at the stations and well as inside the vehicle should be the priority. However, some respondents recommended that the fare should not be expensive so they can afford and use this public transport rather than other modes of transport, such as motorcycle, which are more vulnerable to accidents.

Keywords: MRT, intention to use, transport, public transport

1. Introduction

Changes in the current socioeconomic and political aspects have affected people in various forms of travel depending on different ages and lifestyles. Younger people are growing up in the world dominated by social media with drastic development in information technology. As a result, the lifestyle of the younger generation is different compared to previous generations.

There are various modes of travel in Bangkok such as car, bus, taxi, motorcycle, bicycle, MRT, BTS, and walking. Some people use car for travel since there is no alternative modes in their areas. In addition, public transport, which does not cover residential areas as well as network connections of public transport, is a problem, leaving

people with no choice, so it is necessary to buy a personal car or a motorcycle.

Travel expenses of BTS and MRT is considered a costly trip. Many people cannot afford to travel by this mode. Public transport, which lacks network links, causes high travel costs, such as getting to work from the property, one taking a hired motorbike to the alley and taking the bus to the skytrain or subway. Public transport without networking is problematic. As a result, the cost of travel is high, such as getting to work from the property, taking a hired motorbike to the alley and taking the bus to the skytrain or subway. After getting off the train station, it is necessary to take a hired motorbike to continue the journey to the workplace. It's obvious that one person's commute to work requires a lot of public transport, causing huge costs. Therefore, people are turning to buying cars or motorcycles for travel because of the convenience and not too high the cost.

For young people living in cities like Bangkok, life must be rushed. Therefore, we can see that young people prefer to use the service of BTS and MRT, especially during peak times. However, the reason for choosing BTS or MRT service varies depending on the nature of their lifestyle and age group. Previous studies found that some people used MRT since it could help reducing pollution [1]. Charoensri [2] conducted research in 2017 and found that safety, fare, and marketing promotion are factors influencing the intention to use BTS. However, many research focused mainly on customer satisfaction among all age groups [3][4][5][6][7]. Hence, this study would like to examine factors affecting the intention to use MRT to narrow the research gap on this issue.

2. Literature Review

2.1 Public Transport System

Public transport is defined as "a system of vehicles such as buses and trains that operate at regular times on fixed routes and are used by the public". There are 4 main objectives of providing the public transport operation; (1) to provide access to employment, education, retail, health, and recreational facilities (2) ensuring the possibility to travel for all inhabitants who cannot or do not want to use private cars (3) providing travels compared to which the use of private car is ineffective for economic, time-based, or ecological reasons and (4) being the actual alternative to private car. All of these vehicles differ from each other in operational characteristics. Thereby, the majority of public transport systems use more than one type of vehicles, which helps to achieve synergy effect. The characteristics of public transport vehicles is also determined by the distance of travel they need to cover. Because of the distance or operational area, public transport can be divided into local (urban), regional, national, and international transport.

2.2 MRT

MRT is another major transportation system that covers both the city and outlying business districts. Through many commercial areas, residences, and tourist attractions. At present, MRT operates on two lines: the Blue Line and the Purple Line.

MRT Blue Line is a route starting from Hua Lamphong Railway Station through the business district and shopping malls in Silom, Lumpini Park Queen Sirikit National Convention Center, Asoke Intersection, and along Ratchadapisek Road, where the office, shopping malls, and entertainment venues are located and end the route at Tao Pun Station.

MRT Purple Line starts at Tao Pun Station, passing out of town along Tiwanon Road, crossing the Chao Phraya River towards Nonthaburi, passing Central Plaza Westgate and ending at Khlong Bang Phai Station.

Currently, BTS and MRT have three interconnection points: Sala Daeng - Silom Station, Asoke - Sukhumvit Station and MoChit - Kamphaeng Phet Station, near Chatuchak Park, helping residents of Bangkok easy access to the city centre.

2.3 Factors Influencing Intention to Use Public Transport

There is much research conducted on factor influencing intention to use public transport. A study by Borhan et al. [8] indicated that service quality and attitude are influential factors toward the intention to use public transport. There is an article stated that there are various reasons to use MRT in Bangkok [9]:

(1) Fast, convenient, comfortable, safe and punctual of travel.
(2) Reduce the stress of public travel due to traffic problems.
(3) Does not cause pollution due to the use of electric power to drive the car.
(4) Reduce accidents because there are specialized running paths and computerized control systems.
(5) Promotion of public transport instead of private cars.

(6) Expand and distribute urban development to different parts along the route and skytrain stations.
(7) To promote the urban environment and improve the quality of life for the people. Make the economy more agile.

2.4 Conceptual Framework

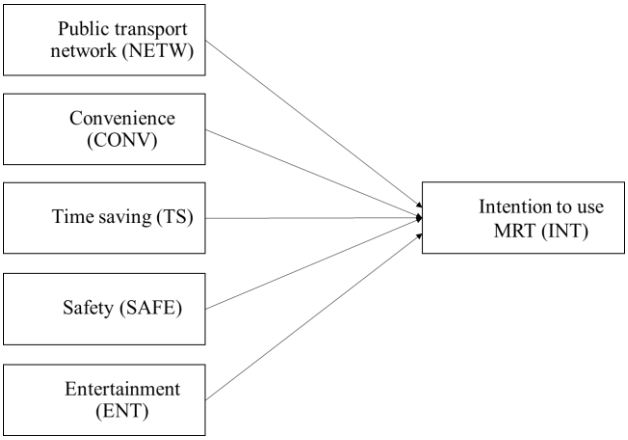


Figure 1 Conceptual framework

2.5 Hypotheses

H_1: Public transport network has an influence on intention to use MRT.

H_2: Convenience has an influence on intention to use MRT.

H_3: Time saving has an influence on intention to use MRT.

H_4: Safety has an influence on intention to use MRT.

H_5: Entertainment has an influence on intention to use MRT.

3. Methodology

This study is quantitative research. The details of methodology are as follows:

3.1 Respondents

The respondents of this study were 137 students at the College of Politics and Government, Suan Sunandha Rajabhat University as detailed in Table 1.

Table 1 Respondents

n=137

Demographic Data	Frequency	Percentage
Gender		
Male	47	34.31%
Female	72	52.55%
LGBTIQ	18	13.14%
Year of Study		
Year 1	75	54.74%
Year 2	35	25.55%
Year 3	26	18.98%
Year 4	1	0.73%
Monthly Expenses		
< 5,000 Baht	55	40.15%
5,001-10,000 Baht	56	40.88%
10,001-15,000 Baht	20	14.60%
15,001-20,000 Baht	4	2.92%
> 20,000 Baht	2	1.46%
Accommodation		
House	63	45.99%
Dormitory	61	44.53%
Rented room	11	8.03%
Condominium	2	1.46%

From Table 1, most of the respondents were female accounting for 52.55%. Around 54.74% were the first-year students. Considering the cost of the monthly expenditure, around 81% spent less than 10,000 Baht per month. Under the normal situation, most students stayed at house with their parents and dormitory. The age of the respondents ranged from 19-22 years old with the average age of 19 years old. The student's family size ranged from 2-10 persons with the average of 4 people.

3.2 Measures

There are 6 measures in this study, which are as follows:

Public transport network (NETW) consists of 5-item Likert's type scale anchored by strongly disagree to strongly agree. The sample items are "MRT has a route that covers the area of your journey," "MRT has a travel network linked to other public services such as buses, taxi," and "MRT has a network covering Bangkok metropolitan area." The Cronbach's alpha of the measure is .894 indicating very good reliability [10].

Convenience (CONV) consists of 5-item Likert's type scale anchored by strongly disagree to strongly agree. The sample items are "Traveling by MRT is convenient," "MRT has a travel network linked to other public services such as buses, taxi," and "Using MRT service is a hassle-free matter."

The Cronbach's alpha of the measure is .932 indicating very good reliability [10].

Time saving (TS) consists of 3-item Likert's type scale anchored by strongly disagree to strongly agree. The sample items are "Traveling by MRT makes you arrive faster," "I choose MRT due to the speed of travel," and "Traveling by MRT saves my time." The Cronbach's alpha of the measure is .952 indicating very good reliability [10].

Safety (SAFE) consists of 5-item Likert's type scale anchored by strongly disagree to strongly agree. The sample items are "I feel safe when traveling by MRT," "Traveling by MRT is safer than traveling by bus or taxi," and "MRT has security guards at all stations that make me a sense of security" The Cronbach's alpha of the measure is .934 indicating very good reliability [10].

Entertainment (ENT) consists of 5-item Likert's type scale anchored by strongly disagree to strongly agree. The sample items are "Traveling by MRT allows me to watch videos about my interests," "At the station of MRT, a billboard for my favorite Korean artist is displayed," and "At the MRT station, there are ongoing projects, especially celebrity, famous singers, and artists public relations." The Cronbach's alpha of the measure is .942 indicating very good reliability [10].

Intention to use MRT (INT) consists of 5-item Likert's type scale anchored by strongly disagree to strongly agree. The sample items are "I intend to use MRT," "I will recommend using MRT service to friends and acquaintances," and "Traveling by MRT is the right type of travel for my lifestyle." The Cronbach's alpha of the measure is .943 indicating very good reliability [10].

3.3 Data Collection

The data were collected online using google form. The link of questionnaire was distributed to all students at the College of Politics and Government, Suan Sunandha Rajabhat University during 1-30 November 2021.

3.4 Data Analysis

The gathered data were analyzed using ordinary multiple regression analysis to test the relationship between independent and dependent variables.

4. Results

An ordinary multiple regression analysis was conducted to evaluate whether public transport network (NETW), convenience (CONV), time saving (TS), safety, (SAFE), and entertainment (ENT) scores were necessary to predict intention to use MRT. The results of the analysis are illustrated in Table 2-4.

Table 2 Model summary

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.878[a]	.772	.763	.44138

a. Predictors: (Constant), ENT, NETW, TS, SAFE, CONV

Table 3 ANOVA

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	86.234	5	17.247	88.527	.000[b]
	Residual	25.521	131	.195		
	Total	111.755	136			

a. Dependent Variable: INT

b. Predictors: (Constant), ENT, NETW, TS, SAFE, CONV

Table 4 Coefficients

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.075	.185		.406	.685
	NETW	-.038	.064	-.039	-.596	.552
	CONV	.268	.100	.263	2.670	.009
	TS	.176	.081	.184	2.172	.032
	SAFE	.254	.088	.242	2.877	.005
	ENT	.316	.053	.336	5.943	.000

a. Dependent Variable: INT

According to Table 2-4, the findings indicated that entertainment, convenience, safety, and time saving were the most influential factors in that order with the beta values of .336, .263, .242, and .184 respectively. Based on the R^2 value of 0.772, these facets of factors could explain 77.20% in the variation of intention to use MRT (INT). Then, the predictive equation would be written.

INT = .263CONV + .184TS + .242SAFE + .336ENT

However, public transport network did not have an influence on the intention to use MRT at all. Hypothesis test results appear in Table 5.

Table 5 Hypothesis testing results

Hypothesis		Results
1	Public transport network has an influence on intention to use MRT.	Not supported
2	Convenience has an influence on intention to use MRT.	Supported
3	Time saving has an influence on intention to use MRT.	Supported
4	Safety has an influence on intention to use MRT.	Supported
5	Entertainment has an influence on intention to use MRT.	Supported

5. Discussion

The results suggest that comfort and convenience, fast travel, saving time, security, and entertainment are a very important factor encouraging younger generation to use the MRT service. Interestingly, entertainment on train stations or on the train itself attracts and incentivizes more young people to use MRT. This result is different from others research findings which found that there are many factors that affect the use of MRT, such as service quality, convenience, speed, cleanliness, and safety. Partly, young generation may be influenced and dominated by K-pop culture as we can see that many young people are fascinated and like South Korean artists. There are many commercial ads and publicity advertisements that appear in the subway station, which has become a place for travelers to take photos, walk, and check in at that point. Convenience is the second most important factor, because it is convenient to travel by MRT. Passengers can travel links to various points in the downtown area, especially, important places or tourist spots. The issue of safety is of great importance, especially for women, children, or old people who must travel alone. If they use other public transport services, such as taxis or motorcycles taxi, which are at risk of accidents, are threatened, or robbed. Hence, traveling by MRT is safer. Time saving is another important factor in deciding to use MRT because MRT travel is a quick journey. There are no traffic congestions and no risk of accidents as train travel is a safe journey compared to other public transport modes.

6. Conclusion

This study examined the factors affecting the intention to use MRT among young generation whose lifestyle is changing in accordance with social and technology change. The authors found very interesting factor that attract young people to use the MRT. The authors call that factor as "entertainment," such as publicity advertisement about K-Pop artists, singers, actors, and actresses. This indicates the dominance of K-Pop culture over young generation. Hence, policy makers should place importance on this factor so entertainment suitable for each age group should be established to attract every age group in the society to use MRT or other public transport modes. However, convenience, time saving, and safety should not be neglected.

References

[1]Thongtem, P. (2020). People's attitudes towards reducing pollution by using MRT in the New Normal era Case study of population in Chatuchak sub-district. Unpbulished master thesis, National Institute of Development Administration.

[2] Charoensri, W. (2017). Factors affecting commuters' decision making of using the Bangkok Sky Train. Unpublished master thesis, Thammasat University.

[3] Homsud., N., Amphan, S., Luechayut, S., & Phromlun, A. (2011). Expectation and satisfaction in service of customers who use service at MRT National Cultural Center Station. Proceedings of the 7th Mahasarakam Research, Mahasarakam.

[4] Chanprasert, N. (2019). Satisfaction of using MRT services through people who live in Huay Kwang District, Bangkok. Retrieved 1 December 2021 from https://mmm.ru.ac.th

[5] Laohacharupat, A. (2014). Customer Satisfaction with the BTS, MRT and Airport Link Service in Bangkok Metropolitan Region. Unpublished master thesis, Thammasat University.

[6] Kamonsiriprasert, T., & Yousapronpaiboon, K. (2015). The effect of service quality on customers' satisfaction from BTS & MRT services. Kasetsart Applied Business Journal, 11, 11-25.

[7] Luangchookiat, K. (2013). Psychological factors influencing behavior and satisfaction on usage of MRT on Saturday and Sunday. Unpublished master thesis, Chulalongkorn University.

[8] Borhan, M.N., et al. (2014). Predicting the Use of Public Transportation: A Case Study from Putrajaya, Malaysia. Scientific World Journal. DOI: 10.1155/2014/784145

[9] Metropolitan Rapid Transit (MRT). Retrieved 1 December 2021 from https://www.mrta.co.th

[10] Hulin, C., Netemeyer, R., and Cudeck, R. (2001). Can a Reliability Coefficient Be Too High? Journal of Consumer Psychology, 10(1), 55-58.

Evaluating Impacts of Teleworking Policy in Jakarta Metropolitan Area by The Analysis of Activity Pattern

Paper Identification number: AYRF-004

Rizky WAHYULINATA[1], Noriyasu TSUMITA[2], Sideney SCHREINER[3], Atsushi FUKUDA[4]

[1,2]Graduate School of Science and Technology
Nihon University, Chiba, 2748501, Japan
Telephone 0-2470-9154, Fax. 0-2427-9063
[1]E-mail: csri20019@g.nihon-u.ac.jp
[2]E-mail: csno20001@g.nihon-u.ac.jp

[3,4]College of Science and Technology
Nihon University, Chiba, 2748501, Japan
Telephone 0-2470-9154, Fax. 0-2427-9063
[3]E-mail: sideney@gmail.com
[4]E-mail: fukuda.atsushi@nihon-u.ac.jp

Abstract

In recent years, many countries have tried to adopt teleworking as a COVID-19 prevention measure in order to reduce the number of infections, especially in the working environment. Teleworking policy changes not only people's modal choice and route choice, but it also has a high likelihood of changing activity patterns of all the people affected either directly or indirectly. Thus, when trying to implement this kind of measure, it is necessary to consider people's travel behaviors in detail. The current method of the conventional trip-based traffic demand forecasting (Four-step model) focuses only on the change of travel behaviors; however, this method could not represent the change of activity patterns when the teleworking policy is implemented. Therefore, it is necessary to apply an Activity-Based Model (ABM) that could explicitly express the change of activity patterns and estimate the effectiveness of implementing this measure. Thus, this study focuses on evaluating teleworking policy based on the changes in activity patterns. By utilizing the ABM, the teleworking policy was evaluated using the typical performance indices such as Vehicle Kilometer Travelled (VKT), Vehicle Hourly Travelled (VHT), and in addition to that, activity patterns that could represent the change in daily activities was introduced in the case of Jakarta Metropolitan Area, Indonesia.

Keywords: Activity-Based Model, Teleworking, COVID-19, Activity Pattern, Jakarta Metropolitan Area

1. Introduction

The global spread of COVID-19 infections has a significant impact on people's day-to-day activities, especially on the transportation aspects within a city. Various measures have been taken to prevent the spread of infection depending on the country or city, but the basic idea is to limit or reduce the opportunity to go out and reduce the opportunity for people to interact with each other as much as possible. Under these circumstances, a teleworking policy was recommended, and it is presumed that the adoption by many companies had a significant impact on traffic demand, and it is necessary to appropriately estimate this impact when considering future transportation policies. In some situations where workers simply reduce the number of workdays, it is possible to estimate the impact of the introduction of telework policy on traffic demand by applying trip-based travel demand forecasting (4-step model). However, there is a possibility that the activity pattern itself may have changed significantly, secondary activities such as shopping will still be conducted even if you do not actually go to work. Therefore, the impact on traffic demand cannot be estimated by using a simple trip-based travel demand forecast. In such cases, it is necessary to apply an Activity-Based Model (ABM), which can explicitly incorporate changes in activity patterns, to estimate the impact on traffic demand.

Thus, this study aims to evaluate the impact of the introduction of teleworking policy based on analyzing the changes of activity pattern by ABM in the Jakarta Metropolitan Area (JABODETABEK), Indonesia.

This paper was organized as follows. In section 2, past studies about ABM and the evaluation method of teleworking policy were reviewed. The details about the analysis framework and the methodology for evaluating teleworking policy by ABM are explained in section 3. In addition to that, the results of teleworking policy based on changes of activity patterns, VKT, and VHT by ABM are presented and discussed. Finally, section 4 summarizes the main idea of the paper.

2. Literature Reviews

The literature reviews on this study will be divided into 2 sections, one is to refer to past studies about ABM and another one is to describe the background and current evaluation method of teleworking policy.

2.1 Activity-Based Model

In recent years, ABM has become broadly recognized. ABM shares some similarities to the conventional 4-step models: activities are generated, destinations for the activities are distinguished, travel modes are determined, and the specific network facilities or routes used for each trip are predicted. However, activity-based models incorporate some significant advances over the four-step trip-based models, for example, the explicit representation of realistic constraints of time and space and the linkages among activities and travel (trip chaining). These trip chaining concepts enable ABM to fully express how, where, when, and why an individual travel on a course of a day by referring to their activities.

In many of the developed cities in the US and Europe, ABM has been estimated and applied. Many of these models have been updated and/or currently still operating. ABM is classified into three approaches, namely, econometric approach, rule-based approach, and hybrid approach. Bowman (1998) and Bowman and Ben-Akiva (2001) developed an initial concept of ABM for the Portland Metro that is based on the conventional Random Utility Maximization (RUM) based discrete choice framework. The model was categorized into the econometric approach due to the nature of RUM theory where utilities were assumed to be selected from several stages of the calculation. Continuing the success of the RUM-based approach, The Comprehensive Econometric Micro-simulator for Daily Activity-travel Patterns (CEMDAP) was developed by Bhat et al., (2004), which is a microsimulation implementation of an activity-travel modeling system. CEMDAP is a system of econometric models that represent the decision-making behavior of individuals. The system differs from the Bowman and Ben-Akiva model because it is one of the first to comprehensively simulate the activity-travel patterns of workers as well as non-workers along a continuous time frame. As a pioneer of ABM in Japan, Fujii and Kitamura (1998) constructed an ABM called (PCATS), it is a micro simulator of individual`s activity engagement and travel within time and space prism. In PCATS, the probability associated with a daily activity-travel pattern is decomposed into a series of conditional probabilities, each associated with an activity episode or trip. Arentze and Timmermans (2000) developed and applied an ABM called ALBATROSS in the Netherlands, the model is considered as a multi-agent rule-based system that predicts activity patterns. The system is based on using choice heuristics to simulate behavior. The recent model such as the MATSim model by Axhausen (2006) was developed with the goal of generating traffic and congestion patterns by following individual synthetic travelers through their daily or weekly activity programme, this model was one of the first to combine both the econometric approach and the rule-based approach. The ABM used in this study will be based on the ABM that was developed by the Swiss Federal Railways (SBB), Scherr (2019) developed a hybrid approach model called the MOBi.plans, the model constructs individual activity and travel plans, balancing for each person preferences with constraints. Preferences are represented by a set of discrete-choice models for number of tours, number and kinds of activities, destination, and mode choice. Constraints are represented in the plan adjustment and scheduling steps, using time budgets and a rule-based approach, which assures plan integrity and consistency.

2.2 Activity Analysis of Teleworking

The introduction of telework may not only lead to a change of mode and route change but also a shift of departing time, reduction of the number of outings, change of stopover destination, etc. Therefore, telework might be categorized as one of the traffic demand management (TDM) strategies. Thus, many studies evaluated the impact of the introduction of telework based on activity analysis.

