Analysis of Demand on Shared Mobility Packages in University Campus

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A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Engineering in Civil Engineering
Department of Civil Engineering
FACULTY OF ENGINEERING
Chulalongkorn University
Academic Year 2019

การวิเคราะห์อุปสงค์ชุดทางเลือกสำหรับการเดินทางร่วมในเขตมหาวิทยาลัย

น.ส.แซนดาร์ วิน

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิศวกรรมศาสตรมหาบัณฑิต
สาขาวิชาวิศวกรรมโยธา ภาควิชาวิศวกรรมโยธา
คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2562

Thesis Title	Analysis of Demand on Shared Mobility Packages in University Campus
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Field of Study	Civil Engineering
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แซนดาร์ วิน : การวิเคราะห์อุปสงค์ชุดทางเลือกสำหรับการเดินทางร่วมในเขตมหาวิทยาลัย. (Analysis of Demand on Shared Mobility Packages in University Campus) อ.ที่ปรึกษาหลัก : รศ. ดร.สรวิศ นฤปิติ, อ.ที่ปรึกษาร่วม : ดร.พงษ์สันธ์ บัณฑิตสกุลชัย

การเดินทางโดยการใช้พาหนะร่วมกันเป็นวิธีการเดินทางรูปแบบใหม่ที่มีความหลากหลายในการให้บริการ จุฬาลงกรณ์มหาวิทยาลัยได้มีการนำหลายรูปแบบการบริการเข้ามาให้บริการแก่นิสิต และบุคลากร เช่น จักรยานเช่า (CU Bike), รถยนต์ไฟฟ้าขนาดเล็ก (Ha:mo), รถสามล้อไฟฟ้า (Muvmi), และรถโดยสารไฟฟ้าปรับอากาศขนาดเล็ก (CU POP Bus) ที่ให้บริการฟรีและมีเส้นทางครอบคลุมทั้งภายในมหาวิทยาลัยและเชื่อมต่อกับระบบขนส่งอื่น ๆ ในบริเวณใกล้เคียง การศึกษานี้มีวัตถุประสงค์เพื่อศึกษาปัจจัยที่ส่งผลต่อการตัดสินใจเลือกใช้รูปแบบการบริการของนิสิตในจุฬาลงกรณ์มหาวิทยาลัยโดยการนำเสนอบริการการเดินทางต่าง ๆ แบบผสมผสาน การศึกษาเก็บรวบรวมข้อมูล 2 ครั้งเพื่อสอบถามความพึงพอใจในการใช้บริการและปัญหาที่พบจากการใช้บริการที่ผ่านมา และศึกษาเกี่ยวกับปัจจัยที่มีผลต่อการตัดสินใจเลือกใช้บริการที่มีการออกแบบลักษณะการให้บริการต่าง ๆ แบบผสมผสานหรือเป็นชุดทางเลือก (Package) และให้กลุ่มตัวอย่างทำการเปรียบเทียบตัดสินใจเลือกชุดทางเลือกบริการ โดยกระจายแบบสอบถามให้แก่นิสิตจุฬาลงกรณ์มหาวิทยาลัยจำนวน 370 คนในการรวบรวมข้อมูลครั้งแรก และ 326 คนในการรวบรวมข้อมูลครั้งที่สอง การวิเคราะห์การถดถอยพหุคูณ (Multiple linear regression) เพื่อแสดงความสัมพันธ์ระหว่างอุปสงค์ของบริการกับราคาค่าบริการ และ พบว่าค่าบริการรถสามล้อไฟฟ้า (Muvmi) มีความอ่อนไหวมากกว่าค่าบริการของรถไฟฟ้าขนาดเล็ก (Ha:mo) และยังพบว่า เพศหญิงมีแนวโน้มที่จะใช้บริการรถสามล้อไฟฟ้า (Muvmi) มากกว่าเพศชาย นอกจากนี้ประสบการณ์ของผู้ใช้เป็นปัจจัยสำคัญที่ส่งผลต่อความต้องการใช้บริการในอนาคตอย่างมาก ในการวิเคราะห์ความพึงพอใจในชุดทางเลือกบริการแบบรายเดือนด้วยแบบจำลองการถดถอยโลจิสติกส์ พบว่า คุณลักษณะในการสามารถทบยอดค่าบริการไว้ใช้ในอนาคตได้ เป็นปัจจัยที่สำคัญที่สุดต่อการตัดสินใจเลือกชุดทางเลือกบริการของกลุ่มตัวอย่าง ผู้ให้บริการควรพิจารณาคุณลักษณะนี้ร่วมในการเสนอการบริการด้วย จากผลการศึกษาทั้งหมดสามารถช่วยให้ผู้ให้บริการเข้าใจถึงความพึงพอใจของผู้ใช้บริการและออกแบบรูปแบบการบริการและชุดทางเลือกบริการได้อย่างเหมาะสม

สาขาวิชา วิศวกรรมโยธา

ปีการศึกษา 2562

ลายมือชื่อนิสิต

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6170362421 : MAJOR CIVIL ENGINEERING
KEYWOR D: Shared Mobility, Mobility on Campus, Integrated Service, Willingness to pay

Sandar Win : Analysis of Demand on Shared Mobility Packages in University Campus. Advisor: Assoc. Prof. SORAWIT NARUPITI, Ph.D. Co-advisor: PONGSUN BUNDITSAKULCHAI, Ph.D.

Shared mobility is the emerging service and comes in various forms. In Chulalongkorn University, innovative shared mobility services such as shared bicycle (CU Bike), small electric vehicle sharing (Ha:mo) and ride sharing tricycle (Muvmi) are offered along with conventional free bus (Pop bus) circulation. This study aimed to explore the attributes of the monthly mobility package which have effect on student's decision while offering the integrated service package for CU students. Two phases of questionnaire surveys were conducted to find out the satisfaction on existing mobility services quality, barriers that discourage students from using shared mobilities, and factors that influence their decision for buying package with improved service qualities. The questionnaire was randomly distributed to 370 students in the first phase and to 326 students in Chulalongkorn university in the second phase. Multiple linear regression analyses display that the demand for shared mobility is dependent on the price. Gender is also correlated with Muvmi demand. Moreover, user experience is the most important factor that highly affects user demand in the future. The logistic regression model was used to analyze the preference of the monthly mobility packages. The most important service attribute to users is the carry-over feature, the remaining trips of service can be transferred to the next consecutive month. The service operator should consider carry-over feature. The results of the analyses could help the operators to understand the users' preferences and to design their service packages appropriately.

Field of Study:	Civil Engineering	Student's Signature .....
Academic Year:	2019	Advisor's Signature .....
		Co-advisor's Signature .....

ACKNOWLEDGEMENTS

Firstly, I would like to express my gratitude to my advisors, Associate Professor Dr. Sorawit Narupiti, Ph.D (advisor) and Dr. Pongsun Bunditsakulchai, Ph.D (co-advisor) for their supportive guidance and encouragement throughout the process of this thesis and studying in Chulalongkorn University. Thank you for your helping hand and guidance whenever I have questions or difficulties related with my research. Secondly, I would like to take this opportunity to thank to my exam committee members: Associate Professor Dr. Saksith Chalermpong,Ph.D (committee chairman) and Associate Professor Dr. Varameth Vichiensan, Ph.D (external examiner) as well for their evaluation and feedback for this thesis. Moreover, I would like to express my gratitude to Chulalongkorn University for financial support throughout these two years. Without this grant, it would not be possible to pursue master program in Thailand. Last but not least, I would like to say to my family and all my classmates who are being with me through thick and thin for their care and support. Special thanks to who actively contribute to this work during data collection and translation. Thank you very much.

Sandar Win

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CHAPTER 1
INTRODUCTION

1.1 Background of Study

Chulalongkorn University (CU) is the first Thai national university which is located in the central business district area (CBD) of Bangkok. The university consists of twenty-one faculties, four colleges and nine research institutes. Currently, there are 37,000 of students in total studying in CU including both undergraduate and graduate students.