Bhat (2007) mentioned that by utilizing ABM, several advantages over the conventional trip-based methods can be shown by the explicit spatial and temporal inter-dependencies in activity and travel choices, detailed consideration of timing and duration of activity and travel, emphasis on household level decision making and interactions among household members. Hence, ABM is more suitable for a realistic policy evaluation. Yamada and Fukuda (2019) designed an ABM for the analysis of a change in activities after a traveler leaves the office in Tokyo, activity patterns were defined as a series of behaviors of when a person goes out. The study also described the creation of the destination choice model in detail. Stratified importance sampling and a time–space constraints were adopted for the choice set formulation to predict traveler destinations. A similar way of constructing the activity pattern will be adopted in this study, however, this study will further investigate the changes of the activity pattern by directly comparing the number of patterns generated in each simulation of the base and teleworking scenario. Teleworking policy itself has seen development in recent years. Kim (2016) stated that teleworking is regarded as a sustainable traffic demand management strategy. Studies typically adopt one method of the following three: (1) multiplying the telecommuting frequency by the round-trip commute distance, (2) measuring travel changes using quasi-experiments, and (3) determining the marginal effect of telecommuting on travel using econometric analyses. However, each approach has some limitations, and previous studies fail to take into consideration various aspects of household related travel other than the telecommuter's commute. The results of Bhat (2003) study supported this premise by showing that individual demographics such as work-related attributes, and household demographics are significant determinants of telecommuting adoption and frequency. Variables such as the environment that represents household characteristics, technology that corresponds to individuals' income, and organizations that signify individuals' work type and office characteristics will be the deciding factor on teleworking choice. However, the actual condition of teleworking needs to be outlined in order to creates a distinctive constraint in the model. In the recent pandemic condition, Hibino (2019) conducted a study where the characteristics of teleworking were clarified by a questionnaire survey on the actual work situation for the workers who are currently conducting telework. The results clarified the actual working conditions such as the number of commuting days of teleworkers, the time of departure from home, the relationship between the intention to move to another place and the choice of place, the requirements required for satellite offices, etc. Similar study was also done by Shamishiripour in (2020), who investigated how and to what extent people's mobility styles and habitual travel behaviors have changed during the COVID-19 pandemic. A stated preference-revealed preference (SP-RP) was implemented in the Chicago metropolitan area. Analysis of the collected data reveals significant changes in various aspects of people's travel behavior. As a result, several insights for policymakers to proactively plan for more equitable, sustainable, and resilient cities was given.

In terms of policy evaluation method using ABM, Shabanpour (2018) developed an integrated framework to provide the empirical evidence of the potential impacts of home-based teleworking on travel behavior, network congestion, and air quality using POLARIS hybrid approach. He also stated that ABM works in time and space, and teleworking provides flexibility to travelers' constraints of both time and space, introduction of teleworking policy would encourage travelers to change their activity pattern in a day. Equivalent to the outcome of Shabanpour's works, a study by Zhu (2014) suggested that telecommuters have more vehicle kilometers traveled for both daily work and non-work trips than non-telecommuters. Adding the findings that telecommuting has no impact on other non-working household member's daily total (nonwork) trips, he argued that households with telecommuter(s) tend to have higher daily total vehicle kilometers traveled.

Hence, to address the current evaluation issues, ABM was used to evaluate this policy and changes in activity patterns will be analyzed by the introduction of this measure. The expected result was to see travelers reducing some of their work-related activity patterns such as from home to work to home, to just become home.

3. Methodology

This section described an outline of research methods that were constructed in the study. It provides information about traffic conditions in the study area and the required datasets, the detailed calculation process, and the evaluation method being proposed. The calculation process was divided into 5 different stages and the procedures that were followed to carry out this study are also included. In addition to that, how to evaluate teleworking policy by ABM and the targeted activity pattern analysis was also discussed.

3.1 Study Area: Jakarta Metropolitan Area

Jabodetabek is chosen as a study area due to the fact that the city is currently planning the implementation of a new transport policy. Compiled of 9 districts, the city has a variety of transport systems for an area populated of 33,918,000 people. Recently, the development of road networks such as flyovers and highways has been prioritized due to massive users of private transport. Several policies have been implemented in an attempt to control the travel demand by limiting road users such as 3-in-1 and odd-even policy.

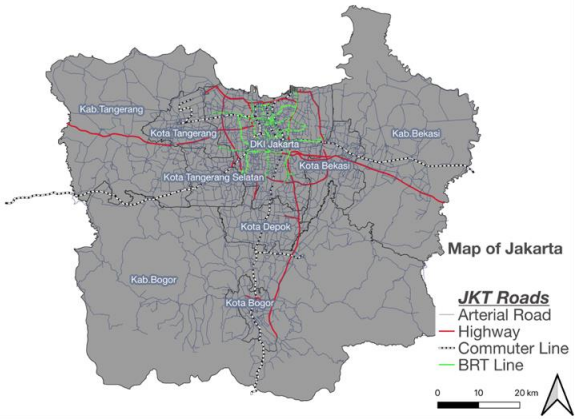


Figure 1*:* Map of Jabodetabek

A joint project between the government of Indonesia and JICA in 2018-2019 titled JABODETABEK Urban Transportation Policy Integration Project Phase-2 (JUTPI2) was formulated as a revision for the 2001 Jabodetabek master plan. In the final report, several long-term issues such as public transport initiatives and TOD (Transit Oriented Development) were addressed. However, this study will focus more on the short-term issues such as considering TDM policy and adaptation of new normal.

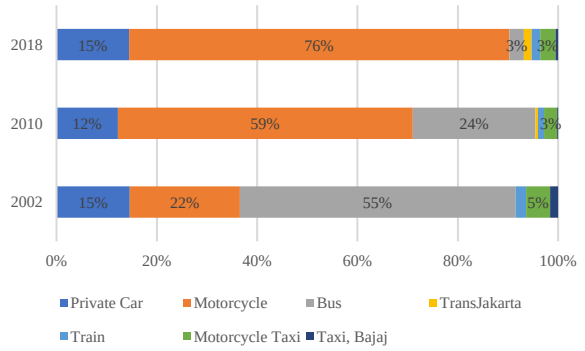


Figure 2*:* Modal share in Jabodetabek by year (JICA 2018)

In regard to the traffic condition of Jabodetabek, Figure 2 shows the modal share in Jabodetabek in the years 2002, 2010, and 2018. The use of motorcycles has been growing exponentially while the use of busses has decreased over time. However, it is also worth noticing that the availability of BRT (TransJakarta) offers riders different alternatives in taking public transport, and it is safe to assume that in recent times people have been changing their modes from bus to motorcycle and BRT.

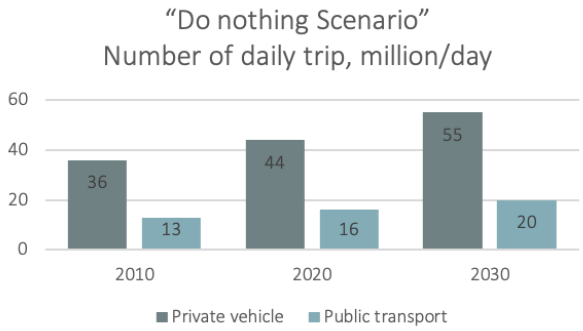


Figure 3*:* Estimated total number of daily trips in "do nothing" scenario (JICA 2018)

Figure 3 represents the estimated number of total daily trips in Jabodetabek in the case of the "do nothing" scenario, meaning that if the current condition of traffic will continue as it is. The number of trips made by private vehicles was estimated to reach a staggering number of 55 million trips per day in 2030, this number corresponds to the previous trends of the modal share values where it shows the increase of motorcycle users which represents the private vehicle. The governments are expected to do something about it by implementing policies such as ERP and even look further into the future such as introducing teleworking policy to reduce these congestions.

This study required the availability of two types of data, one is the Activity Diary Survey (ADS), a travel survey compiled with all the necessary activity diaries of a person in a day that was conducted at the household level, this data was provided by JICA. The main objective of collecting the ADS was to obtain data of activity-travel from each respondent (worker, student, and non-worker) within the Jabodetabek area to collect socio-economic information of each household such as income, auto-ownership, household member's main information, etc. the ADS include 9,000 respondents of people who live in Jabodetabek. Another data that is equally important is the census data, which was used heavily on the weighting part of

the population synthesis process of this study. The census data is available on the open-source website of Statistics Indonesia, BPS (2018).

3.2 Framework of Activity-Based Model

In this study, the MOBi Plans model from the MATSim Model was adjusted and applied to the traffic condition in Jakarta to estimate traffic demand by PTV VISUM. The model itself is classified as the hybrid approach, which combines the features of utility maximization theory for the choice calculation, and the rule-based method of considering time and space constraints. The framework of the calculation process for the traffic demand forecasting by ABM is shown in Figure 4 below. The model is divided into 5 stages, Stage (1) Generation of synthetic population, Stage (2) Estimation of parameter, Stage (3) Estimation of traffic demand, Stage (4) Traffic assignment, and Stage (5) Evaluation of each scenario by performance indices.

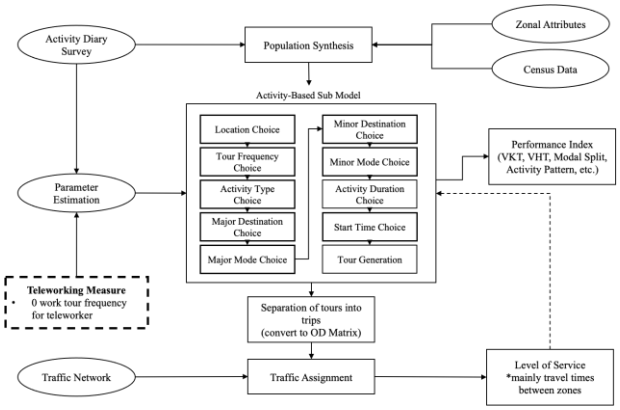


Figure 4*:* Overall framework of research methodology

Stage 1: Generation of Synthetic Population

As input in ABM, it is necessary to generate artificial population data that can represent all people in the study area. By employing the census and ADS data, a synthetic population that includes all 33,918,000 people and 9,133,000 households of Jabodetabek was generated, these data include personal and household information such as income, age, ownership of the vehicle, etc. In the population synthesis stage, it is possible to express not only personal information but also the relationship within a household. The generation of the synthetic population was computed by using IPU (Iterative Proportional Updating) method. The results of population synthesis could significantly affect the outcome of the travel behaviours and activity patterns.

Stage 2: Estimation of parameters

By utilizing the ADS data, the required parameters were estimated by using the discrete choice model based on the random utility and probability theory as shown in Equations (1) and (2).

$$u_A = \sum i\, \beta_{A,i} \cdot x_i \tag{1}$$

$$p_A = \frac{\exp(u_A)}{\sum i \exp(u_{A,i})} \tag{2}$$

Where u_A stands for the utility for choice A, x_i is the attributes of the person and β is the corresponding parameters. The ADS data was filtered and constructed to estimate the parameters for each sub-models within the ABM, these sub-models include the location choice model, tour frequency choice model, activity type choice model, major and minor destination choice model, major and minor mode choice model, activity duration choice model, and activity start time choice model.

Stage 3: Estimation of Traffic Demand

Using the resulting parameters and the synthetic population data, ABM was run to estimate traffic demand in the study area. By following a specific order, the same discrete choice model as the parameter estimation, equations (1) and (2) were used to calculate each choice for each person by ABM, as illustrated in Figure 4, the location of the primary activity is first selected, then the choice of tour frequency and activity type of every person will be estimated. This process creates an individual activity pattern such as Home – Work – Home. Then, choices that will affect travel behaviour such as destination and mode are estimated based on the attraction of each zone and the utility of each mode. As a final step, the activity's duration and start time are estimated to make a complete tour data for each person. "Tour" is a combination of trips that also includes significant information such as its location, frequency, modes of choice, and other details of an activity. These tour data are then broken down into 2 categories, 1 is to express travel behaviour (travel time, modal choice, and origin-destination) and 2 to express the activity (activity type, activity duration, and activity start time). The tour data was also sliced into multiple trips by a script in PTV VISUM, and only after that the trips was converted into OD matrix which represents one whole day.

Stage 4: Traffic Assignment

The OD matrix is developed from the data of travel behaviour and summarized by each mode. The traffic is assigned based on these developed OD matrices and transport network data. As a result of this assignment, the travel time of each mode which acts as the level of service is again calculated for the next step of model iterations. Results such as VKT, VHT and traffic volumes will be the outcome of this stage.

Stage 5: Telework Evaluation

Finally, based on these results, the teleworking condition was evaluated by comparing VKT, VHT, and changes in activity patterns before and after the policy introduction.

The teleworking policy scenario was integrated by modifying the "Tour Frequency Choice sub-model" inside the ABM. As mentioned in Stage 2, ABM consists of several sub-choice models, this particular model calculates the frequency of tour for each individual, giving a result of how many times a person does an activity in a day. By modifying the parameters within this sub-model, the choice of people to go to work or not can be influenced. By including work-related variables such as work type and income levels, the population synthesis program generated a choice for each person who will telework or not, these choices were stored in VISUM as an attribute of a person. People with specific work types and income levels will have a higher tendency to not travel to work based on the teleworking parameter. It is necessary to clarify the actual choice of teleworking in detail. However, a survey related to this condition has not been conducted yet in the study area. Hence, this study will assume the teleworking choice by work type referring to the past literature reviews and the latest news in Jabodetabek. It is important to mention that the classification of work type shown in this study is based on the actual population census data of Jabodetabek.

Table 1 summarizes the assumption of which type of work will be able to telework or not under the policy. It is also important to note that the study will enforce a 100% condition of teleworking in the simulated scenario. This issue was again due to the lack of information about the actual frequency of teleworking in the study area. A new travel behavior survey regarding the lockdown condition in Jabodetabek is currently being designed to address the lack of data in this study, in the hope of achieving a better result for future studies.

Table 1: Teleworker assumptions

Will Telework	Won't Telework
Craftsman	Farmer, fisherman, miner
Industry/business owner	Factory works/labors
Sales, merchant	Construction laborer
Professor, manager, director, etc.	Armed forces/Police
Expert (lecturer, teacher)	Professionals (doctor, engineer, accountant)
Administration staff	Waiter, bartender
Technician	Goods transport driver
	Public transport driver
	Private driver
	Housemaid, office boy, cleaning service, gardener
	Security officer

The formula for this policy was derived from Equations (1) and (2) of ABM where it calculates the utilities and then probabilities of the choices. This particular sub-model will calculate how frequent a worker makes a work-related tour in a day, the utility is for the choices of 0 work tour, 1 work tour and 2 work tours. Equations (3) and (4) define the formula of the ABM sub-model where the specifications of teleworkers were included in the tour frequency choice model for the primary activity of "Work" and "Telework", the formula was written in the VISUM syntax. As stated in Stage 2 of the calculation, the choice model considers the attributes of a person x_i and its corresponding parameters β. The person attributes being considered in this calculation include the employment category, age category, presence of a child at home, and distance to work by car. The parameter β_6 was acquired by a trial-and-error method and the value ±2 was decided to be the coefficient that can influence teleworkers to make 0 work tours and 1 or more telework tours. The formula for Tour Frequency Choice model for both "work" and "telework" activity written in VISUM syntax form are as follows,

$$U_{TFWork\,(0,1,2,3)} = (\beta_1 \cdot Empl_{pct}) + (\beta_2 \cdot Age_{cat}) + (\beta_3 \cdot Has_{child}) + (\beta_4 \cdot Car_{dist_{work}}) + (\beta_5 \cdot Constant_{value}) + (\beta_6 \cdot Teleworking) \quad (3)$$

$$U_{TFTelework\,(0,1,2,3)} = (\beta_1 \cdot Empl_{pct}) + (\beta_2 \cdot Age_{cat}) + (\beta_3 \cdot Has_{child}) + (\beta_4 \cdot Car_{dist_{work}}) + (\beta_5 \cdot Constant_{value}) + (\beta_6 \cdot Teleworking) \quad (4)$$

The location for teleworking were set up according to the home location of each person reffering to Work From Home (WFH) condition. However, it is necessary to consider a more complex approach about the location of teleworking such as working from café, co- working space or even satellite office in the future.

3.3 Activity Pattern Analysis

Another performance indicator that is equally substantial is the activity pattern of each person, as shown in Table 2, the targeted activity patterns were constructed beforehand. The number of activity patterns generated in the base scenario will be directly compared with the number of activity patterns generated in the teleworking scenario. The year 2018 was chosen mainly due to the availability of datasets. In ABM, the availability of ADS is very crucial, however, this survey costs a lot of time and capital which is not possible to be done under the current condition. The teleworking policy scenario were simulated after manipulating the tour frequency choice model, introducing a new activity type and teleworking attribute for workers that was assumed. Changes compared to the base scenario was done by strictly looking at the difference in the number of tours in the activity patterns generated. Simulation-wise, there are still many varieties of activity patterns that came as the results of the model, however, in this study, only 11 activity patterns will be analysed due to the significance of these patterns associated with the policy being evaluated. Due to that reason, the total number of the activity patterns may seem unbalanced towards the comparisons.

Table 2: Targeted activity pattern

Activity Patterns in Jabodetabek			
Target	No.	Activity Pattern	Abbreviation
Workers	1	Home → Work → Home	HWH
	2	Home → Work → Shopping → Home	HWSH
	3	Home → Work → Private → Home	HSWH
Students	4	Home → Education → Home	HEH
	5	Home → Education → Private → Home	HEPH
Others	6	Home → Shopping → Home	HSH
	7	Home → Private → Home	HPH
	8	Home → Shopping → Private → Home	HSPH
	9	Home → Private → Shopping → Home	HPSH
	10	Home → Private → Private → Home	HPPH
All	11	Home / Work From Home	H/WFH

4. Results

The base year for the model was set as 2018, which was also the year the ADS was conducted. Table 3 shows the changes in activity patterns that were revealed after the simulations. Some values were written in colors to indicate the significant changes in the activity pattern. The red color highlights the increase in the number of activity patterns being conducted, while blue signifies the decrease. It is also important to underline that the home activity (H) in this study includes not only people who are staying at home but also all the H activity generated from all the other patterns, for example, an (H – W – H) pattern will add 2 (H) activity in the analysis. As it currently stands, the numbers on the last row represent the total number of home activity that was done by each occupational categories of workers, students, and others.

Table 3: Activity pattern results

Activity Patterns in Jabodetabek				
Target	No.	Activity Pattern	Base (Tours)	Teleworking Impact (Tours)
Workers	1	HWH	7939206	3112758
	2	HWSH	890703	414216
	3	HWPH	1218789	582813

Students	4	HEH	1361250	1361250
	5	HEPH	366300	366258
Others	6	HSH	515790	439659
	7	HPH	1470150	1263735
	8	HSPH	2623698	2036232
	9	HPSH	2842587	2251359
	10	HPPH	4992570	4060386
All	11	H/WFH	43037676	62086662

The results from Table 3 indicated the change of number activity patterns generated after the introduction of teleworking policy. The expected result of the teleworking policy was to see the number of home activities increasing as work activities decrease; the actual results have corresponded to the initial hypotheses. While the number of work activities decreases, home activities have increased. This can be seen from the result where the number of work-related patterns such as (H – W – H), (H – W – S – H) and (H – W – P – H) decreased significantly, while other secondary activity patterns such as (H – S – H) and (H – P – H) also experienced a slight decline, while (H / WFH) activity patterns increased.

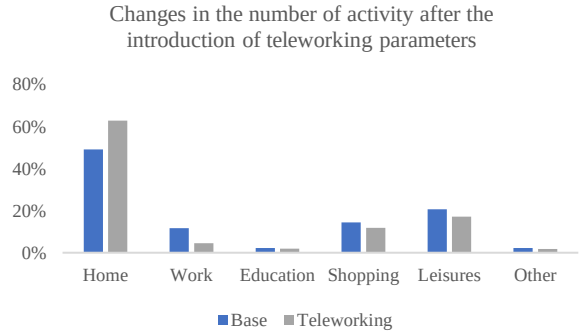


Figure 5*:* Activity executions results

Figure 5 compares the number of each activity generated under both scenarios, in the teleworking case a huge drop of percentage in the work activity was converted into home activities.

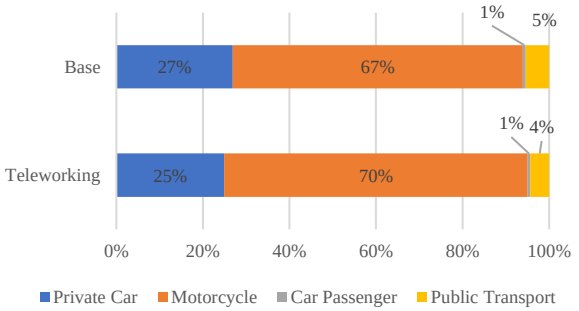


Figure 6*:* Modal choice results

In addition to that, figure 6 shows the changes in modal share after the introduction of teleworking policy, the mode type being considered in the model includes private car, motorcycle, public transport, and car as passengers. Moreover, the modal share for the teleworking case was shown, the increased number of motorcycle share was caused by the decreased number of trips generated in teleworking case. According to the census data, 35.99% of the households in Jabodetabek own more than 2 motorcycles.

In total, the results of VKT and VHT of each scenario were compiled, the base results show that over 800 million Vehicle Kilometers were traveled and over 37 million vehicle hours were traveled. Table 4 shows the results of each scenario, these results will also be the indicator of how effective the teleworking policy scenario is in reducing congestions in the study area. Based on the results of the activity pattern analysis, it can be understood that the teleworking scenario has managed to decrease the VKT and VHT values.

Table 4: Results of VKT and VHT in Jabodetabek

ABM Results		
33,918,000 people	Base Scenario Results	Teleworking Scenario Results
VKT in Kilometers	867,053,377	645,267,426
VHT in Hours	37,293,510	22,267,710

The result in this study shows how teleworking policy affects the traveler's choices in generating their schedule and thus, resulting in the change of their travel behavior. It was understood that there are many methodologies in implementing different policy scenarios via the ABM used in this study, however, due to the lack of past paper,

information about which method is the best is still limited. There are roughly three Activity-Based demand forecasting approach, first being the Utility-based, second is the Rule-based, and third is basically the Combination of both approaches. This study used the model to simulate the choices that maximize individual preferences under time and space constraints. In the process of estimating the results, multiple ways were discovered to express the policy, and the current method shown in this study is deemed to be the best-suited method. The results of the simple comparisons of VKT and VHT show how the introduction of teleworking policy decreases both values. Teleworking policy was evaluated in this study to show the flexibility and sensitivity of the model in evaluating a new kind of policy. In this study, ABM provides a better indication in evaluating the policy by expressing the changes in the activity pattern of each traveler.