As CU is located in CBD area and surrounded by numerous public transportation stations, students can reach CU by various modes such as public bus, Bangkok Mass Transit system (BTS) sky train, Metropolitan Rapid Transit (MRT) subway and minivans. In order to reduce the number of vehicular trips generated from campus and encourage the students to commute by public transport to and from CU, university provides a free shuttle bus service (CU Pop Bus), connecting to bus stations and BTS stations nearby CU. Generally, CU Pop Bus runs in six different routes inside and nearby campus area, serving in and out campus access as well as internal circulation within the campus.

In order to get around CU campus comfortably and conveniently, CU also cooperates with other private companies and provides many alternative means of transport. An electric car sharing service (Ha:mo), a single occupancy vehicle, has approximately 30 stations around CU campus, and the fare starts at 20 baht for the first 15 minutes and additional 2 baht per minute will be charged on the additional travelling time.

Muvmi, an electric sharing Tuk Tuk service, is another available mode in CU campus. It is very convenient for short distance travel as booking and payment can be done through the application (App) by adding pickup and drop off point. Nevertheless, this service is only available around Chulalongkorn University and some designated areas in Bangkok. The fare ranges from 15 baht to 25 baht per ride depending on the distance travel.

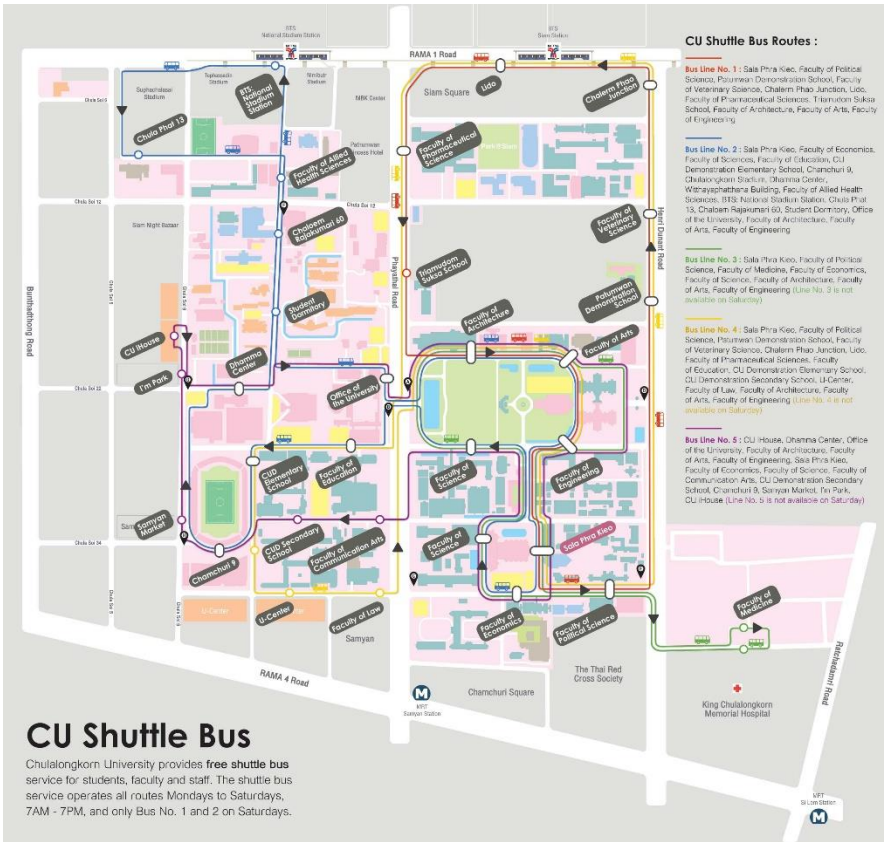


Figure 1: CU Pop Bus routes in Chulalongkorn university
(*Source*: *https://www.chula.ac.th/en/about/green-university/cu-shuttle-bus/)*