Table 3 has managed to capture and express the changes in which a traditional trip-based method could not. In the teleworking case, some of the work-related activity patterns such as (H – W – H) was converted into home activity pattern such as (H / WFH) by a big margin. This was due to the parameter setting of tour frequency choice, in this study only the work tour frequency choice sub-model was modified. However, if the study was trying to portray the actual condition of the pandemic, all tour frequency choices such as (education tours and others tours) should be affected by teleworking impact to correctly express the situation. By doing so, the outcomes of teleworking policy will offer a different analysis by the huge decrease in VKT and VHT values.

Several limitations of the study were also discovered, the parameter for the base network in this study was calculated using the ADS data, however, the parameters used in the teleworking policy scenario were based on the trial-and-error method. Moreover, only Work from Home (WFH) was considered as a teleworking response in this study.

5. Conclusion

This study evaluated the impact of the introduction of teleworking policy on traffic demand using ABM that was applied in Jabodetabek, Indonesia. There were 3 key findings in this study,

1) Population synthesis which was developed by employing the census and ADS data plays an integral part in ABM calculation. the generation of activity patterns is greatly related to the household type and individual variables such as income, vehicle ownership, and teleworking choice.
2) Teleworking policy was introduced with the corresponding parameters to express the condition where most workers had to choose to work at home instead of at the office. The result of activity pattern analysis has shown the increased numbers of home activity pattern due to the policy. Impact such as the decrease of VKT and VHT values of 15% and 25% respectively can also be seen in the model.

The analysis of changes in activity pattern also provides the originality of this study, to summarize, the number of activity pattern for each person were estimated and compared by the introduction of teleworking policy. 11 significant activity patterns for workers, students, and non-workers were categorized, the results clarify the variations of people being affected by the traffic demand management measure, and these results are directly associated with the changes in travel behaviors, which a conventional trip-based method could typically express. Hence, in this study, it was concluded that the analysis of activity patterns can provide additional information for decision-makers to consider in implementing a policy that might impact people's activity patterns. Learning from the current pandemic condition, society understood how a humble virus can greatly affect trip behavior in a city and a country through a lockdown policy, which causes people to not be able to leave their houses for work, school, and shopping. Understanding the importance of activity patterns will contribute into the development of a much more efficient planning in times of another emergency as measures to be organized in the future.

Regarding the future application of ABM, past studies have shown that the current development of ABM is not a reliable tool for long-term travel demand forecasting, the model needs to be calibrated with specific data such as Big Data (Cell Phone Data) which is not widely available yet. To assess the reliability of the model in this study, future studies will include the verification of the model by referring to the real traffic count data of the study area, this data is supposedly available to be referred from the most recent masterplan study of Jabodetabek. In addition to that, a survey will be conducted to do an analysis of how the PPKM (lockdown) condition due to covid-19 affects travel behavior in Jabodetabek. Moreover, instead of assuming the teleworkers based on the type of work and income levels, a regression analysis will be done to produce a weight in the population synthesis process where each person will be assigned

to estimate their choice of teleworking. Thus, future studies might be able to incorporate other responses such as work from café / satellite office or even flextime. Likewise, the survey will also address the parameter issue in this study as well.

6. Acknowledgment

The authors would like to thank JICA for providing all the significant data for the study, PTV Japan for granting the use of thesis license and to the editors and the anonymous referees for their valuable comments and suggestions that improve the quality of this paper.

References

[1] A. Horni and K. Axhausen, "MATSim Agent Heterogeneity and a One-Week Scenario" (ETH Zürich and IVT, 2012).

[2] A. Shamshiripour et al., "How is COVID-19 reshaping activity-travel behavior? Evidence from a comprehensive survey in Chicago" (Transportation Research Interdisciplinary Perspectives, 2020).James, H.B. (1998) *Introduction to Transportation Engineering*, McGraw-Hill, New York.

[3] A. Tajaddini, et al., "Recent Progress in Activity-Based Travel Demand Modeling: Rising Data and Applicability" (Intech Open, 2020).

[4] C. Bhat and Y. Pouri, "On Modeling Choice and Frequency of Home-Based Telecommuting" (Transportation Research Records, 2003).

[5] E. Ansong, "Organizational adoption of telecommuting: Evidence from a developing country" (EJISDC, 2017).

[6] H. Asgari and X. Jin, "Toward a Comprehensive Telecommuting Analysis Framework" (Transportation Research Record Journal of the Transportation Research Board, 2015).

[7] J. Auld and A. Mohammadian, "Framework for the development of the agent-based dynamic activity planning and travel scheduling (ADAPTS) model" (Transportation Letters, pp. 245-255, 2009).

[8] J. Auld et al., "POLARIS: Agent-based modeling framework development and implementation for integrated travel demand and network and operations simulations" (Transportation Research Part C: Emerging Technologies, 2016).

[9] J. Bieser et all., "Impacts of telecommuting on time use and travel: A case study of a neighborhood telecommuting center in Stockholm" (Travel Behaviour and Society, volume 23, pp 157-165, 2021).

[10] J. Bowman and M. Ben-Akiva, "Activity-based disaggregate travel demand model system with activity schedules" (Transportation Research Part A, 2000).

[11] J. Ortuzar and L. Willumsen, "Modelling Transport, 4th Edition" (Aptara Inc., 2011).

[12] JICA and ALMEC Corporation, "JABODETABEK Urban Transportation Policy Integration Project Phase 2 in the Republic of Indonesia" (2019).

[13] M. Ben-Akiva and J. Bowman, "Activity Based Travel Demand Model Systems" (Equilibrium and Advanced Transportation Modelling pp 27-46, 1998).

[14] N. Hibino et al., "FUNDAMENTAL ANALYSIS FOR CLARIFICATION OF THE INFLUENCE IN COMMUTING BEHAVIOR AND WORKPLACE AND RELOCATION OF DWELLING BY CHANGE OF WORK STYLE" (Journal of JSCE, 2019).

[15] P. Zhu and S. Mason "The Impact of Telecommuting on Personal Vehicle Usage and Environmental Sustainability" (International Journal of Environmental Science and Technology, 2014).

[16] R. Kitamura et al., "An evaluation of telecommuting as a trip reduction measure" (1991).

[17] R. Shabanpour et al., "Investigating the applicability of ADAPTS activity-based model in air quality analysis" (Travel Behaviour and Society, 2017).

[18] R. Shabanpour et al., "Analysis of telecommuting behavior and impacts on travel demand and the environment" (Transportation Research Part D, 2018).

[19] S. Handy and P. Mokhtarian, "Forecasting telecommuting" (Transportation 23, 1996).

[20] S. Kim, "Is telecommuting sustainable? An alternative approach to estimating the impact of home-based telecommuting on household travel" (International Journal of Sustainable Transportation, pp 72-85, 2016).

[21] S. Yagi, D. Nobel, and H. Kawaguchi, "Review of Past Urban Transportation Studies and Implication for Improvement on Travel Surveys and Demand Forecasting Methods in Developing Countries" (Journal of the Eastern Asia Society for Transportation Studies, Vol.13, 2019).

[22] S. Yamada et al., "Development of an Activity-based Model System for Tokyo Metropolitan Urban Rail Planning" (Journal of the Eastern Asia Society for Transportation Studies, Vol.13, 2019).

[23] Suarlan, "Teleworking for Indonesian Civil Servants: Problems and Actors" (International Journal of Administrative Science & Organization, 2017).

[24] T. Arentze and H. Timmermans, "Albatross: a learning-based transportation-oriented simulation system" (Citeseer, 2000).

SESSION 2: AYRF 2021 SPECIAL SESSION OF RESEARCH PAPER PRESENTATION
From Paper ID: 005-2021 To Paper ID: 008-2021

PAPER ID/ Page No.	Paper entitled	Presented by
005-2021 **p.33**	"Dynamic Simulation Analysis of Impact on Teleworking Policy for After COVID-19 Using Land-Use and Transport Model: Case Study of Japanese City within Population Decline"	**Dr.Hiroki KIKUCHI** Nihon University, Japan
006-2021 **p.41**	"Study on Improvement of Star Rating Approach to Extract Traffic Hazardous Location in Nakhon Ratchasima Province, Thailand"	**Mr.Takeru MIYOKAWA** Nihon University, Japan
007-2021 **p.52**	"The impact of COVID-19 on the travel behavior of carsharing users in Bangkok"	**Ms.Monthira PHAMORNMONGKHONCHAI** Kasetsart University, Thailand
008-2021 **p.61**	"Supply Analysis of an Access Mode for Local Travel: The Case of Tricycles in the Philippines"	**Prof.Dr.Alexis M. Fillone** De la Salle University, The Philippines

Dynamic Simulation Analysis of Impact on Teleworking Policy for After COVID-19 Using Land-Use and Transport Model: Case Study of Japanese City within Population Decline

Paper Identification number: AYRF-005

Hiroki KIKUCHI[1], Atsushi FUKUDA[2]

[1]Department of Transportation Systems Engineering,
College of Science and Technology
Nihon University
Telephone +81-47-469-5355, Fax. +81-47-469-5355
E-mail: kikuchi.hiroki@nihon-u.ac.jp

[2]Department of Transportation Systems Engineering,
College of Science and Technology
Nihon University
Telephone +81-47-469-5355, Fax. +81-47-469-5355
E-mail: fukuda.atsushi@nihon-u.ac.jp

Abstract

In Japan, the spread of COVID-19 will unexpectedly promote telework, and it is necessary to evaluate how this impact will affect future land-use and transportation. Therefore, this study clarified the impact of telework policy on land-use and transportation fields and analyzed a telework dissemination policy scenario premised on the progress of ICT for Japanese cities with a declining population. For the analysis, the MARS (Metropolitan Activity Relocation Simulator) based on the principle of system dynamics (SD) was adopted, and the impact by 2060 was simulated. As a result, it was clarified that teleworking policy and ICT advances significantly affect land-use and transportation. In particular, the findings show that the percentage of public transportation riders will dramatically decrease, and the percentage of car and motorcycle users will increase. However, it was concluded that more promotion would keep the expanded residential areas while maintaining the convenience level of the suburban areas due to unnecessary commute and move to the urban areas.

Keywords: Dynamic Simulation, Teleworking Policy, Land-Use and Transport Model, Population Decline, Japanese City

1. Introduction

Information and communication technology (ICT) innovations spread teleworking around the world. For example, many companies in the US are setting up remote work policies to fulfill many employees' desires for flexible working. The share of workers who frequently work at home or other remote locations increases every year [1]. In contrast, according to statistics published by the Ministry of Internal Affairs and Communications in Japan, the national penetration rate of teleworking is at a low level of around 10% to 15% [2]. As the Japanese workforce is expected to become scarce due to a population decline, it has been strongly required that ICT-based teleworking is speeded gradually towards the future. Unexpectedly, the spread of COVID-19 suddenly teleworking has promoted in Japan because the opportunities for people to go out have to be limited. This promotion led to an increase in the rate of staying home and a decrease in the use of public transportation [3]. Hence, this spread has impacted on land-use and transportation fields significantly.

Many existing studies have analyzed the impact of teleworking diffusion due to ICT innovation on land-use and transportation fields. For example, Soler, et al. identified the user profiles and spatial aspects that affected teleworking and online shopping adoption and explored the potential impact on transport demand. They concluded that teleworking appears to have a high potential mainly in specific services sectors, affecting commuting

patterns predominantly in large urban areas [4]. Vakilian and Edrisi obtained a correlation for travel demand using a regression model based on independent variables. Those with an appropriate significant level were presented in the model among the variables studied. They found that the history and percentage of teleworking, the time delay between home and work, and the distance traveled in the model related to the transport demand of this community had the most significant impact on the demand for telework [5]. Elldér captured travel behavior during the defined period when the telework was practiced, distinguishing different telework arrangements and analyzing a range of travel behavioral outcomes. He clarified that telework leads to reduced travel demand, more usage of active transport modes, and congestion relief [6]. In the land-use field, Stoica, et al. considered the main aspects of telework from the perspective of local experience, the main elements of the internet of everything (IoE), and presented a mathematically based model for choosing the residence in the context of telework in the information society and digital economy [7]. Wang and Ozbilen proposed a novel analytical approach to explore the influences of the duration of telework on sustainable travel. The findings suggested that well-designed telework provisions could complement compact development policies shifting from automobile dependency to sustainable travel [8]. Previous studies have found that teleworking policy can significantly affect urban activities such as land-use and transport fields. However, there has been little research regarding the long-term policy impact on urban activities.

Therefore, in order to clarify the impact of teleworking policy on land-use and transportation, this study developed scenarios towards ICT advances and teleworking diffusion policies for a city with a declining population in Japan and simulated those scenarios using the land-use and transport model. The model adopted the MARS (Metropolitan Activity Relocation Simulator) based on principles of system dynamics (SD).

2. Methodology

2.1 Study Area

Chiba is the capital city of Chiba Prefecture, which is one of the five Tokyo Metropolitan Area prefectures designated by government ordinance in 1992. As shown in Figure 2, Chiba is divided into six regions (Chuo-ku, Hanamigawa-ku, Inage-ku, Wakaba-ku, Midori-ku, and Mihama-ku), covers an area of 272.08 km^2, and had a population of approximately 0.98 million in 2020 living in approximately 0.45 million households [9]. In the last 30 years, the working-age population has been aging and the young population percentage has been decreasing, which indicates that Chiba is an aging, shrinking city [10].

Chiba experienced rapid urban and economic growth from the 1960s to the 1980s. In the 1960s, the urban areas along the railway corridors were developed, which then gradually expanded into suburban areas.

Transport networks in Chiba include railways, monorails, and buses. The railways connect Chiba to the nearby Tokyo Metropolitan Area, with many residents in Chiba commuting to Tokyo every day. The monorail and buses connect the residential suburban areas to the railway stations. However, as Chiba has a higher ratio of private cars than other ordinance-designated cities in the Tokyo Metropolitan Area, the public transportation networks do not fully cover the suburban residential areas.

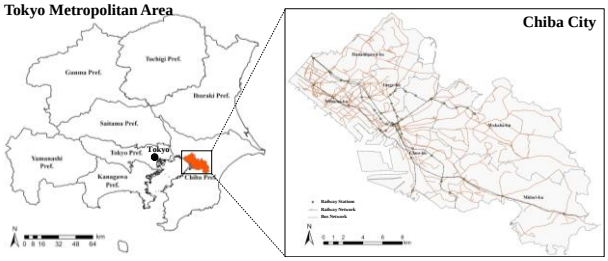


Figure 2 Location of Chiba

To apply the MARS, transportation, land-use, population, and employment data were collected from the Japanese Government Statistics portal, "e-Stat." In addition, it was necessary to divide the city into spatial zones and simulate the policy impacts in each zone separately. Therefore, based on the traffic analysis zones (TAZ) extracted from Tokyo Metropolitan Area trip surveys, Chiba was divided into 24 TAZ, as shown in Figure 3. This study defined two regions: urban areas (19 zones) and suburban areas (5 zones).

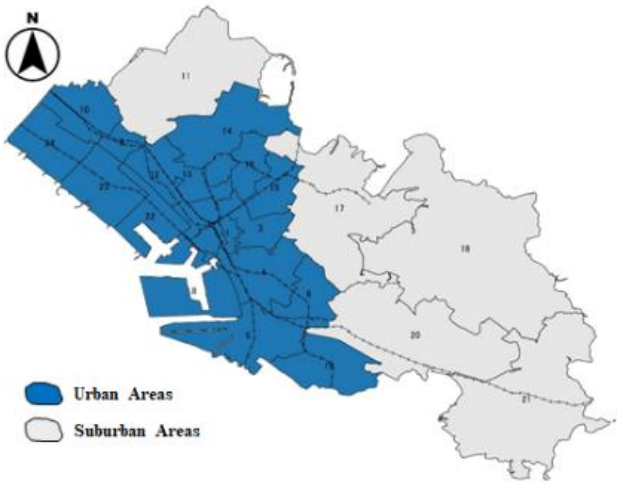


Figure 3 Map of traffic analysis zones (TAZ)

2.2 Land-Use and Transport Model (MARS)

This study used the MARS to simulate the impact of teleworking policy on land-use and transport interactions.

The MARS is one of the LUTI models based on SD and synergetic principles. Pfaffenbichler [11] constructed the MARS components using a Vensim which is SD programming environment, with the final model including a transport sub-model to simulate the population travel behaviors related to residential and workplace locations, a land-use sub-model that included a housing development model, a household location choice model, a workplace development model, a workplace location choice model, a fuel consumption model, and an emissions model, as shown in Figure 4. All these sub-models in the MARS are interconnected and can be iteratively simulated over a nominated period. The transport sub-model includes a passenger transport module comprising trip generation, trip distribution, and mode choice, which are simulated using a gravity (entropy-maximizing) type model for the various transport modes: walking, cycling, car, and public transportation (bus and rail). The accessibility indicators are input into the household location sub-model, and the available land is calculated. In the land-use sub-model, new housing and workplace developments within the different zones are estimated. The new housing development model (residential model) is split into supply- and demand-side models, and the workplace model is based on the market forces within each area, such as the economic growth rate. The spatial distribution and available land assessments from the workplace location sub-model are passed to the transport and household location sub-models, and all sub-models run iteratively over a specified simulation period.

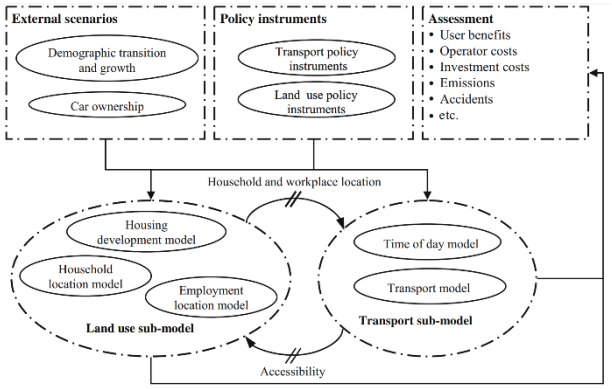


Figure 4 Model structure of the MARS model [12]

2.3 Scenario Settings

This study established two scenarios (A and B), as shown in Table 1, to generate long-term policies for adapting the "New Normal" lifestyle, with each scenario comprising a city image goal and the actions needed to achieve that goal. The scenario details are as follows.

S Scenario A was business as usual, which assumes that the future land-use and transport development trends follow past ones, and no policies are implemented. Scenario B assumed that the local governments positively introduce information and communication technology (ICT) into the public facilities to maintain urban service levels, with commuting gradually reducing by 50% by 2060 as teleworking becomes more popular based on teleworking diffusion goal in Japan. Also, not only reducing commuting trips due to teleworking policy, as the ICT diffusion is expected to digitize application forms and books, this study assumed that the administrative facilities and libraries are aggregated, and smaller facilities removed. This scenario assumes that the new normal under the COVID-19 pandemic will become conventional. This means that significant changes in the digitalization of the public facilities under the pandemic may affect the process of compact cities in the long term.

Table 1 Scenario details

Scenario	Purpose of Scenario	Scenario Actions
A	・No implementation of policies ・Baseline scenario	・No actions
B	・Maintain urban service levels using advanced information and communication technology (ICT) on the assumption of the "New Normal" lifestyle after the COVID-19 pandemic	・Gradual reduction in commuting trips by 2060 due to teleworking popularization (Goal: reduction by 50%) ・Removal of administrative facilities and libraries by digitizing application forms and books

2.4 Model Simulation and Validation

The model simulation execution period was 50 years, from 2010 to 2060. Therefore, to clarify the teleworking policy effects and feasibilities after the target year, the model simulated from 2020 to 2060. This study simulated the model by six modes of transportation: walk, bicycle, car, motorcycle, rail (including monorail), and bus. Also, this study did not run simulations of telework policies by occupation for simplicity of modeling.

In order to verify the model application's accuracy, this study simulated the first ten years (2010 to 2020) without any implemented policies. This study selected variables calculated endogenously in the model simulation from the land-use sub-model and the transport sub-model, respectively. For the land-use sub-model, the number of residents by zone was selected. The validation period for the accuracy of the number of residents by each zone is from 2010 to 2020. For the transport sub-model, the modal split was selected. The model accuracy was validated using the data from the 6th Tokyo Metropolitan Area Person Trip Survey in 2018, as the only person trip survey conducted in the decade from 2010 to 2020 was in 2018. The results of the validation are shown in Figure 5 and Figure 6.

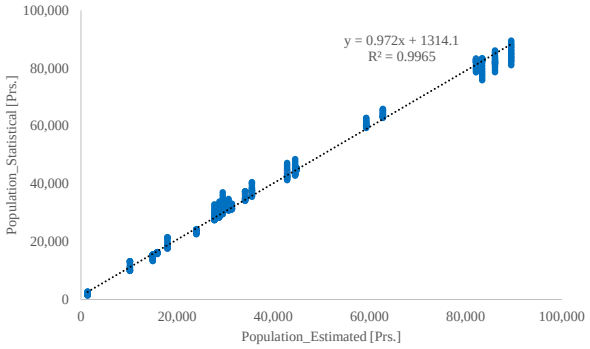


Figure 5 Validation result for land-use sub-model

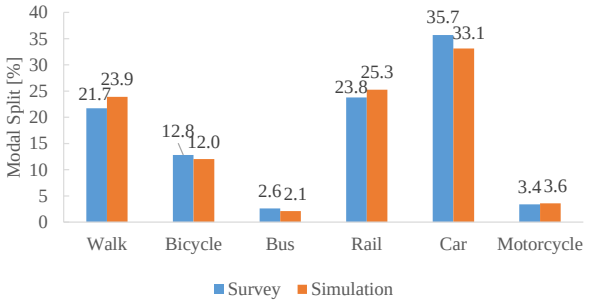


Figure 6 Validation result for transport sub-model

As a result of verifying the accuracy of the land-use sub-model, the coefficient of determination R-square of the number of residents by zone was 0.9965 (Figure 5). This means that the value was close to the coefficient of determination of 1. The overall mean error of the transportation ratio was 1.3% (Figure 6). Thus, the land-use sub-model and the transportation sub-model were high accuracies.

3. Results

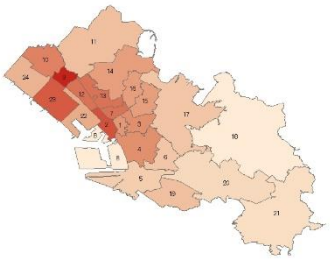
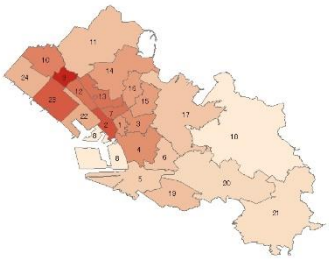
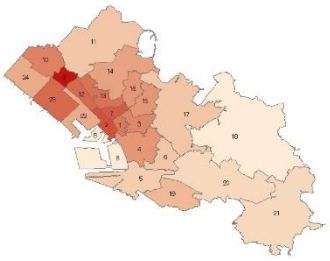
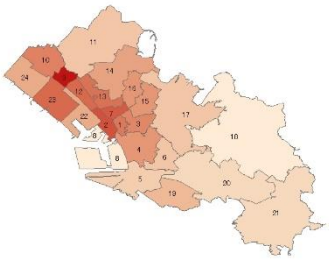
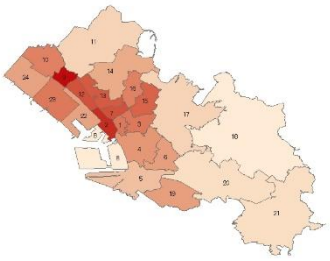
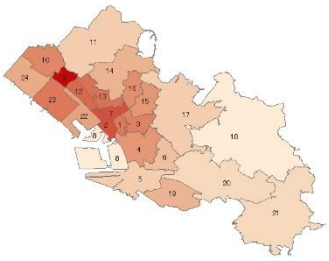
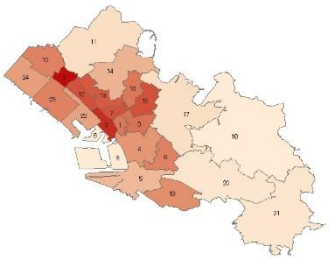
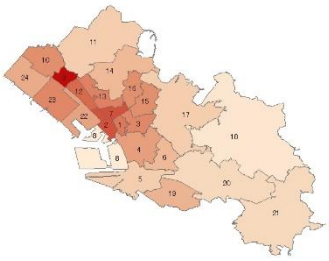
3.1 Population Density

The simulation results of population density for each scenario every ten years are shown in Figure 7, and Figure 8 shows the rate of the suburban population to the total population.

In Scenario A, since no policy is implemented during all simulation periods, it shows how the density of population in the city will change over time in the future. The findings show that the population density in the urban areas was higher than that in the suburban areas, but a certain level of density was maintained even in the suburban areas. This means that Chiba has a certain population distributed throughout the city. However, it clarified that the population density gradually decreased mainly in the suburban areas due to the progressive decrease in population in the latter half of the period. The result shows that the number of people in the

suburban areas has been reducing gradually because of moving to the urban areas having high convenience as time passes.

In Scenario B, residents living in suburban areas tend not to move to urban areas because the promotion of teleworking eliminates the need to commute to employment sites primarily distributed in the urban areas. Especially in southern suburban areas, the population density was higher than in Scenario A because there are developable residential areas compared with other regions. It means that telework policy leads to urban sprawl, although local governments aim to realize the compact city. The rate of the suburban population has barely changed during the simulation periods. Consequently, in the final simulation year (2060), it was a difference of 20% between the two scenarios.

Year	Scenario A	Scenario B
2010		
2020		
2030		
2040		

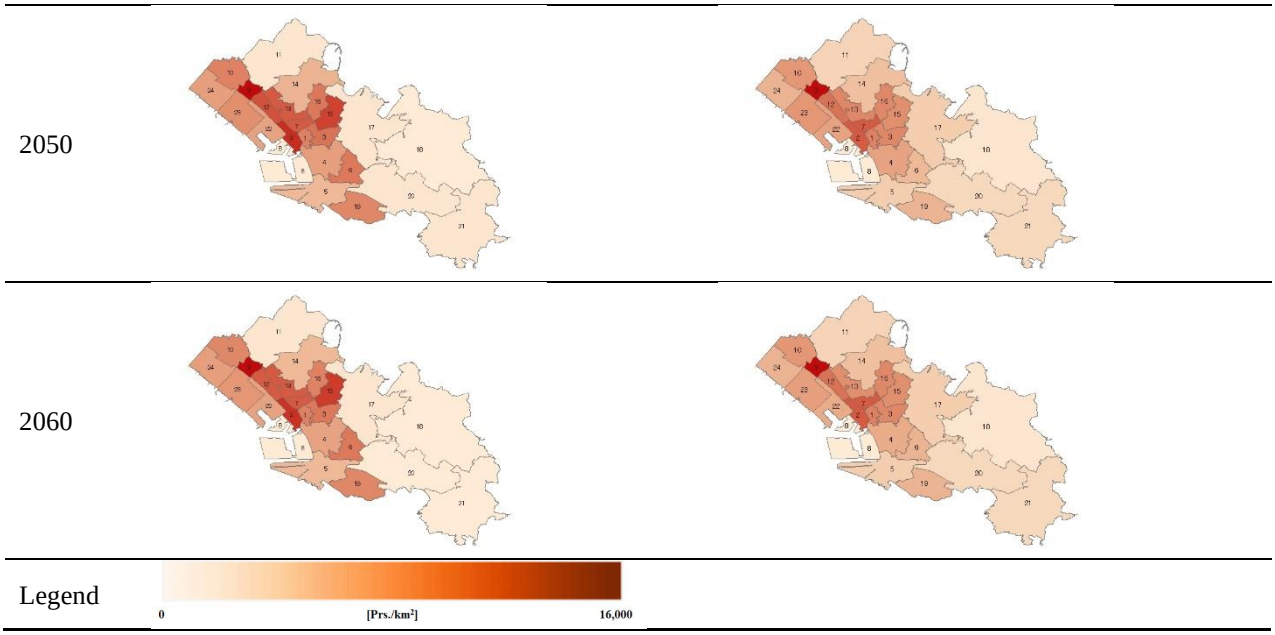


Figure 7 Population density each scenario

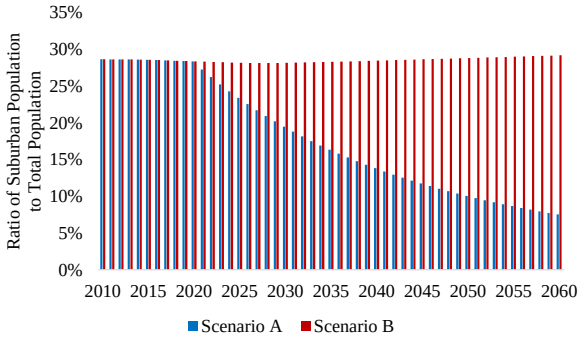


Figure 8 Rate of suburban population to total population

3.2 Modal Split

This study analyzed the modal split of each scenario which was estimated endogenously by the transport sub-model, as shown in Figure 9 and Figure 10. This study covered six modes: pedestrians, bicycles, buses, rails, cars, and motorcycles.

As shown in Figure 9, Scenario A shows the modal split without teleworking policies. Although there was no significant change in the percentage by 2060, it was clarified that the share of public transportation (rail and bus) would decrease in the future due to the distribution of residents throughout the suburban areas. And there was a tendency to shift to cars and motorcycles gradually.

As shown in Figure 10, in Scenario B, the proportion of public transportation decreased significantly from 2020 because the number of commuting trips gradually reduced due to the implementation of teleworking policy (approximately 5%). In particular, since many public transportation trips in Chiba were for commuting purposes, the proportion of public transportation decreased significantly as ICT advanced. In addition, it was found that the proportion of cars and motorcycles tended to increase because people live in suburban areas far away from the public transportation network.

These results indicated that the ICT advanced would lead to a decrease in mobility and increase convenience, but the proportion of people using private transport such as cars and motorcycles would increase.

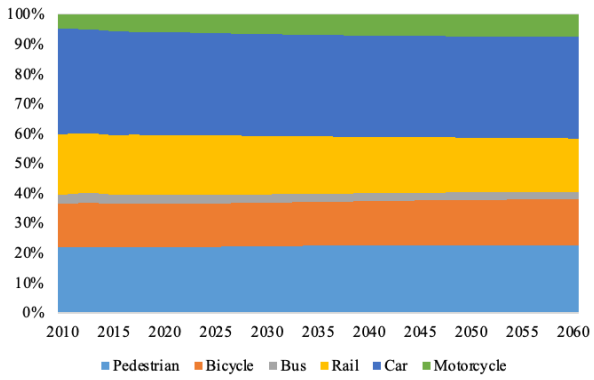


Figure 9 Modal split (Scenario A)

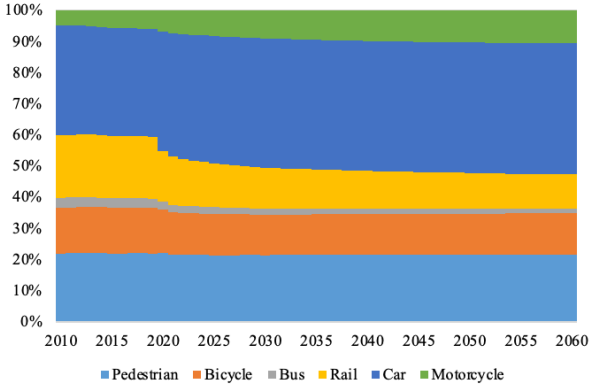


Figure 10 Modal split (Scenario B)

4. Conclusion

This study simulated the impact of implementing teleworking policy under population decline in Chiba using the MARS, a land-use and transport model based on system dynamics. It analyzed the policy implementation affects two scenarios.

The results show that teleworking policy and ICT advances affect land-use and transportation. In particular, the findings show that the percentage of public transportation riders will decrease significantly, and the rate of car and motorcycle users will increase.

In conclusion, the more diffusion of teleworking and ICT advances will keep the expanded residential areas while maintaining the convenience level of the suburban areas due to unnecessary commute and move to the urban areas. However, the teleworking policies will hamper urban compactification in the cities within population decline because the residents living in suburban areas do not move to the urban areas. In cities with large numbers of commuters using public transportation, there is a possibility that fewer users of public transit will decline due to more prominent teleworking people. Thus, the government and municipalities will need to respond to these negative aspects as ICT become more widespread.

Further study needs to analyze travel time and urban service levels due to teleworking and ICT advances diffusion. Also, the proposed model cannot simulate the fact that not all workers in every sector can do teleworking. It is necessary to improve the model for simulating the impact of the teleworking policy on the different types of employment.

References

[1] United States Office of Personnel Management. (2021) 2021 Guide to telework and remote work in the Federal Government: Leveraging telework and remote work in the Federal Government to better meet our human capital needs and improve mission delivery, 79pp.

[2] Ministry of Internal Affairs and Communications. (2020) Report of the basic survey on the information and communications usage, 72pp. (in Japanese).

[3] Kikuchi, H., Ushijima, Y. and Fukuda, A. (2020) Analysis of impact of COVID-19 measures on travel behavior: Perspective from international comparison, *Proceeding of ATRANS Young Researcher's Forum 2020*, 11pp.

[4] Soler, J., Christidis, P. and Vassallo, M.J. (2021) Teleworking and online shopping: Socio-economic factors affecting their impact on transport demand, *Sustainability*, Vol.13, No.13, 24pp.

[5] Vakilian, R. and Edrisi, A. (2020) Modeling factors affecting the choice of telework and its impact on demand in transportation networks, *Civil and Environmental Engineering*, Vol.16, Issue 1, pp.21-29.

[6] Elldér, E. (2020) Telework and daily travel: New evidence from Sweden, *Journal of Transport Geography*, Vol.86, 102777.

[7] Stoica, M., Ghilic-Micu, B. and Mircea, M. (2021) The telework paradigm in the LoE ecosystem –A model for the teleworker residence choice in context of digital economy and society, *Economic Computation and Economic Cybernetics Studies and Research*, Vol.55, Issue 3, pp.263-278.

[8] Wang, K. and Ozbilen, B. (2020) Synergistic and threshold effects of telework and residential location choice on travel time allocation, *Sustainable Cities and Society*, Vol.63, 102468.

[9] Chiba City Government. (2021) Population data of Chiba city, https://www.city.chiba.jp/sogoseisaku/sogoseisaku/kikaku/tokei/top.html, (in Japanese) Accessed in December 2021.

[10] Chiba City Government. (2019) Future population, https://www.city.chiba.jp/sogoseisaku/sogoseisaku/kikaku/population2.html, (in Japanese) Accessed in December 2021.

[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, 275pp.

[12] Pfaffenbichler, P., Emberger, G. and Shepherd, S. (2008) The integrated dynamic land use and transport model MARS, *Networks and Spatial Economics*, Vol.8, pp.183-200.

Study on Improvement of Star Rating Approach to Extract Traffic Hazardous Location in Nakhon Ratchasima Province, Thailand

Paper Identification number: AYRF-006

Takeru MIYOKAWA[1], Hiroki KIKUCHI[2], Tuenjai FUKUDA[3],
Rattanaporn KASEMSRI[4], Atsushi FUKUDA[5]

[1]Graduate School of Science and Technology, Nihon University, Funabashi, Japan
Tel. & Fax. +81-47-469-5355
Email: csta20016@g.nihon-u.ac.jp

[2]Department of Transportation Systems Engineering,
College of Science and Technology, Nihon University, Funabashi, Japan
Tel. & Fax. +81-47-469-5355
Email: kikuchi.hiroki@nihon-u.ac.jp

[3] Research Institute of Science and Technology, Nihon University, Funabashi, Japan
Tel. & Fax. +81-47-469-5355
Email: noynoifukuda99@gmail.com

[4]Industrial Science of Technology,
Suranaree University of Technology, Nakhon Ratchasima, Thailand
Tel. +66-4422-3000, Fax. +66-4422-4070
E-mail: rattanaporn7777@gmail.com

[5]Department of Transportation Systems Engineering,
College of Science and Technology, Nihon University, Funabashi, Japan
Tel. & Fax. +81-47-469-5355
Email: fukuda.atsushi@nihon-u.ac.jp

Abstract

Road traffic accident data is not properly collected in developing countries so that traffic accident analysis is not sufficiently carried out. Thus, it is often not possible to select and apply appropriate traffic safety measures. Under such circumstance, many developing countries have tried to employ iRAP (International Road Evaluation Program) proposes which can be applied without relying on road traffic accident analysis. By employing the evaluation method based on Star Rating Approach of iRAP, the places where traffic safety measures are required can be selected based on external inspection of road facilities (road geometric structure, road attachments, road surface condition). However, the degree of danger evaluated by Star Rating Approach and the danger point based on traffic accident data may not match. It is not always clear whether Star Rating Approach contributes to reducing road traffic accidents. In this study, we clarified the problems of the existing Star Rating Approach by comparing the evaluation results with the hazardous locations based on the traffic accident data and the "Hiyari Hatto" data for the local cities in Thailand, and proposed the improvement of the existing Star Rating Approach.

Keywords: Road Safety, Star Rating Approach, Hiyari Hatto, Traffic Accident, iRAP

1. Introduction

In ASEAN countries, the rapid increase in road traffic fatalities and injuries has become a major social problem due to the rapid progress of motorization. For most of countries, the effective traffic safety measures should be implemented immediately. However, since traffic accident data is

not collected correctly in these countries, the cause of the traffic accident cannot be identified, and appropriate traffic safety measures can't be selected.

To tackle these problems, Thailand, Malaysia, the Philippines, Vietnam, etc. are trying to introduce the evaluation system for safety of roads by the approach of road facilities (road geometric structure, road attachments, road surface condition) which is proposed by iRAP (International Road Evaluation Program) [1]. This approach chooses for the road segment where should be implemented road safety measures based on Star Rating Score (SRS). However, there are reports that the evaluation by SRS isn't correlate with the number of road traffic accidents sometimes. So, it is necessary to improve the approach by SRS evaluation.

Therefore, this paper confirmed whether the evaluation by SRS reflected the actual occurrence of road traffic accidents in Nakhon Ratchasima Province, Thailand as a case study. Additionally, if the road traffic accidents were not reflected in the SRS, the improvement of the Star Rating Approach was proposed.

2. Literature Review

The iRAP Star Rating Approach has been applied in many countries, such as the U.K., Australia, the U.S., and New Zealand [2], [3], [4]. Especially in ASEAN countries, Thailand, Malaysia, Vietnam, and the Philippines have introduced this approach on a trial basis [5], [6], [7]. In other countries such as India and Latin Americas, this approach also has been applied officially [8], [9], [10].

Many existing studies are discussing the iRAP Star Rating Approach as reviewed below. Hoque et al. [11] applied the SRS to extract traffic danger points in Bangladesh. They found that the type and danger of a particular traffic accident are related to the road design. Harwood et al. [12] compared SRS and crash rates on roads in Iowa and Washington State in the U.S. and clarified the relationship between SRS and crash rates. Many studies have been applied the approach to evaluate road traffic safety. Kamiya et al. [13] assessed the SRS for roads in Japan and compared it with the traffic accident data. As a result, there was no correlation between the risk level based on the SRS and the road traffic accident data. It clarified that road traffic accidents with casualties occurred at intersections with no right-angled (deformed intersections) as a characteristic of the sections where no correlation.

However, previous studies clarified no correlation between the degree of danger according to SRS and the danger point where the traffic accident occurred. They discussed that it is necessary to improve the iRAP Star Rating Approach items because there is a shortage of them.

Thus, when the Star Rating Approach is applied in ASEAN countries, it is necessary to check whether there is a correlation between the road points where actual road traffic accidents occur, or Hiyari Hatto points with a high degree of danger. If there is no correlation, it is necessary to understand the cause of the no correlation and improve the Star Rating Approach. In this study, the evaluation index for SRS was added as an approach improvement.

3. Methodology

3.1 Overview of Methodology

This paper calculated the SRS by applying the Star Rating Approach of iRAP and compared the SRS results with the number of Hiyari Hattoes and the number of road traffic accidents collected by the Department of Highway in Thailand (DOH). Mainly, this paper focused on the road segment that is rated as relatively safe using the current approach but has a high number of Hiyari Hatto and traffic accidents. In order to improve the current approach, this paper added the missing index to the evaluation index of the current approach. Finally, the SRS of the same road segment was assessed using the improved approach.

3.2 Star Rating Approach

a) Overview of Star Rating Approach

The Star Rating Approach evaluates the safety of road facilities (road geometry, road accessories, and road surface condition), which affect the likelihood of road traffic accidents and the degree of damage. The safety level of each road segment is determined for each user (car occupants, motorcyclists, bicyclists, and pedestrians) based on the SRS.

Historically, the Star Rating Approach was first developed by the EuroRAP in 1999 [14], [15]. The EuroRAP Approach model was based on assessments of road attributes, such as safety barriers, that afford protection to car occupants in the event of a crash. The equations and risk factors used in the EuroRAP model were developed by a working group comprising representatives of the Swedish

National Road Administration, the Dutch Ministry of Transport, National Roads Authority, Republic of Ireland, Transport Research Laboratory (TRL) and with contributions from the English Highways Agency, Germany federal research agency, BASt, and engineers and analysts from leading European motoring organizations and EuroRAP staff. After Euro RAP was developed, the AusRAP was also developed the Star Rating Approach in 2013 [16]. The AusRAP Approach model was based on assessments of road attributes that affect both the likelihood that a crash will occur such as delineation and those that provide protection in the event of a crash such as safety barriers. The AusRAP model was used over the period 2006 to 2008 to assess more than 20,000km of national highways and more than 5,000km of State highways.

b) How to Calculate SRS with Star Rating Approach

The SRS is calculated for each 100 meters segment of road, using the following equation (1):

$$SRS = \sum Crash\ Type\ Scores \quad (1)$$

The SRS represents the relative risk of death and serious injury for an individual road user as the following equation (2).

$$\begin{aligned} Crash\,Type\,Score = {} & Likelihood \times Severity \\ & \times Operating\ Speed \\ & \times External\ flow\,\text{inf}\,luence \\ & \times Median\,travers\,ability \end{aligned} \quad (2)$$

Likelihood refers to road attribute risk factors that account for the chance that a crash will be initiated. Severity relates to road attribute risk factors that account for the severity of a crash. Also, operating speed refers to factors that account for how much risk changes with speed. External flow influence factors account for the degree to which a person's risk of being involved in a crash is the function of another person's use of the road. Median ability factors account for the potential that an errant vehicle will cross a median (only applies to vehicle occupants and motorcyclists' run-off and head-on crashes).

Crash Type Score is calculated by weighting attribution and Evaluation Index. Evaluation Index is finely classified according to the geometric road structure, as shown in Figure 1. For example, the Evaluation Index for Intersection is subdivided into five items, as shown in Table 1.