1.2 Problem Statement

Even though there are four available modes for students' daily mobility in CU, CU Pop Bus is the most popular mode among four currently. It is obvious that

demand is high because the service is provided for free and open access to all users to get around CU. Furthermore, five routes are well connected to BTS stations and many places inside the campus as well. According to the monthly report of passenger trip using CU shuttle bus for procurement and supplies the inspection board (September 2019), 10,258 trips were generated and there were 552,486 of passengers in total. During the morning peak hours, less than 20 percent of commuter travel by Pop Bus from BTS Siam and going inside the campus. Moreover, one third of users relies on CU Pop Bus for going outside of the campus during the evening peak hour.

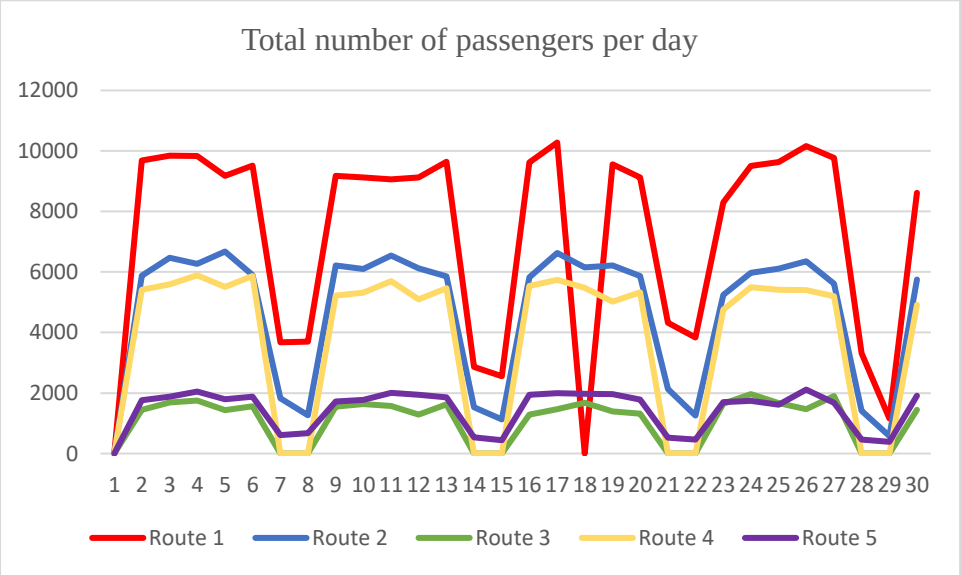


Figure 2: Numbers of passengers of CU Pop Bus
(Source: Monthly report of passenger trip using CU shuttle bus for procurement and supplies the inspection board)

As seen in Figure 2, route 1 and route 2 have the highest demand as they connect with two BTS stations and the student dormitory. On average, there are 62 passengers per trip on both route 1 and route 2, which are too crowded and exceed the capacity of the bus. In addition, traffic congestion normally occurs along Henri Dunant Road and Rama 1 road, especially at Chalermpao intersection and it increases

both waiting time and travel time to get access to the nearest BTS stations, especially in the evening peak hours.

The number of users of the other modes (i.e., Ha:mo, Muvmi and CU bike) are lesser in number compared to CU Pop Bus. Perhaps a few of students choose the other modes due to the fare conditions, reliability, and availability of the service. In order to provide a cheaper price for the students and to encourage the use of active modes such as CU bike, the concept of bundle mobility service, Mobility-as-a-Service (MaaS), will be used to bring an effective and convenient mobility integrated service for the students. Before creating the discount service package for students, it is necessary to understand the current travel activities of the students, the reason why they rarely choose the other options than CU Pop Bus and the factors influencing the mode choices.

1.3 Objectives

The ultimate goals of this study are to improve the service quality and cost-effective modes in CU such as CU bike, Muvmi and Ha:mo in order to get around the campus comfortably and conveniently and to encourage students to use shared mobility. In order to meet the ultimate goals, the specific research questions and research objectives of the study can be defined as follows.