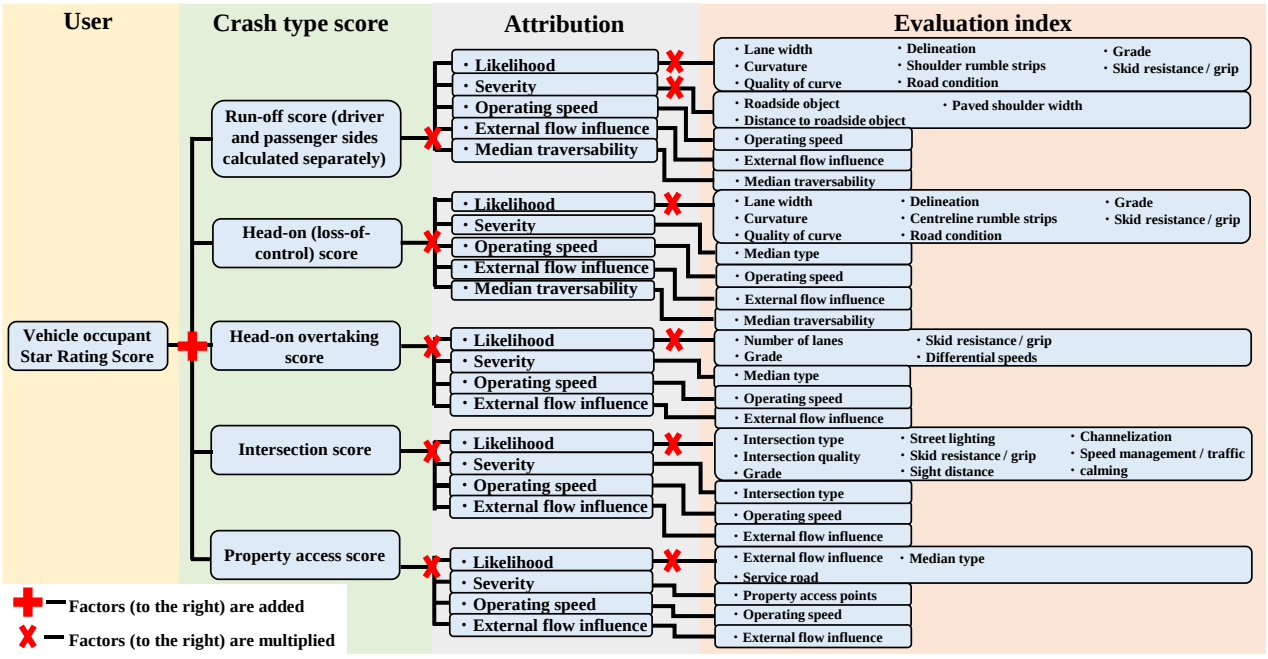


Figure 1 Vehicle occupant SRS

Table 1 Evaluation index for "Intersection"

		Likelihood	Severity
Intersection type	Merge lane	6	15
	Roundabout	15	15
	3-leg (unsignalised) with protected turn lane	13	45
	3-leg (unsignalised) with no protected turn lane	16	45
	3-leg (signalised) with protected turn lane	9	45
	3-leg (signalised) with no protected turn lane	12	45
	4-leg (unsignalised) with protected turn lane	16	50
	4-leg (unsignalised) with no protected turn lane	23	50
	4-leg (signalised) with protected turn lane	10	50
	4-leg (signalised) with no protected turn lane	15	50
	Unused code (non-major inters.)	0	0
	None	0	0
	Railway Crossing - passive (signs only)	1	150
	Railway Crossing - active (flashing lights/boom gates)	0.5	150
	Median crossing point - informal	0.5	45
	Median crossing point - formal	0.3	45
	Mini roundabout	16	35
	** Commercial access 1+	2	50
	** Residential access 1+	1.3	50
	** Residential access 1 or 2	1	50
Intersection channelization	Not present	1.20	-
	present	1.00	-
Intersection quality	Adequate	1.00	-
	Poor	1.20	-
	Not applicable	1.00	-
Property access points	Commercial access 1+	2.0	50.0
	Residential access 3+	1.3	50.0
	Residential access 1 or 2	1.1	50.0
	None	1.0	0.0

3.3 Study Area

A case study is Nakhon Ratchasima province in Thailand. The province is located in the Northeast part of Thailand (about 259 km from Bangkok of the capital city). The road segment is a part of National Highway No.2, which runs through the central part of Nakhon Ratchasima province, has much-passing traffic in the city. The target section of this study is about 36 km of the city area and suburban area National Highway No.2 as shown in Figure 2.

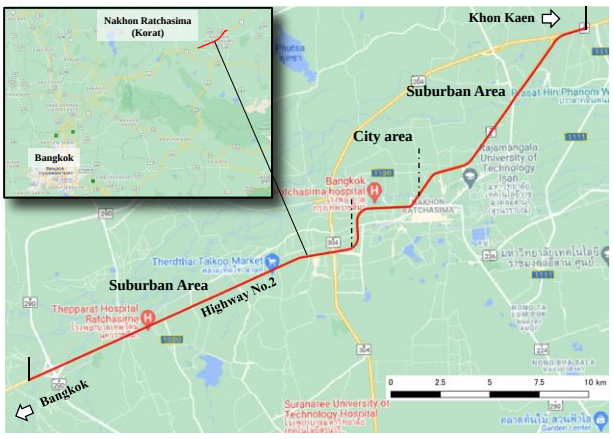


Figure 2 Map of the study area

3.4 Data Collection

a) Traffic Accident Data

This study used traffic accident data between 2015-2020 from the Highway Traffic Accident Information Management System (HAIMS), provided by DOH. This data is recorded traffic accident information such as the location of traffic accident occurrence, collision type, road type, the severity of traffic accident, and time of traffic accident occurrence on the national roads under their jurisdiction.

b) Hiyari Hatto Data

Hiyari Hatto Data was collected by conducting a questionnaire survey. The survey method was distributed to the respondents using the Hiyari Hatto event answer sheet and the occurrence point answer sheet. This survey targets residents who use National Highway No. 2 on a daily basis. Figure 3 shows an example of the answer on the Hiyari Hatto Events. As a result of the survey, 170 samples were collected for plotting the Hiyari Hatto locations as the data of Hiyari Hatto spots (Figure 4).

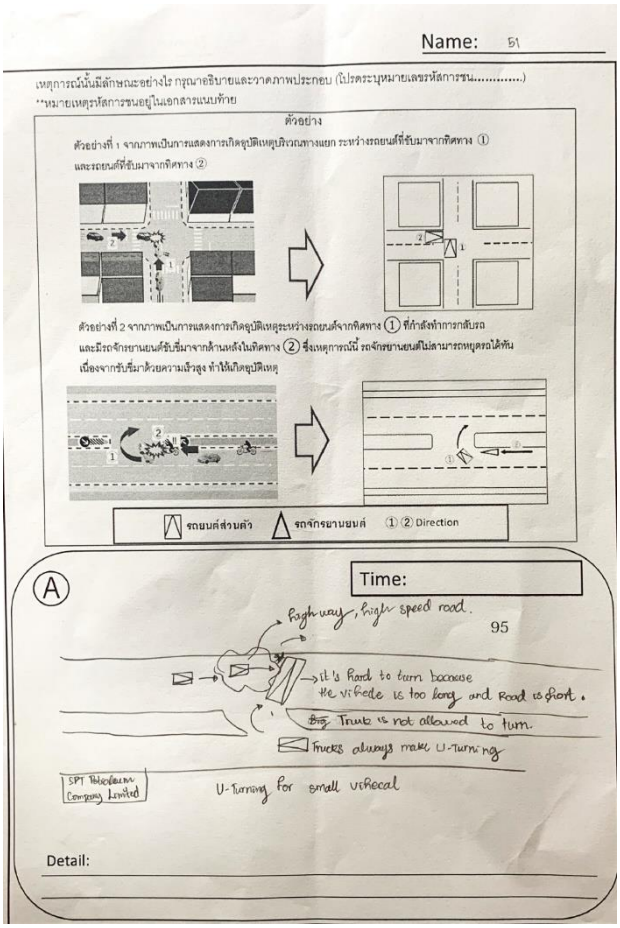


Figure 3 Example answer of Hiyari Hatto Event

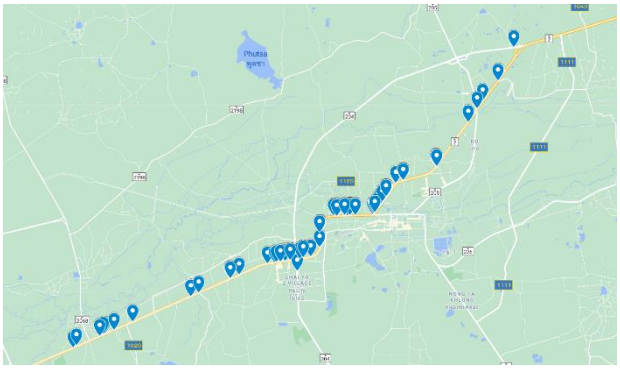


Figure 4 Hiyari Hatto Locations

4. Results

4.1 SRS

Figure 5 shows the result of the SRS on the target segment of National Highway No.2 for each of the inbound lanes and outbound lanes. The graphs in-dictate the road segment every 100 meters on the horizontal axis and the SRS on the vertical axis. The SRS every 100 meters are displayed on the blue line. The SRS resulted in many segments of one star on the outbound lanes in suburban areas, especially. This means that these segments are evaluated as "unsafe" by the criterion of Star Rating Approach.

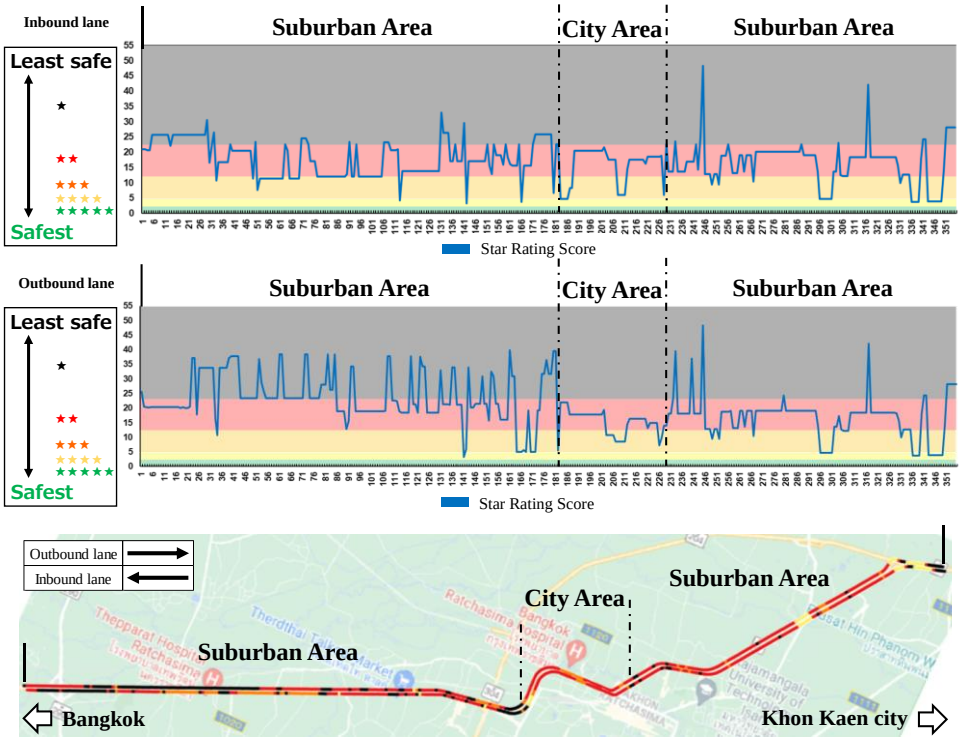


Figure 5 SRS in Highway No.2

4.2 Relationship between SRS and Hiyari Hatto Data and Traffic Accident Data

In order to clarify the reasons for evaluating low by the SRS in sections of suburban areas, this study firstly compared with data of the number of traffic accidents and the number of Hiyari Hatto in the result, as shown in Figure 6. The figure shows the five classifications of the relationship between the SRS, traffic accidents, and Hiyari Hatto. This study found that these road segments have something in common on the analysis of the Hiyari Hatto and traffic accident data. The common points were that traffic safety measures such as guardrails were insufficient in sections where the SRS is low. Traffic accidents and Hiyari Hatto have occurred in these sections, consistent with the SRS evaluation. It was also found that there are Arterial roads and intersections, U-turn lanes, and parking entrances and exits as non-matching sections.

However, the items of SRS need to reclassify because the section where the traffic accident occurred was included as a human factor. This study grasped the sections where the traffic accident occurred due to the road factor that is the subject of this analysis. It was classified as "sections caused by road factors" and "sections caused by human factors," as shown in Fig 7 and 8. The events that occurred as human factors were traffic accidents due to uncontrollability while driving. The most common occurrences of road factors were rear-ended collisions on the parking entrance and U-turn lanes, as shown in Table 2.

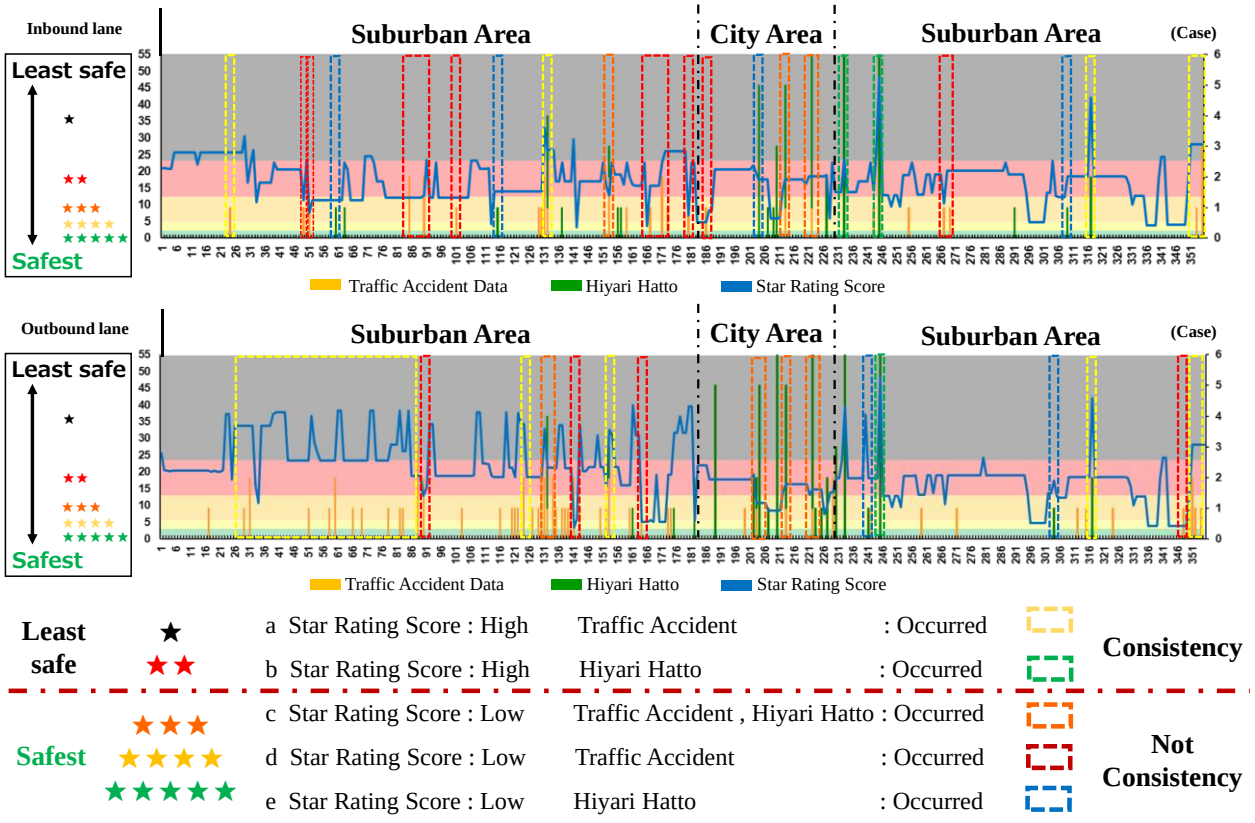


Figure 6 Relationship between SRS, Hiyari Hatto data and traffic accident data

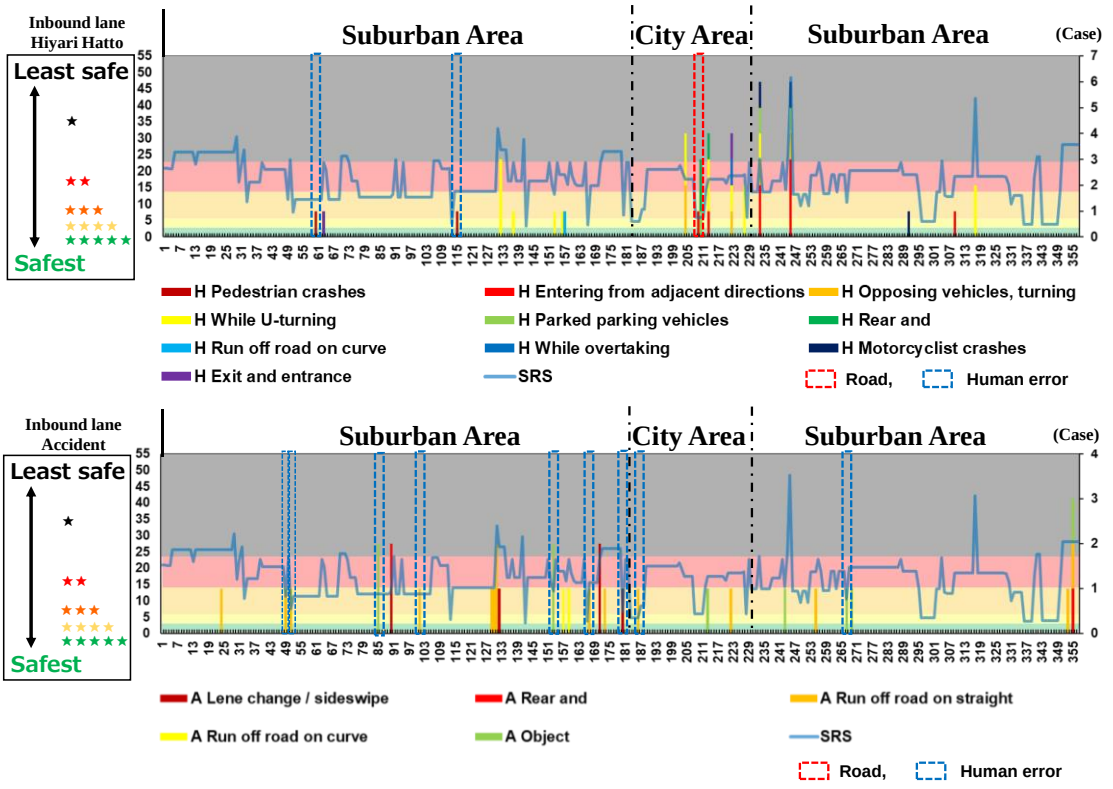


Figure 7 Relationship between SRS, Crash Type of Hiyari Hatto and Traffic Accidents in Inbound Lane

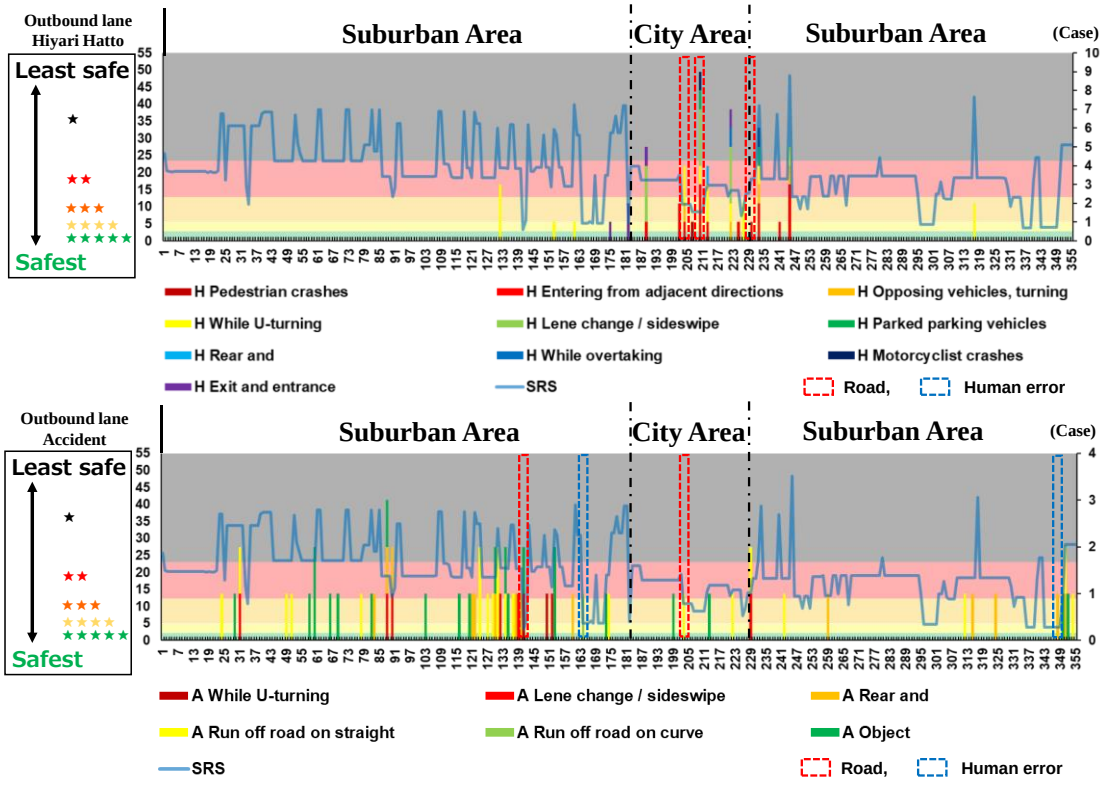


Figure 8 Relationship between SRS, Crash Type of Hiyari Hatto and Traffic Accidents in Outbound Lane

Table 2 List of events on road segments

Inbound lane				
Aria	Road type	SRS	Hiyari-Hatto (case)	Traffic Accident (case)
48-49	Arterial roads	★★★	0	1
50-51	Arterial roads	★★★	0	1
59-60	Arterial roads	★★★	1	0
84-85	Arterial roads	★★★	0	2
100-101	Arterial roads	★★★	0	1
115-116	Arterial roads	★★★	1	0
153-154	Arterial roads	★★★	2	1
167-168	Arterial roads	★★★★	1	0
179-180	Curve	★★★	0	1
186-187	Arterial roads	★★★★	0	1
209-210	Arterial roads	★★★	3	0
266-267	Arterial roads	★★★	1	0

Outbound lane				
Aria	Road type	SRS	Hiyari-Hatto (case)	Traffic Accident (case)
140-141	U-turn-lane	★★★★	0	2
163-164	Arterial roads	★★★	0	1
203-204	Intersection U-turn-lane	★★★	5	0
209-210	Parking entrance	★★★	12	0
226-227	U-turn-lane	★★★	2	0
347-348	Arterial roads	★★★★	0	1

4.3 Dangerous Factors in Parking Entrance

The existing evaluation indexes for the parking entrance are as follows:

- the speed limit is 60km/h for city areas
- the number of routes is five
- the width of the lanes is 2.75m to 3.25m
- Property access points is Commercial access 1+

The results of SRS were 8.69 scores with three stars (outbound lanes). This is indicated as the safe in the SRS despite the Hiyari Hatto was occurred. Therefore, the target segments were checked by Google Street View as shown in Figure 9 and Figure 10.

Figure 9 Google Street View of outbound lanes on segment 209-210

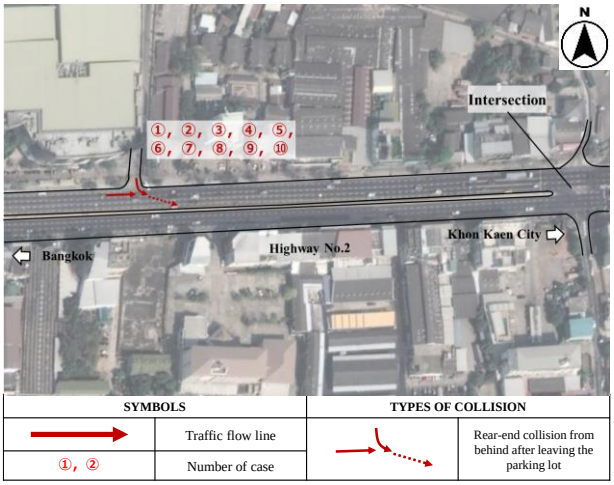


Figure 10 Occurrences for Hiyari Hatto in parking entrance

4.4 Improvement of Evaluation Indexes for Parking Entrance in Star Rating Approach

This study proposed the improvement of evaluation indexes for parking entrances in the Star Rating Approach based on the analysis of the SRS and the Hiyari Hatto and traffic accident data. The proposed evaluation indexes are described in Figure 11. The improvement is to add the evaluation indexes of Safety measures at parking entrances and exits in the Property access score. Thus, this improvement is reflected to the SRS the characteristic of the occurrence of Hiyari Hatto and traffic accidents at parking entrance in Thailand

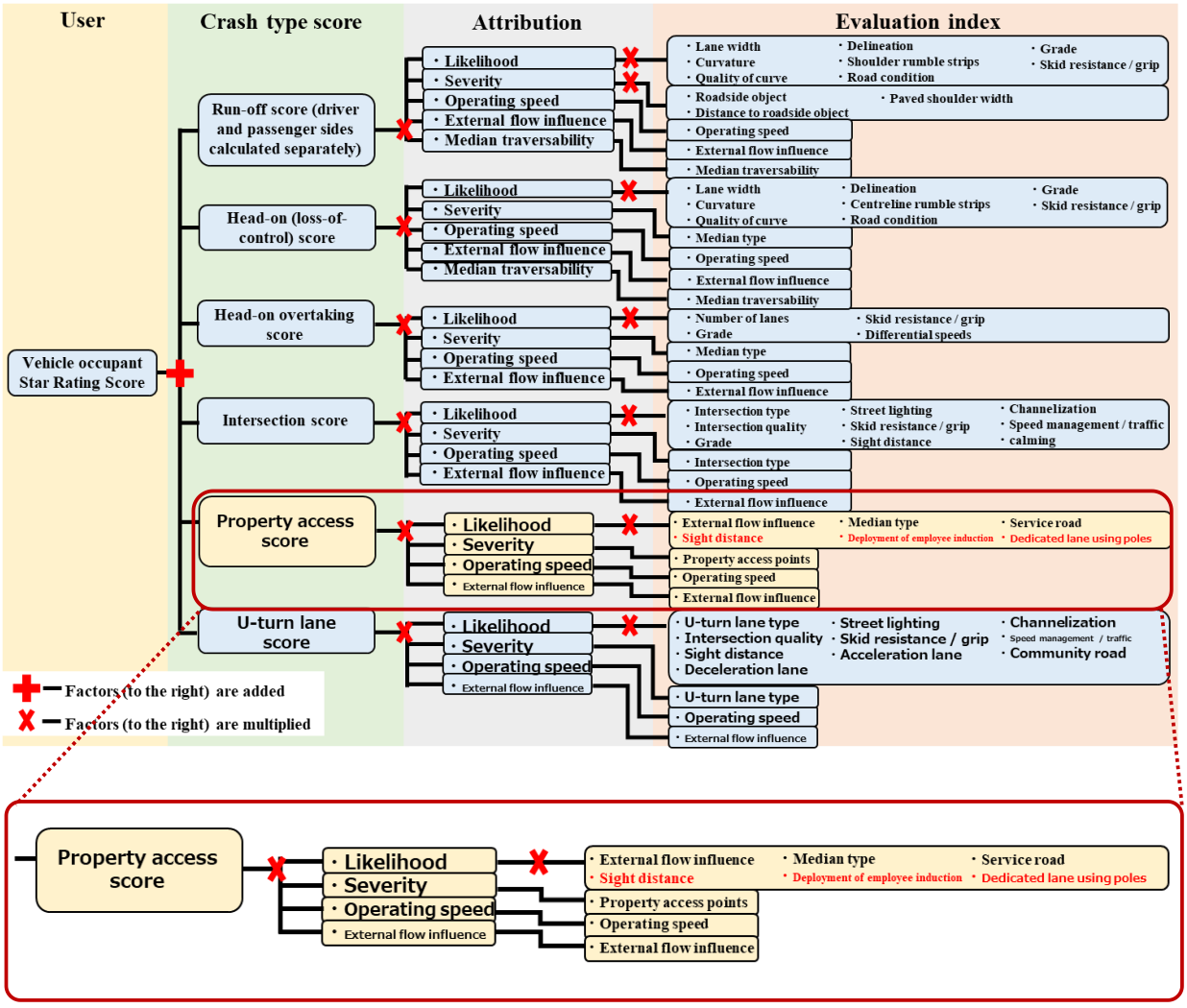


Figure 11 Improvement of evaluation indexes for parking entrance

4.5 Dangerous Factors in U-turn Lanes

The existing evaluation indexes for the U-turn lanes are as follows:

- the speed limit is 60km/h for city areas
- the number of routes is four
- the width of the lanes is 2.75m to 3.25m
- the median has a concrete guardrail (shoulder width is 0m to 1m)

The results of SRS were 18.89 scores with two stars (inbound lanes), and 7.30 scores with three stars (outbound lanes). This is indicated as the safe in the SRS despite the Hiyari Hatto was occurred. Therefore, the target segments were checked by Google Street View as shown in Figure 12 and Figure 13. The reason for the occurrence of Hiyari Hatto is that the lack of the auxiliary lanes for safe vehicle entry into the main lanes after the U-turns. Also, the existing Star Rating Approach has no evaluation indexes for the auxiliary lanes in the U-turn lanes. It is necessary to add these evaluation indexes.

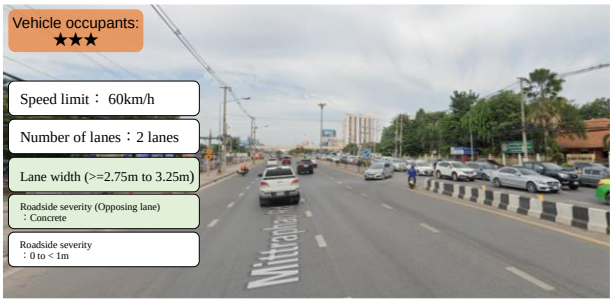


Figure 12 Google Street View of outbound lanes

on segment 226-227

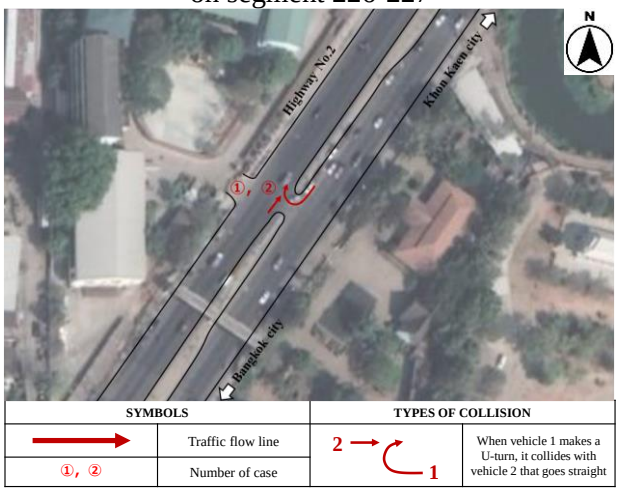


Figure 13 Occurrences for Hiyari Hatto

in U-turn Lanes

4.6 Improvement of Evaluation Indexes for U-turn Lanes in Star Rating Approach

This study proposed the improvement of evaluation indexes for U-turn lanes in the Star Rating Approach based on the analysis of the SRS and the Hiyari Hatto and traffic accident data. The proposed evaluation indexes are described in Figure 14. The improvement is to add the evaluation indexes of median crossing point-protected turn lane in the intersection type. Thus, this improvement is reflected to the SRS the characteristic of the occurrence of Hiyari Hatto and traffic accidents at U-turn lanes in Thailand.

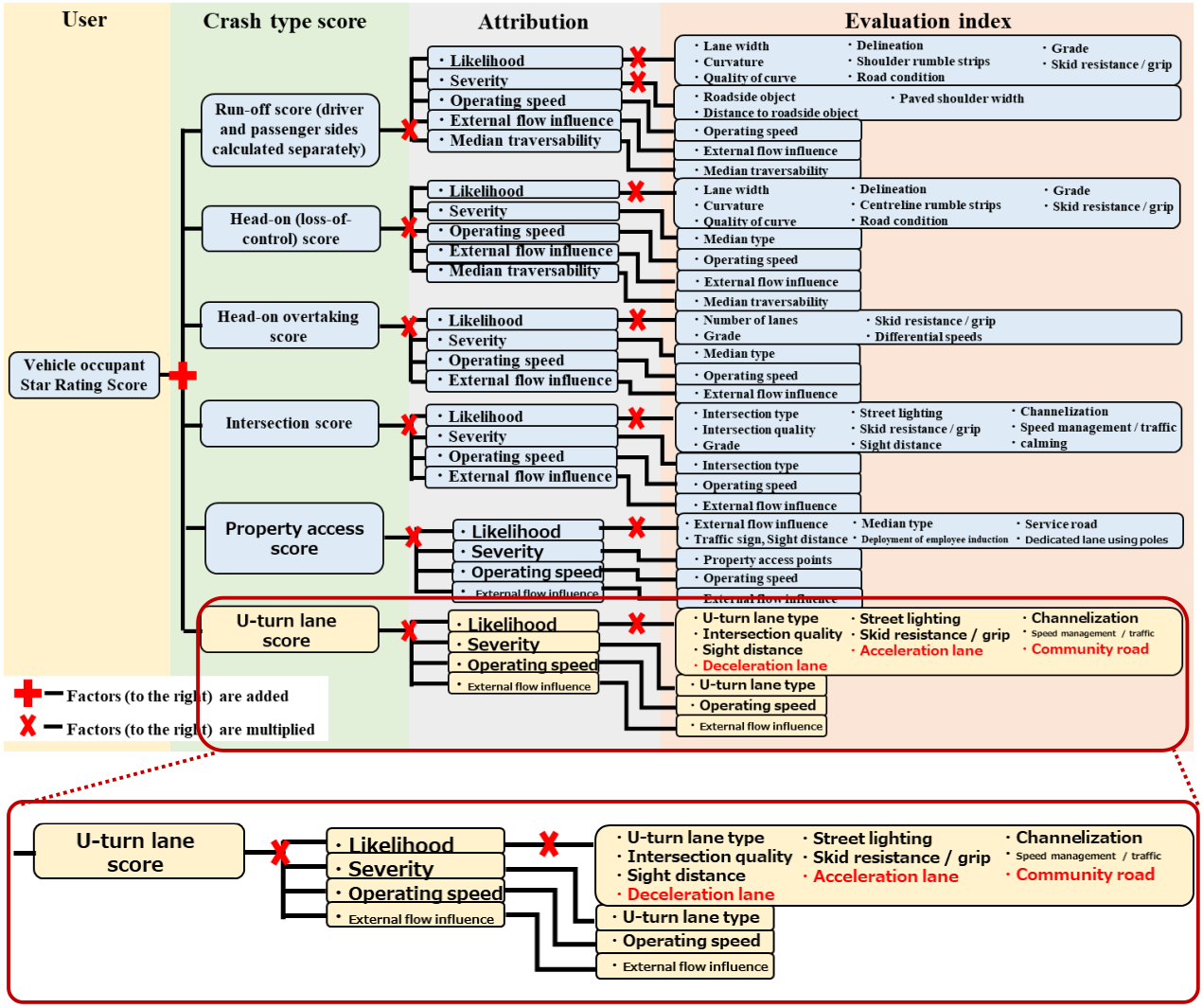


Figure 14 Improvement of evaluation indexes for U-turn lanes

5. Conclusion

This study evaluated road segments of National Highway No.2 in the urban and suburban areas of Nakhon Ratchasima Province by the Star Rating Approach and compared the number of Hiyari Hatto and traffic accidents with the SRS to grasp the problems in the evaluation indexes of the Star Rating Approach. As a result, it was clarified that there were problems in the evaluation indexes of the iRAP Star Rating Approach for the parking entrance and U-turn lanes and that the danger of the parking entrance and U-turn lanes could not be grasped. In addition, this study determined the danger points in the parking entrance and U-turn lanes by improving the evaluation indexes of the parking entrance and U-turn lanes in the SRS.

For further studies, it is necessary to verify the effectiveness of the iRAP Star Rating Approach by actually improving the rating items and conducting the evaluation in cities other than the target city.

References

[1] iRAP : Star Rating, https://irap.org/3-star-or-better/.
[2] iRAP. (2011) Crash rate – Star Rating comparisons, iRAP.
[3] AusRAP. (2013) Star Rating Australia's National Network of Highways, iRAP.
[4] AusRAP. (2005) The Australian Road Assessment Program (AusRAP) , iRAP.
[5] iRAP. (2019) Speed Variation Analysis – A Case Study for Thailand's Roads , iRAP
[6] Kasem, C., Kerkritt, S and Pinthip S. (2018) Road Safety Assessment and iRAP Star Ratings for High-risk Schools in Bangkok.
[7] iRAP. (2012) iRAP Philippines, Phase 2 Technical Report and Results, iRAP.
[8] Ujjwal, B., Sumit, K., Vilas, P., Vikas, K and L Durga, Prashanth. (2020) Road Safety Ratings for Selected Accident-Prone Sections in Urban Areas: IOP Conference Series: Materials Science and Engineering.
[9] iRAP. (2015) Federative Republic of BraziliRAP Pilot Technical Report, iRAP.
[10] Nabarjun Vashisth. (2016) Roadway Safety Assessment and Test Application of iRAP along National Highway 3 in Haiti, by Nabarjun Vashisth August 2016.
[11] Hoque, M., Hossain, Z. and Mahmud, S. (2010) Im-proving highway safety in bangladesh: Road Improvement and The Potential Application of iRAP, *24th ARRB Conference – Building on 50 years of road and transport research*.
[12] Harwood, D., Bauer, K. and Gilmore, D. (2010) Validation of U.S. road assessment program Star Rating protocol, *Article in Transportation Research Record Journal of the Transportation Research Board December 2010*, Vol. 2147, pp. 33-41.
[13] Kamiya, S., Ozaki, Y. and Yabu, M. (2014) A study on the extraction method of black spot area based on road geometric structure for effective traffic safety countermeasure, Japan Society of Civil Engineers. *Infrastructure Planning and Management*, Vol. 50, CD-R.
[14] EuroRAP : http://www.eurorap.org.
[15] David L, (2012) Development of Risk Models for the Road Assessment Programme, iRAP.
[16]AusRAP : http://www.http://ausrap.aaa.asn.au/.

The impact of COVID-19 on the travel behavior of carsharing users in Bangkok

Paper Identification number: AYRF-007

Monthira PHAMORNMONGKHONCHAI1*, Saroch BOONSIRIPANT2, Peraphan JITTRAPIROM3

[1]Department of Civil Engineering, Faculty of Engineering
Kasetsart University
Telephone (+66) 098-3914862
E-mail: monthira@mobinary.org
*Corresponding author

[2]Department of Civil Engineering, Faculty of Engineering
Kasetsart University
E-mail: saroch.b@ku.th

[3]Nijmegen School of Management
Radboud University, Nijmegen, the Netherlands
E-mail: peraphan.jittrapirom@ru.nl

Abstract

The pandemic outbreaks of coronavirus or COVID-19 have caused significant impacts on public transport and shared mobility services. Travelers have changed their travel behaviors in accordance with public guidelines and each traveler perceived risks. This study aims to analyze the attitudes of Bangkok's carsharing users during the epidemic period, in conjunction with identifying the effects of changing travel behaviors. Phone interviews were conducted with 217 respondents who used carsharing service between August and November 2021. Additionally, the corresponding carsharing data, such as reservation, vehicle trajectory, and user information, from a dominant carsharing operator's database was used in the analysis. Our preliminary analysis reported here found that 22% (47 respondents) of the respondents did not change their carsharing usage and 12% (26 respondents) did not have concerns regarding COVID-19 during their carsharing usage. Finally, 35% of the respondents chose to continue using carsharing because they believed that carsharing has a lower infection risk than other public transportation options. Our findings {implications of the findings}

Keywords: COVID-19, Travel behavior, Carsharing

1. Introduction

Since its emergence in late 2019, the novel Coronavirus or COVID-19 has rapidly spread beyond nations' borders and caused significant impacts on the livelihoods of people around the world. As of early February 2021, nearly 106 million pandemic cases have been observed worldwide and resulted in 2.33 million mortalities [1]. The associated socio-economic impacts of this event have also been far-reaching as en-mass losses of employment have continued, heightening the potential large-scale collapse of global economics.

The transport sector is one among several that have been heavily affected by the outbreaks. Governments around the world have imposed travel restrictions and issued recommendations to limit the traveling of their citizens to contain the outbreaks. The urban areas are particularly affected, several cities halt or limit the number of public transport services. The perceived risks and fear of infection that may incur during traveling (e.g., in buses and mass transit) also influence travelers to adjust their travel behavior, switch their modes of transport, commute time, or cancel their planned trips altogether [2].

Similarly, ridership and usages of shared mobility services, such as carsharing and ride sharing are also adversely affected [3].

In examining specifically how the public transport systems are affected by the outbreak, two studies stood out: 1) [4] provided a list of possible impacts to public transport operations and identify possible intervention measures for transport service providers and 2) analyzed ridership data in Sweden to quantify the impacts to the public transport system. Their findings highlight how public transport ridership in several cities has plummeted due to the outbreaks. Additionally, there is also a trend in increased usage of private vehicles and non-motorized modes. Hensher [5] also explored possible implications of the outbreak to public transport and Mobility as a Service (MaaS) under possible scenarios in the post-COVID-19 period.

Besides public transport, studies also reported severe impacts to shared mobility services. For instance, Future Bridge [3] highlights the impacts on ride-hailing and their shared services and purport three possible scenarios for shared mobility, a slow return to normalcy, the collapse of shared mobility, and increase adoption of Autonomous Vehicles. A Delphi survey [6] presented a set of challenges and opportunities for shared mobility services in the post-COVID era.

However, there is still a lack of academic studies that use empirical data to elucidate the impacts on shared mobility due to the outbreak. As shared mobility is an integral part of solutions to enhance sustainability and accessibility of the transport system, such a study can be highly beneficial. Transport planning agencies and mobility providers can utilize such evident-based analysis to support their efforts in responding to the changes in users' traveling behavior of shared mobility in this critical period.

This study aims to address this niche by identifying how carsharing users in Bangkok changed their behavior as a result of the outbreaks, what may be the factors (e.g., risk perception, change in work pattern, and governmental advice) that influence these changes. Moreover, it will highlight users' preferences on how shared mobility should be provided in this uncertain period. The case study of this project will be a carsharing service in Bangkok city.

2. COVID-19 Situation in Thailand

The COVID-19 in Thailand is part of the worldwide pandemic of COVID-19. The first wave of outbreak started from Lumpini Boxing Stadium Cluster in March 2020 [7]. The government declared a state of emergency on 26 March 2020, to control the situation. Public places and businesses were ordered to close. All commercial domestic and international flights were suspended. and lockdown measures. The rate of the new case decreased to near zero, therefore the government has ordered to easing to lockdown and cancel curfew in June 15, 2020.

In December 2020, new cases spiked due to a new cluster in the Seafood Market in Mahachai Samut Sakhon, 46 km south of Bangkok. The Bangkok Metropolitan Administration announced would close schools and daycare centers and then the Ministry of Education ordered all schools closed for January 2021 [7].

Vaccinations began at the end of February 2021 [8], the vaccine was distributed to healthcare workers first. Despite measures to control, a big cluster in nightclubs in April 2021 [7], the wave led to the largest cases in the country and rapidly spread in Bangkok as well as throughout the country.

As of July 2021, although there have been vaccines and government measures, the number of new cases increases to more than 10,000 cases/days due to the delta variant. There was a total of 543,305 confirmed cases in July 2021 [9].

The transportation sector in Thailand also has been severely affected by COVID-19. In May 2020, Bangkok Mass Transit System (BTS), Metropolitan Rapid Transit (MRT), Airport Rail Link (ARL), and buses in Bangkok were ordered to adjust their operating schedule to comply with government measures. The bus terminal was suspended in March 2020. Domestic flights were suspended at the end of March. People also avoided the use of public transport and taxis as they were concerned about infection from using such shared services.

3. Data Collection

In this study, we analyzed two types of data including user attitudes and reservation data. The attitudinal data was obtained by phone interview with the carsharing users and the reservation data was obtained from the carsharing operator's database.