1. To find out current travel characteristics and satisfaction of students based on the existing service quality;
2. To find the factors that influences on the number of usages of each mode in future;

3. To determine the attributes of the shared mobility package which have effect on student's decision.

1.4 Scope of work

As this study aims to improve the mobility inside and nearby Chulalongkorn University area, the data collection would be done by collecting travel behavior and mode choices among four main modes, CU Pop Bus, CU Bike, Ha:mo, and Muvmi, that are available in CU campus.

Initially, CU students will be asked about demographic characteristics of the respondents, the satisfactory level of the current mobility service provided in CU and willingness to pay for each paid mode using the questionnaire survey method. The data from internal mobility demand questionnaire will be analyzed using statistical software and the result will be used to develop shared mobility package questionnaire that explores demand for monthly service package for the students who are currently studying in Chulalongkorn University. The data from this questionnaire would be analyzed using logistic regression to explore the factors influencing their choice on package.

1.5 Structure of Report

This thesis report is composed of eight chapters in total. Chapter one mentions about the background of the study, the main objective of the study and the scope of work. The previous studies and findings from many researchers about MaaS will be discussed in Chapter two and followed by Chapter three: the methodology that will be used in data treatment and analysis. Chapter four will discuss about the data collection procedure, the descriptive analysis of the respondents, travel behavior of the current

students in CU and mode choice in general by analyzing the data obtained from questionnaire one. Chapter five will mention about demand model for shared mobility service (Ha:mo and Muvmi) in CU. The way to create the service package design and descriptive analysis will be presented in Chapter six while analysis for preference of the package will be covered in Chapter seven. Finally, Chapter eight will conclude important findings from the results of data analyses and will give suggestion that should be considered in designing the service packages and improve the mobility in CU campus.

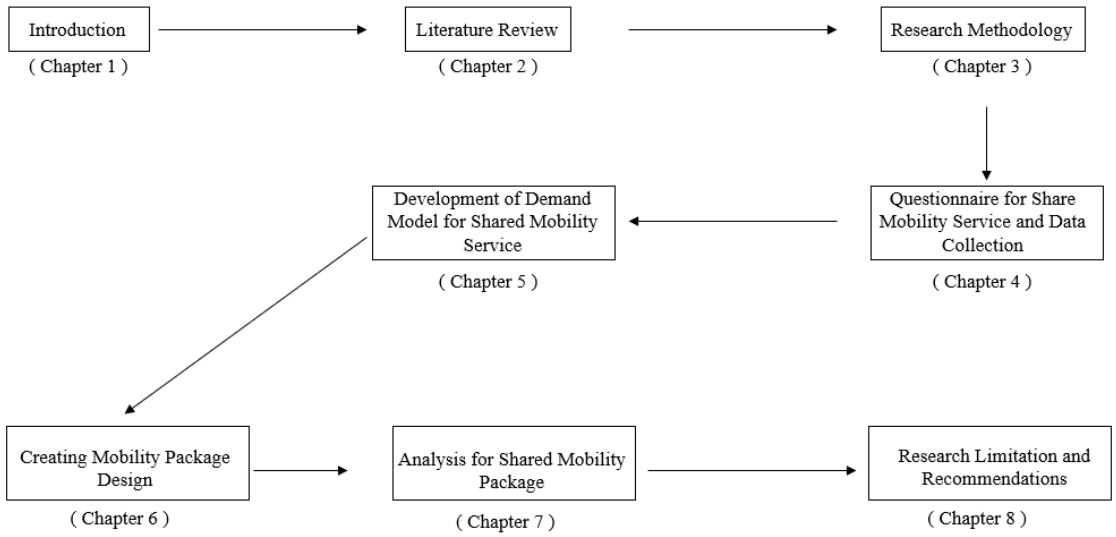


Figure 3: Structure of Research

CHAPTER 2
LITERATURE REVIEW

The details about the Mobility-as-a-Service (MaaS) and its definition, the different types of integration behind the MaaS system in order to eliminate the barriers among service providers and let the users travel smoothly, the core features of MaaS, case study from many countries will be reviewed in following sections.