The questionnaires used during the phone interview attempted to answer the following questions:

- Destination data: Where did the user go?
- Activity data: What did the user do at the destination?
- General travel behavior: How does COVID-19 affect their general travel behaviors in terms of perception, preference, and behaviors?
- Carsharing usage behavior: How does COVID-19 affect their carsharing usage behaviors in terms of perception, preference, and behaviors?

The Questionnaire structure consisted of 3 sessions. The first section comprised questions related to carsharing usage including:

- Where do you go?
- What is the purpose of the trip?

In the second section, the respondents were asked how COVID-19 impacts their carsharing usage including:

- How much does COVID-19 affect your carsharing usage?
- How much does COVID-19 concern you while using carsharing services?
- Do you increase or decrease your carsharing usage during the COVID-19 pandemic?
    - Why do you increase your carsharing usage during the COVID-19 pandemic?

The last section included the socio-economic of the respondents such as gender, age, education, vehicle ownership, occupation, and income.

The questionnaire survey was conducted through phone interviews between August and November 2021. A list of reservations was obtained daily from a carsharing operator in Bangkok, Haupcar Company Limited. The research team validated if the reservations were paid reservations (as opposed to promotional reservations and internal staff reservations) and were hourly and daily reservations (as opposed to monthly and yearly reservations).

Before contacting carsharing users, the research team verified whether the reservation data including reservation duration and driving distance are available and accurate. We contacted a total of 484 carsharing users but only 230 carsharing users (47.52 percent response rate) agreed or were available for the phone interviews. The interviews took place between 6 pm to 7 pm to avoid office hours. Phone calls made during weekends received a lower response rate while Monday and Tuesday yielded higher responses rates.

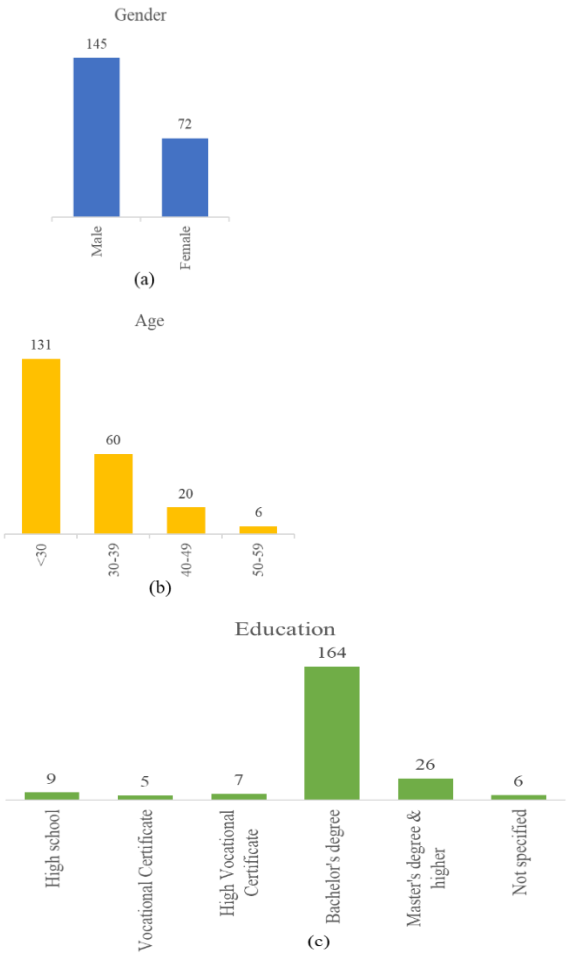
As a results, there were 217 (use only one of these numbers) respondents from the phone interview used in the analysis. Note that some of the respondents refused to provide information regarding their personal data such as income, number of vehicles in the household, and education.

4. Results

This section described the socio-demographics of the respondents, their attitudes during the epidemic period, and the effects of the COVID-19 pandemic to their travel behaviors.

4.1 Respondents' socio-demographics

The descriptive statistics for the socio-demographic attributes are summarized in Figure 1. Figure 1 showed that the majority of the respondents were men (67%), with age less than 30 years old (60%) which represents the carsharing user population in Bangkok. Eighty-eight percent of the respondents had at least a bachelor's degree. 90% percent of the respondents had at least a personal car or motorcycle. 58% percent of the respondents were engaged in private business and government employees and 24% had incomes ranging from 30,000 to 50,000 THB.



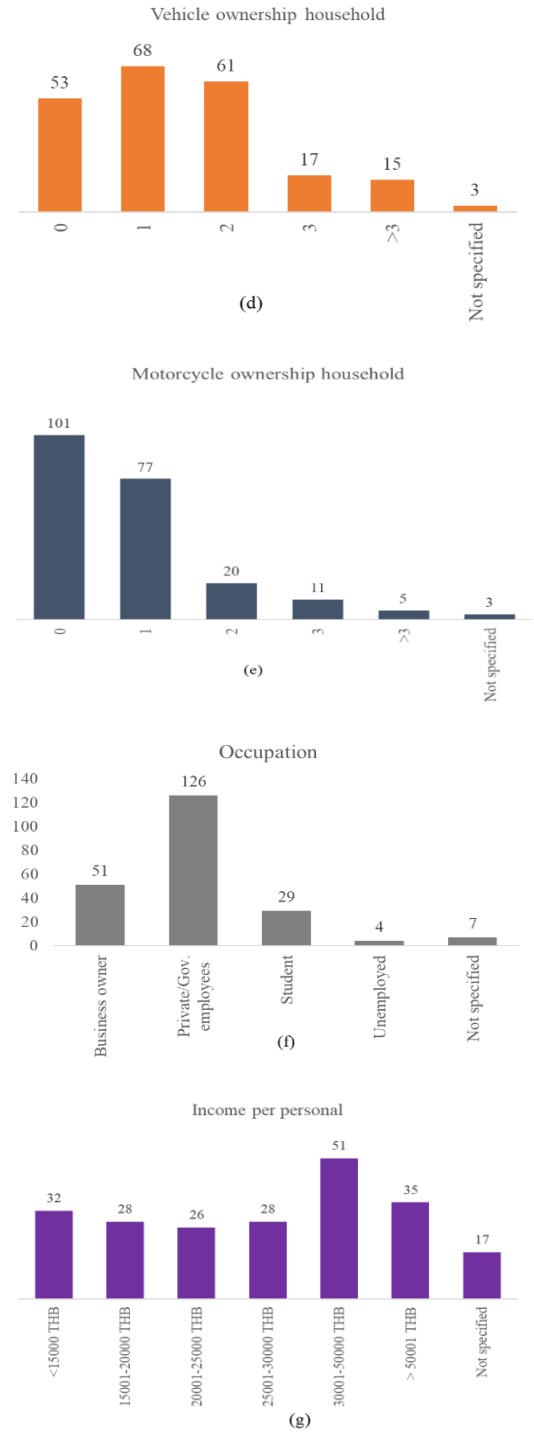


Figure 1 Socio-demographic of the 217 carsharing users (a) gender, (b) age, (c) education, (d) motorcycle ownership per household, (e) vehicle ownership per household, (f) occupation, and (g) income

4.2 Carsharing users' attitudes towards the COVID-19 situation

Two questions were asked to the 217 carsharing users regarding their attitudes towards the COVID-19 situation. The first question is "How much COVID-19 situation impact your carsharing usage?". We deployed a 5-point Likert scale to measure the magnitude of impact, where the score of 1 denotes "no impact" and the score of 5 denotes "highly impact". During the interview, the word "impact" was described as a demand for carsharing usage. A high impact would mean that the users significantly increase/decrease their carsharing usage. No impact means the users did not change their behavior in using carsharing at all.

The second question is "How concerned are you regarding using carsharing services during the pandemic?" Respondents would also answer on a 5-point Likert scale from 1 for "unconcerned" to 5 for "strongly concerned". During the interview, the word "concerned" was described as the users' concerns regarding the sanitization and cleanliness of the shared vehicles.

The results showed that the respondents, who thought the COVID-19 had no impact on their carsharing usage (no impacts = 1) still had concerns about their cleanliness and safety from infection as shown in Figure 2.

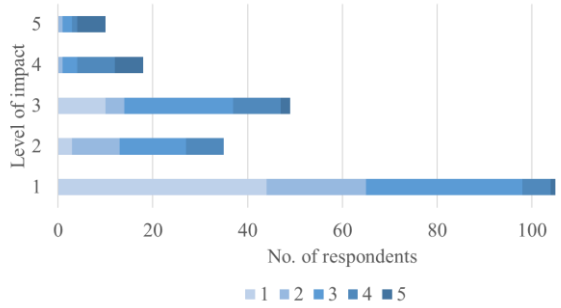


Figure 2 Relationship between impact and concern of carsharing usage during COVID-19 pandemic

Next, we use the socio-demographic data to group the impact and concern during the pandemic as shown in Figure 3. The results showed that the COVID-19 pandemic equally affected the carsharing usage of male and female users. However, male users were more concerned about vehicle sanitization than female users.

In terms of age, the respondents with ages between 50 and 59 perceived that COVID -19 had affected their carsharing usage more than did other age ranges. They were also more concerned about the risk of infection during the carshare usage than other age ranges.

In terms of education, the respondents who had at least a bachelor's degree thought COVID -19 had affected their carsharing usage and were more concerned about cleanliness and sanitization than other respondents.

In terms of occupation, the business owner respondents thought COVID-19 had affected their carsharing usage than other respondents, but on average, students had the highest concern.

In terms of income, the respondents with high income thought COVID-19 had affected their carsharing usage and were more concerned about cleanliness and sanitization than other respondents.

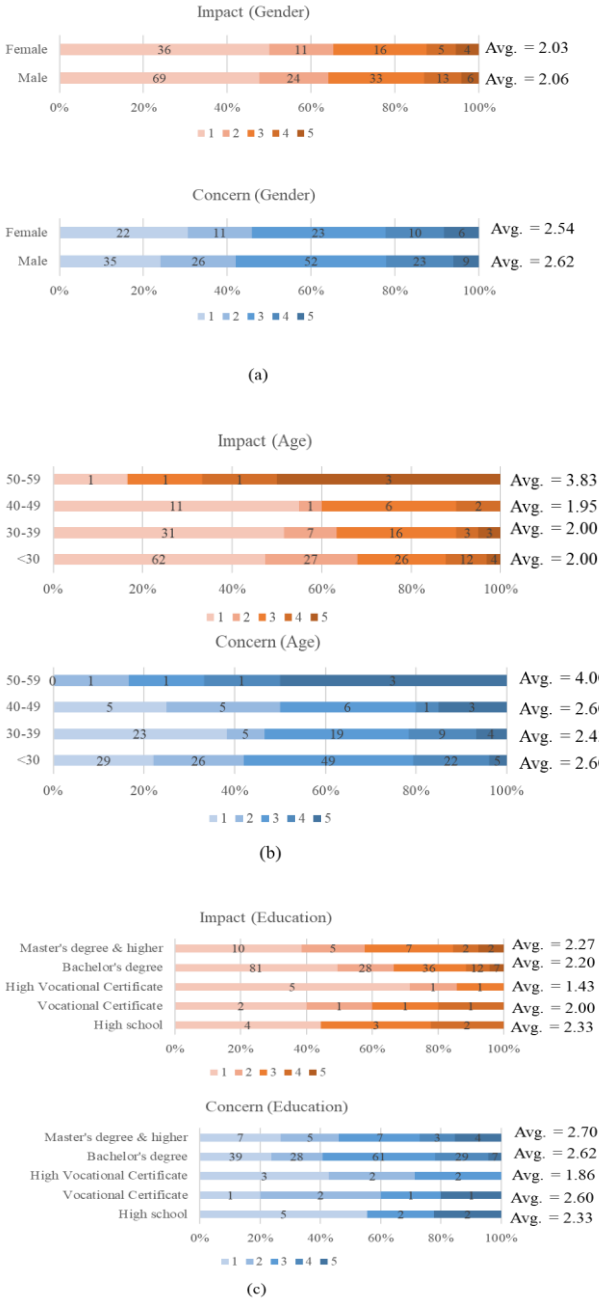
We also asked for the trip purpose from respondents to determine the relationship between trip purpose and the impact and concern during the pandemic period. The results showed that the respondents who used carsharing during the COVID -19 pandemic seemingly were unaffected from COVID-19 and did not concern or had few concerns about carsharing usage.

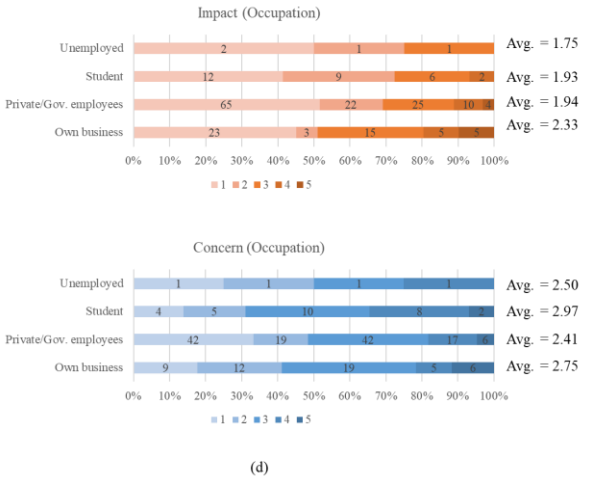
We also asked a question regarding the trip purpose of their carsharing usage. Some of the most frequently mentioned answers include shopping, pick up or sending goods (21%), travel and religious ceremony (20%), meeting/work (16%), and errands (7%). Interestingly, the respondents who used carsharing to get vaccinated tended to be more affected by COVID-19 in using carsharing service and are more concerned about the risk of infection than other respondents as shown in Figure 4.

We considered carsharing based on interview results. By comparing before the COVID-19 outbreak and during the current COVID-19 outbreak, the changes in the usage of carsharing are shown in Figure 5. Thirty-five percent of respondents used carsharing more, the same (46%) and decrease (19%). And reasons why respondents chose carsharing as shown in Figure 6. The reason of respondents

for the increased use of carsharing was a lower risk of infection (91%), avoiding public transport (89%), marketing campaign (68%), and need for travel (43%).

In addition, we collected reservation duration (hours) and driving distance (km) of carsharing usage to compare with the perceived impact and concern during the pandemic period. The result found that the level of concern and the level of impact on carsharing use during the COVID -19 pandemic have irrelevant with the reservation duration and the driving distance as shown in Figure 7 and Figure 8





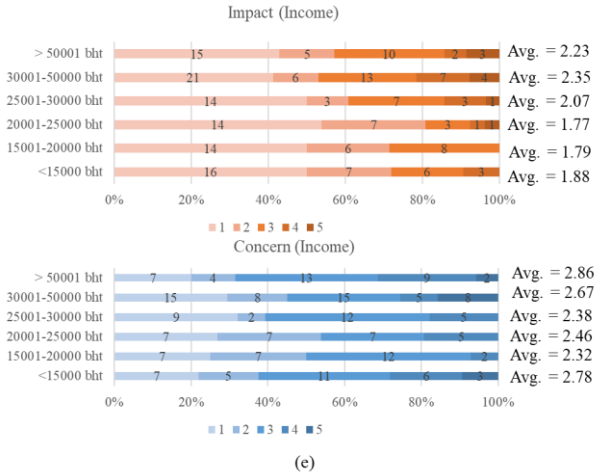


Figure 3 Relationship between perceived impact and concerns with the socio-demographics including (a) gender, (b) age, (c) education, (d) occupation, and (e) income

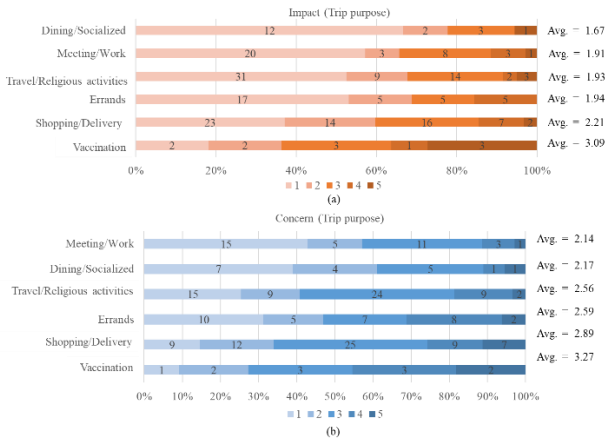


Figure 4 Relationship between perceived impact and concerns with the main purpose (a) perceived impact, and (b) perceived concern

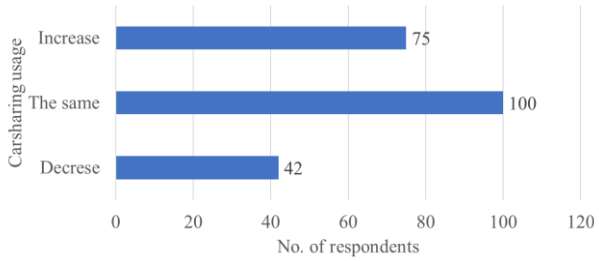


Figure 5 Changes in carsharing usage due to COVID-19 situation

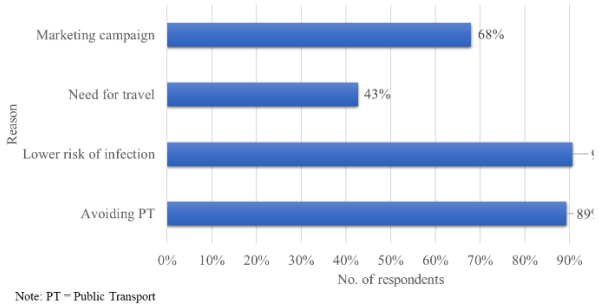


Figure 6 Reasons for choosing carsharing service over other transportation modes during COVID-19 pandemic (for those who answer "Increase in carsharing usage")

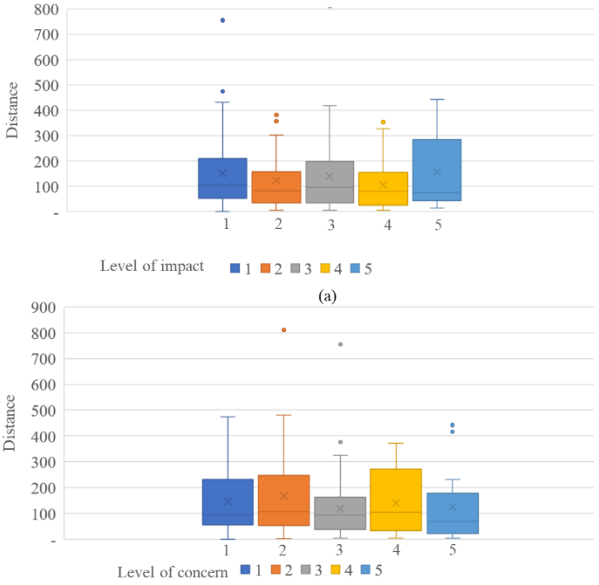


Figure 7 Relationship between perceived impact and concerns with distance (a) perceived impact, and (b) perceived concern

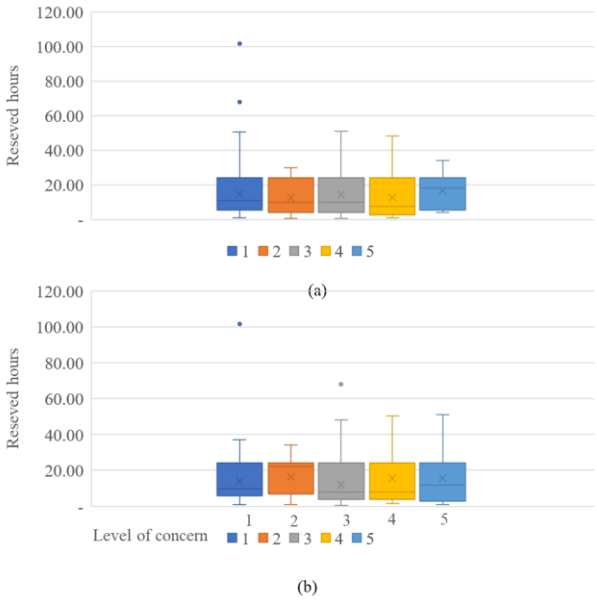


Figure 8 Relationship between perceived impact and concerns with reserved hours (a) perceived impact, and (b) perceived concern

5. Discussion and Conclusion

The study found that the most of respondents felt that COVID-19 had not affected carsharing usage and chose to continue using carsharing during the epidemic situation, but there are concerns about the risk of infection. It is noted that the respondents are people who decided to use carsharing to travel during the COVID-19 pandemic. Thus, they might be less concerned about COVID-19 than the general population, especially people who decided not to travel at all.

In terms of gender, male users (concern score = 2.62) are concerned about the risk of infection during carsharing usage slightly different from female users (concern score = 2.54).

Regarding the age ranges of the carsharing users, the elderly group (50+) are more concerned than other groups, possibly due to the higher fatality rate in this when infected with COVID-19. For education level, respondents who had at least a master's degree are more concerned (concern score = 2.70). It is likely that people with higher education are more well-informed about the COVID-19 and perceived the severity of the epidemic more than other groups.

Business owner people reported that their carsharing usage is highly impacted by COVID-19 (impact score = 2.33) since they use

carsharing for work-related. High-income groups (income more than 50,000 THB/Mo) are more concerned (concern score = 2.86) than other groups. 42% of them used carsharing more than before the COVID-19 outbreak.

The trip purpose of their carsharing usage. Interestingly, the respondents who used carsharing to get vaccinated tended to be more affected by COVID-19 in using carsharing service and are more concerned about the risk of infection than other respondents.

The change of carsharing usage during the current COVID-19 outbreak. Thirty-five percent of respondents are used carsharing more. By reasoning that carsharing lower risk of infection more than public transport, avoiding public transport, marketing campaign and need for travel.

The perceived impact and concern during the pandemic period have irrelevant with the reservation duration and the driving distance of carsharing usage. Some respondents said coronavirus did not affect their travel decision but what affects travel is more than government or agency measures, such as curfews, lockdowns, or the work-from-home policy that affected carsharing usage.

6. Future Research

The results described in this paper are part of the ongoing research project "Impact of COVID-19 on Carsharing Usage Behaviors". In the main study, vehicle trajectories will be analyzed to compare the stop activities of carsharing users before and during the COVID-19. The results from the main study will help us to understand how carsharing users changed their behavior during the COVID-19 pandemic.

7. Acknowledgment

Support for this research work was provided by the Asian Transportation Research Society (ATRANS) under the research project "Impact of COVID-19 on Carsharing Usage Behaviors". Data support from Haupcar Company Limited is also gratefully acknowledged and appreciated.

References

[1] WHO, "Coronavirus disease (COVID-19)," 2021. https://www.who.int/csr/don/archive/year/2021/en/ (accessed Feb. 11, 2021).

[2] EIT, "COVID-19: what is happening in the area of urban mobility | European Institute of Innovation & Technology (EIT)," 2020. https://eit.europa.eu/news-events/news/covid-19-what-happening-area-urban-mobility (accessed Feb. 10, 2021).

[3] FutureBridge, "Impact of COVID-19 on Shared Mobility - FutureBridge," 2021. https://www.futurebridge.com/industry/perspectives-mobility/impact-of-covid-19-on-shared-mobility/ (accessed Feb. 11, 2021).

[4] K. Gkiotsalitis and O. Cats, "Public transport planning adaption under the COVID-19 pandemic crisis: literature review of research needs and directions," *Transp. Rev.*, pp. 1–19, Dec. 2020, doi: 10.1080/01441647.2020.1857886.

[5] D. A. Hensher, "What might Covid-19 mean for mobility as a service (MaaS)?," *Transport Reviews*, vol. 40, no. 5. Routledge, pp. 551–556, Sep. 02, 2020, doi: 10.1080/01441647.2020.1770487.

[6] S. Shokouhyar, S. Shokoohyar, A. Sobhani, and A. J. Gorizi, "Shared mobility in post-COVID era: New challenges and opportunities," *Sustain. Cities Soc.*, vol. 67, Apr. 2021, doi: 10.1016/j.scs.2021.102714.

[7] Wilipedia, "COVID-19 pandemic in Thailand," 2021. https://en.wikipedia.org/wiki/COVID-19_pandemic_in_Thailand#Government_response (accessed Jul. 29, 2021).

[8] covidvax.live, "Live COVID-19 Vaccination Tracker-Thailand," 2021. https://covidvax.live/en/location/tha (accessed Jul. 29, 2021).

[9] Department of Disease Control, "Corona Virus Disease (COVID-19)," 2021. https://ddc.moph.go.th/viralpneumonia/eng/index.php (accessed Jul. 29, 2021).

Supply Analysis of an Access Mode for Local Travel: The Case of Tricycles in the Philippines

Paper Identification number**:** AYRF-008

Alexis FILLONE[1], Maria Cecilia PARINGIT[1]
, Marlon ERA[2], Krista Danielle YU[3]

[1]Department of Civil Engineering, Gokongwei College of Engineering
De la Salle University, 2401 Taft Avenue, Manila
Telephone 063-5244611 loc. 231
E-mail: alexis.fillone@dlsu.edu.ph,
maria.cecilia.paringit@dlsu.edu.ph

[1]Department of Sociology and Behavioral Sciences, College of Liberal Arts
De la Salle University, 2401 Taft Avenue, Manila
E-mail: marlon.era@dlsu.edu.ph

[3]School of Economics
De la Salle University, Manila
Telephone 043-261457, Fax. 043-261457
E-mail: krista.yu@dlsu.edu.ph

Abstract

Is there an optimum number of tricycles the needs to operate to serve commuters in a given locality? The future of tricycles that serve most if not all localities in the country may be in peril or to say the least, in limbo given the pronouncement of the current administration that this form of transport will not be allowed to operate anymore along national roads of the country. However, there are still many areas say in a locality that they can offer their services. What is needed is a properly designed local transport plan that considers the socio-demographic characteristics, demand and travel behavior of commuters that use tricycles as means of mobility. Hence, the primary objective of this study is to determine the most appropriate number of tricycle units that a given locality (municipality or city) should serve given the estimated passenger demand and their travel characteristics taking into consideration the existing national and local policies and social acceptability of the community residents. Hence, the specific objectives include (1) to determine the existing supply of tricycles in each of the sample local government unit (LGU), (2) to determine the travel characteristics of commuters in the study area to know the frequency of usage of tricycles, and (3) to determine other LGU-related variables that are highly correlated to the number of tricycles and its usage in the locality.

Keywords: Tricycle, Public transport, Route planning, Access mode

1. General Introduction

Tricycles or also termed motor-tricycles are intended for use on local streets given that they are slow moving compared to the standard public transport mode like jeepneys, buses or even multicabs, and carry few passengers and hence are intended in areas where there is less demand. As shown in Figure 1, the original intention of tricycles is that it should only be used in the local area as access and egress mode. However, due to limited public transport service in rural areas where demand is low and cannot sustain the operation of PUVs with higher capacities like jeepneys or even multicabs, tricycles eventually serve this slack in supply resulting to what we currently have as shown in Figure 2. Due to the slow response in regulation on the operation of public transport in rural areas and even in cities and urbanizing municipalities, tricycles in most roads of the country are available to provide service when needed. There are, however, many issues regarding their operation especially along national roads where other vehicles are fast moving since tricycles are slower and its lack of limited safety features compared to other vehicles. Tricycles are also overloaded as shown in Figure 3. This is the reason Memorandum Circular 2007-01, was introduced; to remove them from operating along national roads, which was followed by Memorandum Circular 2011-68 and 2020-036. Although this law was introduced in January 2, 2007, it was not always enforced for obvious reasons such as the lack of available public transport services in areas they serve even along national roads. In the current PUV modernization program of the national government, where the primary objective is to modernize the public transport system of the country and with the power to plan and recommend routes for franchising given to the LGU, this could eventually remove tricycles along national roads.

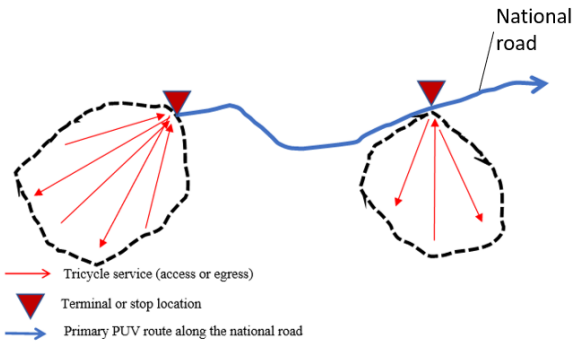


Figure 1. Recommended typical tricycle service area with respect primary modes serving the national road.

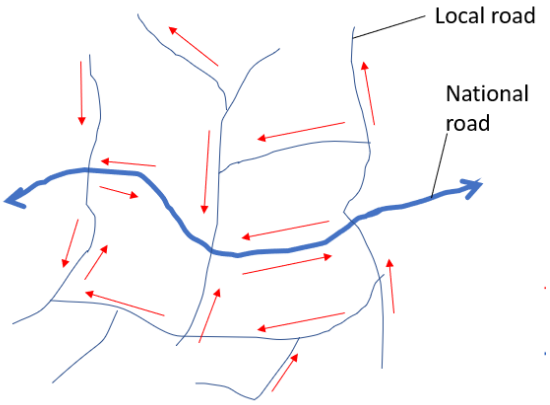


Figure 2. Current type of tricycle service in most municipalities/cities in the country

Figure 3. Overloaded tricycles during operation

In some municipalities/cities, due to the high number of tricycles given the permit to operate, they would tend to congest in areas where there is high passenger demand such as schools, public markets, malls, among others. The municipality/city is usually divided into zones or districts and a certain number of tricycles is assigned to each zone/district. Tricycles can only operate on a particular zone or district they are assigned. However, the issue of tricycles using national roads are still not being addressed, hence the need to properly study the supply of tricycles and how they should operate in the locality without using the national roads.

There is proliferation of tricycles in the locality where they serve. Being a tricycle driver is one of the basic means of earning a living for individuals especially in rural areas, given the ease now in owning a motorcycle while the tricycle body is locality manufactured. Since the municipality or city issues permit to operate, they have the control of how many tricycles should

operate in their locality. It is a known fact that local politicians use this also a way of earning political mileage or even out right votes during the election period. More so the need to study this issue to put a cap on the number of tricycle units that should ply a given locality.

The primary objective of this study is to determine the most appropriate number of tricycle units that a given locality (municipality or city) should serve given the estimated passenger demand and their travel characteristics. Hence, the specific objectives would include (1) to determine the existing supply of tricycles in each of the sample LGU, (2) to determine the travel characteristics of commuters in the study area to know the frequency of usage of tricycles, and (3) to determine other LGU-related variables that are highly correlated to the number of tricycles and its usage in the locality.

2. Literature Review

Local public transportation developed from motorcycles or scooters exist in different countries. In Thailand, these are called "tuktuks", in Cambodia, these are known as "moto-dubs", in Indonesia, they are called "helicaks", and in the Philippines, these are known as "tricycles". A tricycle is a motorcycle with a one-wheel side car attached to it or a two-wheel cab. These tricycles are categorized as motor vehicles [1].

Public transportation modes that are motorcycle-based, like tricycles, continue to exist and grow in cities of developing countries mainly because of the limited or non-availability of public transport service in areas with low demand. Tricycles if not properly managed and regulated would sometimes charge higher fares than that of the standard public transport service such as jeepneys and buses but commuters most often have no other choice but to ride the tricycle. Informal transport modes like tricycles usually serve areas that formal transport modes fail to serve. In numerous areas, informal modes are the only means of transport [2]. In Cotabato Province, there are barangays that use an informal mode, the habal-habal, as their main mode of transport due to the lack of other modes of transportation in the area [3]. Informal modes also allow individuals who do not have their own vehicles get to their jobs, buy and sell their produce, and access medical care [2]. In cities like General Santos City, the tuna capital of the Philippines, they rely heavily on tricycles in transporting their goods [4].

In the Philippines, the tricycle is one of the most preferred transportation mode because of its structure, its small size, and its ability to drop off passengers at specific points [5]. In addition, results of a study conducted by [6] has shown that possible factors in choosing informal modes such as Public Utility Jeepneys (PUJs) and tricycles are individual's characteristics: age and gender. These factors also show direct relationship with anticipating the utilization of formal modes such as buses and taxis or informal transportation modes. Household variables, such as income, size, and number of vehicles in the household were not significant factors, even though it was initially assumed to be possible factors.

Although it is a preferred mode, compared to jeepneys and taxis, the number of people it can carry is very limited. As shown in Table 1, with a capacity of 3 passengers, the tricycle can only carry around 36-180 passengers per hour per direction. However, there are tricycle designs in other parts of the country that can seat 5 to 6 passengers.

Table 1. Service characteristics of transport modes and their estimated passenger capacity per hour

Transportation Modes	Assumed Seated Passengers	Typical Travel Speed (kph)	Range of Frequency/Hour (Headway in Minutes)	Passenger Capacity / Hour / Direction
Articulated bus or double-decker bus	120	25–50	12–60 (1–5)	1,440–7,200
Standard bus	50	25–40	12–120 (0.5–5)	600–6,000
Minibus	35	25–40	12–120 (0.5–5)	420–4,200
Jeepney/UVs	18	20–40	12–60 (1–5)	192–1,080
Filcab	12	20–30	12–60 (1–5)	144–720
Tricycle	3	15–25	12–60 (1–5)	36–180

Source: LPTRP Manual, Vol. 1, DOTr

Aside from this, it can only travel at a limited distance, which depends on the tricycle's location itself. Passengers also experience discomfort when riding in the side car of the tricycle. Studies have shown that discomfort is the primary reason why majority of the passengers find the tricycle ride experience to be unsatisfying [5]. With this, comfort is one of the major design improvements to be done to e-trikes, together with safety and functionality. The said design improvements include: adding cushions in the seat for bumpy roads and long duration travels, adding spring parts to inhibit jolted impact when passing bumps and humps in the road, as well as providing more comfortable seat covers [7].

3. Methodology

The data about the tricycle supply (both the standard and e-trike) will be obtained from the local public transport route plan (LPTRP) and other planning documents of LGUs such as their comprehensive land use plan (CLUP), comprehensive development plan (CDP), and ecological profile. Tricycle data is definitely included in the LPTRP report of the city or municipality in Region 6. Other secondary data such as socio-demographic data as well as land use and road network design can also be obtained from these mentioned documents. There are also other sources of information that could come from national government agencies such as the Department of Public Works and Highways (DPWH) about the road system and their classification as well as the Land Transportation Office about vehicle registration and Land Transport Franchising and Regulatory Board (LTFRB) about franchise availability in the province or city.

As stated in the flowchart, the existing number of tricycles operating in the LGUs are provided in the LPTRP planning documents. The tricycle demand and travel characteristics can be obtained from the HIS surveys (see Annex about the survey form) conducted by the municipalities/cities in 2019, 2020 and even during the pandemic in 2021. For those HIS conducted during the pandemic, the travel characteristics before the pandemic were asked. Eventually, once the country surpasses this pandemic, it is expected that the travel characteristics of people in Region 6 would be similar to the pre-pandemic conditions. It should be noted that the local planning staff conducted the surveys and through our research collaboration and signed memorandum of agreement (MOA) we have access to the data.

Table 2. Important endogenous and exogenous variables to be used in the study

Endogenous Variables	Description
Number of tricycles with permits Estimate of the number of tricycles without permits	-Those with permits can be obtained from the planning documents -Those without permits may also be provided in planning documents but are only estimates
Exogenous Variables	
a. Natural Environment	May include the terrain, vegetation and whether it is a coastal or interior (maybe mountainous, flat) town
b. Design Environment	This is about the land use characteristics and layout, road network layout, grade of roads, among others
c. Political Environment	Presence and number of public transport cooperatives, organizations (both formal and informal) of tricycles
d. Availability of Other Public Transport Services, both formal and informal	Presence and number of other PUV routes serving within the municipality or those that pass through as well as informal transport such as pedicabs and habal-habal
e. Socio-Demographic Characteristics of the Town/City and its Households	This may include the population and density, land area, road density, class of the municipality or its annual income, poverty level, household car ownership, HH income, average family size, average number of working household members, average number of children going to school, among others.

Secondary data about the LGU can be gathered from several sources but most can be obtained from the LPTRP document that they are developing. Several LGUs have already an approved LPTRP, others are under review by the LTFRB while there are others more who are still under development. Nevertheless, these LPTRPs will be a good source about socio-demographic profile of the LGU, the land use and road network lay out, the physical or natural environment of the place, the political environment, as well as information about other public transport service in the locality. See Table 2 for the summary of these endogenous and exogenous variables. Relationships from among these variables and strength of association with the tricycle supply available will then be established.

After processing and statistical analysis of data, models were then be developed using

regression analysis. The models were compared and assessed whether which model could provide better estimates of the needed tricycle units to be issued permits to operate in the LGU. It should be noted that the estimates could also be in a range of values since we expect high variability in the data that we were gathered.

4. Initial Results

From the LPTRP of the municipalities and cities, we can already gather the following information such as land area, population, population density, number of households. Table 3 shows the correlation among these variables. There is a strong relationship between the number of tricycles as against the population and number of households.

As seen from the plot (Figure 4) between tricycles and the number of households, the R^2 = 0.8329 and from the equation of the trendline, for every 100 households, 5.56 tricycles are needed. While a polynomial relation was established between the number of tricycles and population of the study area in Figure 5.

Table 3. Correlation Analysis of Variables

	Number of Households (Estimated)	Land Area (Hectares)	Total Population (2020)	Population Density	No. of Tricycles (y)
Number of Households (Estimated)	1				
Land Area (Hectares)	0.57575	1			
Total Population (2020)	0.99971	0.58732	1		
Population Density	-0.02171	-0.29949	-0.03038	1	
No. of Tricycles (y)	0.91261	0.46434	0.913995	-0.02483	1

5. Conclusion/Discussion

From the preliminary results, the number of tricycles that are issued with permit to operate can be related to the number of households and population of the study area. Further analysis will be conducted to establish a more robust model that can be used by the local government units in determining the most appropriate number of tricycle units given other important variables such as average income, vehicle ownership, competition from other modes, availability of other routes, and safety criteria if data on safety is available. Other models such as artificial neural network (ANN) models will also be used for more robust models.

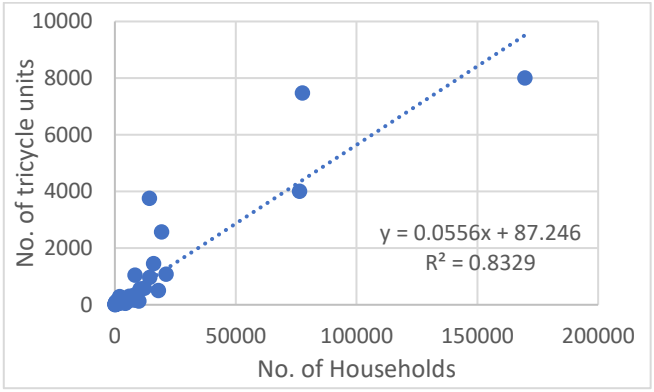


Figure 4. Regression line between the no. of tricycles and the no. of households

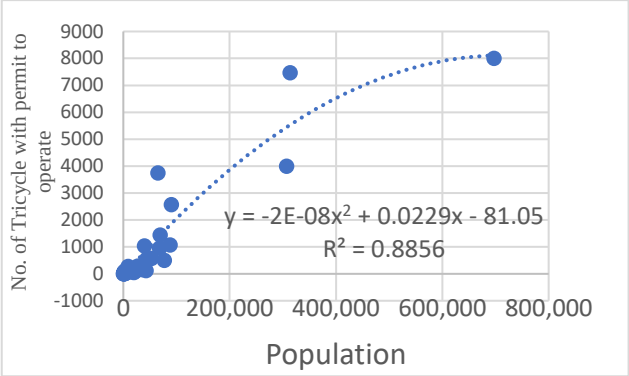


Figure 5. Parabolic curve showing relationship between the population

References

[1] M. Guillen and H. Ishida, "MOTORCYCLE-PROPELLED PUBLIC TRANSPORT AND LOCAL POLICY DEVELOPMENT: The Case of "Tricycles" and "Habal-habal" in Davao City Philippines", *IATSS Research*, vol. 28, no. 1, pp. 56-66, 2004.

[2] R. Cervero and A. Golub, "Informal transport: A global perspective", *Transport Policy*, vol. 14, no. 6, pp. 445-457, 2007.

[3] K. Alucilja and A. Fillone, "Operational Characterization of Habal-habal in Selected Municipalities of North Cotabato", in *Transportation Science Society of the Philippines*, Cagayan De Oro, 2018.

[4] G. Cueto, F. Uy and K. Diaz, "Exploratory Data Analysis of Electric Tricycle as Sustainable Public Transport Mode in General Santos City Using Logistic Regression", 2021. [Accessed 21 August 2021].

[5] N. Dorado, P. Fabros and C. Rupisan, "An Ergonomic Analysis of Tricycle Sidecars in Quezon City", *Procedia Manufacturing*, vol. 3, pp. 2816-2823, 2015.

[6] M. Guillen, H. Ishida and N. Okamoto, "Is the use of informal public transport modes in developing countries habitual? An empirical study in Davao City, Philippines", *Transport Policy*, vol. 26, pp. 31-42, 2013.

[7] R. Luansing, C. Pesigan and E. Rustico, "An e-trike ICE Project - Innovative, Concrete and Ergonomic: Systems Design to Support Sustainable e-trike Commercialization", *Procedia Manufacturing*, vol. 3, pp. 2333-2340, 2015.

[8] P. Romero, "Lawmaker wants training for trike drivers", *The Philippine Star*, 2015.

[9] M. Montemayor, "QC exec seeks to 'overhaul' tricycle franchising system", *Philippine News Agency*, 2018.

[10] D. Dike, "An Empirical Study of the Use of Tricycle as a Public Transport Model in Nigerian Cities", *Journal of Social Sciences and Public Affairs*, vol. 2, no. 2, pp. 66-76, 2012.

[11] J. Aydinan, "Knowledge and Level of Compliance of Tricycle Drivers on Traffic Rules and Regulations: A Case of the Tricycle City of the Philippines", *International Journal of English Literature and Social Sciences*, vol. 5, no. 2, pp. 528-535, 2020.

[12] F. Kassa, "Informal transport and its effects in the developing world: a case study of Addis Ababa, Ethiopia", *Journal of Transport Literature*, vol. 8, no. 2, pp. 113-133, 2014.

[13] S. Agatonovic-Kustrin and R. Beresford, "Basic concepts of artificial neural network (ANN) modeling and its application in pharmaceutical research", *Journal of Pharmaceutical and Biomedical Analysis*, vol. 22, no. 5, pp. 717-727, 2000.

List of ATRANS Young Researcher's Forum 2021 Organizing and Scientific Committee

AYRF Organizing and Scientific Committee			
1		Ms. Kanjana Saengkham	Rangsit University
2		Ms. Sutthikarn Weluwanarak	Burapha University
3		Ms. Boonyaporn Thuraphan	Kasetsart University

List of Mentors of ATRANS Young Researcher's Forum 2021 Committee

AYRF 2021 Mentors			
1		Mr. Naruphol Niyom (AYRF Alumni and Mentor of ATRANS Young Researcher's Forum Committee 2017-2021)	PlanPro Corp., Ltd., (Transportation Consultant)
2		Ms. Suwishada Fukuda	ATRANS Secretariat officer for In-House Management
3		Ms. Narisara Pongpakdiboribarl	ATRANS Secretariat officer for Academic Affairs

PROCEEDINGS OF

ASIAN TRANSPORTATION RESEARCH SOCIETY (ATRANS)
902/1,9TH FLOOR, VASU1 BLDG., SOI SUKHUMVIT25, KLONGTOEY-NUA,
WATTANA, BANGKOK 10110, THAILAND
TEL (66) 02-661-6248 FAX (66) 02-661-6249