2.1 What is Mobility-as-a-Service (MaaS)?

Generally, Mobility-as-a-Service (MaaS) is a system that offers the multiple mobility services to fulfill the customer needs instead of buying the transportation mean for the daily mobility needs. The public and private operators need to collaborate with each other and integrate all the transport means including the payment system in order to get access to the different transport means through a single platform such as smartphone application or website. This is a platform where the MaaS operator offers the designated monthly mobility packages or pay-as-you-go packages so that the customer can choose the package that meets their travel demand. Furthermore, the users get the real-time information, traffic and travel condition for every single moment, therefore, the users can choose their desired mode, book and get the ticket, plan for their daily trips and make the payment in one single app.

The concept of MaaS is a new trendy concept in transportation field and there is no exact definition about MaaS. Mobility-as-a-Service is a system that promote the use of the public transportation mode by using any mobility package that customer needs rather than owning a vehicle (Kamargianni et al., 2016). In Australia (2018), MaaS is the integration of all current transport modes, public and private service providers, and offers the service in a single platform. Giesecke et al. (2016) specifies

that it is a user-centric service as the user can choose the preferred mode, buy a ticket, make a payment and get the real time information through the mobile application. Kamargianni et al. (2015) mentions that MaaS is bundling the multiple mobility services into a package that can benefit both users and service operators. MaaS is a way to present the integrated multiple mobility options for going from the original point to the destination point (Burrows et al., 2015).

There are many different opinions about the occurrence of the MaaS concept as well. Johansson (2017) argues that it is one of the solutions that can handle the shortage of the urban transportation supply and discourage people using own private cars. Under the sustainable mobility concept, the government starts promoting the use of public transportation modes and discourages citizen from using private cars. The travel pattern of the young people is changing with the popularity of the shared economy like ride sharing, bike sharing and carpooling service. MaaS brings the concept to provide the flexible and personalized mobility service to promote the public transport service, to satisfy the daily demand and reduce the critical congestion problem in the urban area.

On the other hand, Kamargianni et al. (2015) argues that the introduction of various mobility services, such as bike sharing, car sharing, ride hailing service or on demand transport service and public transport services, creates the complexity of the payment system and planning the trip. Having different apps installed in the mobile phone, owning the various card to access to different transport service and lack of real time information make people think about the one stop mobility service like MaaS in order to blur the complexities of the multimodal trips.

From the users' point of view, enabling to travel smoothly and seamlessly is the crucial characteristic of MaaS. The combination of different transport modes and service providers, one stop service payment, and the availability of the service packages which satisfy the customer's demand are the core characteristics of MaaS (Jittrapirom et al., 2017). Karlsson et al. (2016) states that the simplicity of the combined mobility packages is the unique characteristic that can attract the users.

A trial project in Sweden will be mentioned here in order to increase understanding about the users' acceptance and the potential market of MaaS, The Ubigo project developed in Gothenburg; Sweden was one of the full integrated MaaS services. A multimodal subscription was provided by uniting the existing transportation services, including the public transport, taxi, car and bike sharing and car rental services. A six-month field operation test was carried out to study about people acceptance on MaaS, how MaaS could discourage the use of private car, and the characteristics that could appeal to the users. A mixed method including interview, travel diaries, and three phases of questionnaire survey ("before", "during" and "after") was employed. The result of the study indicated that not only the curiosity on the new technology and mobility pattern but also the convenience and flexibility of MaaS could attract passengers to use the MaaS service. Furthermore, the result of "after" questionnaire data analysis showed that the use of private cars decreased and there was a positive intention to the usage of public transport, walking and bicycle (Sochor et al., 2014).

MaaS can be implied as an environmental-friendly and sustainable service. Moreover, the integration among service providers is the key action to provide the

multimodal seamless mobility service. Integration can blur the barriers between the parties and inconvenience of travel.

Table 1: Mobility-as-a-Service and their Characteristics (Australia, 2018)

MaaS service	Country	Year	Core Characteristics	
			Transportation modes	Non Transportation features
UbiGo	Sweden	2014	Public transport, car rental, car-share, taxi, bike-share	Incentive, bonus Trip history Customer service support FAQ
Whim	Finland	2016	Local public transport, taxi and daily car rental service	Ticketing and payment system Offer pay-as-you-go plan Personalized journey planner
Moovel	Germany	-	Car2go, national car-share service, national taxi and rail service, selected bike-share service.	Ticketing and payment system Personalized journey planner Offer pay-as-you-go plan
WienMobil	Austria	-	Local public transport, car-share, taxi, car park and bike-share services	Booking, ticketing and payment system Multi-modal journey planer Compare time and cost of different modes and environmental impact
EMMA	France	-	Local tramway lines and buses, car-share, car park, on street parking, bike-share and bike park service	Monthly or yearly packages Special prices for students and old customers Pay-as-you-go plan with discount rates Real-time updates on public transport service and parking availability
Mobility shop	Germany	2016	National rail service, car-share, local taxi	Trip planner No single smart card
HelloGo	Netherlands	2017	Bus and train service, bike rental, taxi service, car sharing	Realotime information Multi-modal journey planer Booking and payment integration
Didi	China	2018	Biggest ride-share service provider	Single pay-as-you-go- plan Trip planner
myCicero	Italy	-	Public transport and car parking service	Single pay-as-you-go- plan Trip planner

2.2 MaaS as a System Integration Service

According to the dominant concept of MaaS which provides flexible and convenient bundling mobility service packages for the users, the integration between the public and private organizations becomes one of the most critical components in MaaS. The following sections will describe various types of integration to supply the seamless transportation service.

2.2.1 Ticket and Payment Integration

The ticket integration is the most fundamental component for combining payment for single modal transport service. The electronic payment system becomes popular and the smart card is a widely used technology for combining the payment electronically. Basically, users can top-up money and access to different type of transportation means using only one single pass when users are changing from one mode to another. It can not only lessen the transit time but also bring about the convenience of transfer among the transportation services.

Discernable examples of the ticket integration are presented here. The EZ-link card which is widely used in Singapore. The smart card is a stored-value card which can be used to access to all modes of public transport such as bus, Mass Rapid Transit (MRT), Light Rail Transit (LRT) and the amount of payment varies by travel distance. Furthermore, non-transit payment such as the road toll payment and parking payment can also be done with this single card. The complexity of using various cards for different transport service is reduced. The Octopus card in Hong Kong which was launched in 1997 is a successful common ticket as well. According to the study of Smart Card Alliance (2003), 95% of the commuters in Hong Kong uses the Octopus

card for daily travel and the Octopus card could bring the convenience and speed up the time for buying ticket from 15% to 20%. In addition, the barriers among the transportation services operators can be eliminated. Although the common tickets in Singapore and Hongkong are used for all public transit, the payment for each mode is still paid separately. Similarly, there is a widely usage of rabbit card in Bangkok, Thailand, which can be used for payment in some participating restaurants and BTS links. Given the fact that the potential of a common ticket which is an accessible pass to all public transport modes can be clearly seen as most of the commuters are already familiar with the usage of card system.

2.2.2 ICT Integration

The information communication technology (ICT) integration is the combination of service-related information of all different modes. The integration aims to provide the real-time information such as travel time, waiting time or traveling conditions to the travelers through the designated mobile application (app). With a single app, the commuters can plan the trips for the whole day in advance, book and buy the tickets. Moreover, they also can get the updated information about all kinds of transit modes and can compare travel times and, costs, and other conditions among the different modes. ICT integration always comes along with the ticket and payment integration among the participating partners. Jittrapirom et al. (2017) points out that ICT plays a crucial role not only to combine data and share the information between in the participating partners but also to provide the effective and fast service system as well.

Travel information becomes a vital MaaS component in order to improve the quality of transportation service as the traveling behavior of commuters becomes more complex and the commuters are using several transportation modes during a single journey, or various modes for different purposes. By providing the real-time travel information, people are encouraged to switch their travel mode to the fastest (or the most desirable) mode (Grotenhuis et al., 2007). The travelers have various options in hand and can choose the suitable mode that would meet personal demand. Eryilmaz et al. (2014) mentions that the intermodal travel behavior is increasing with the increase in travel demand of inhabitants in the metropolitan area. Many people prefer an easier and more convenient modes such as private car or taxi due to the complexity of the payment system that requires the travelers to use different mobile application for different modes and lack of the integrated information (Kamargianni et al., 2016).

Moovel is the integrated mobility service which was launched in Germany in 2016. The users can make use of mobile application to get access to participating partners services such as car-sharing service; Mytaxi, a national taxi service; Deutshe Bahn, the German national rail service provider; and the selective bike-shared companies. Customers can access to the public transport service through the Moovel as well in some cities of Hamburg and Stuttgart. Currently, Moovel is still using the pay-as-you-go system for the payment even though MaaS in other countries are providing the subscription mobility package for the travelers.

2.2.3 The challenges and issues of implementing MaaS service

MaaS is an emerging trend to create a more desirable service that could be the answer of transport solution and solve problems that are facing in transportation field, but it is still at the early stage of implementation. Unlike traditional transport services, MaaS service needs the partnership between the participating parties and it thus has the institutional, operational and technical challenges that must be overcome to bring MaaS service to the users in wider practice. Furthermore, the design of the fixed subscription package should be carefully designed for all the heterogenous travel patterns.

The outcomes of MaaS system can be varied depending on the objective of the MaaS service. If the aim is to provide a service that can substitute the use of private car, there is a potential to reduce the car ownership by supplying a good quality and reliable public transport and shared mobility services. On the contrary, the number of unnecessary trips can be unpredictably increased if the aim is to create the transport-oriented city. For the above reason, the service operating organization should be well established and offer the monthly subscription packages in order to handle the unnecessary trip generation and supply the sustainable public transport (Johansson, 2017).

2.3 Bundling of the Mobility Service Package

The service package is one of the feature of MaaS and different kinds of service packages were tested in the past studies. Ratilainen (2017) mentions that the bundling service is the heart of the MaaS system, and the transport service modes are correctly packed with the new mode like bike sharing, thereby having potential in the

increased use of the sustainable modes. Moreover, the bundling products or services are more attractive to the customers and travelers are more likely to buy the package service or products rather than the individual item (Bakos & Brynjolfsson, 1999). Schmalensee (1984) and Stigler (1963) states that bundling two goods which are negatively correlated could make more profit for the sellers.

In additionally, when the sharing services, bike sharing and car sharing, are taken into the package, they improve the flexibility and convenience of the trip and this is an ideal concept of MaaS (Jittrapirom et al., 2017). Kamargianni et al. (2015) also supports the statement by stating that the service package with only traditional transportation modes such as public buses and taxi cannot bring the flexibility to the travelers.

There are many studies on the willingness to pay for MaaS service packages and three kinds of package type are considered in most of the studies. They are

1. Fixed monthly mobility package type
2. Flexible monthly mobility package type and
3. Pay-as-you-go subscription package type

Even though the service package is the main feature of MaaS which can appeal the travelers to use the service, there is still unclear how to design the service package that meets the users' needs. While the service packages are provided by the operators does not reach the users' demand, the users are not willing to pay for the new service.

2.4 International studies about MaaS

2.4.1 Case Study in Helsinki, Finland

In 2017, A study in Helsinki emphasized on the users' intention to the MaaS and their willingness to pay for the multimodal transport service (Ratilainen, 2017). Moreover, the users' acceptance and the factors influencing the willingness to pay in Finland were studied using the fixed service packages offering. This study targeted to four focus groups: student, young professional, middle-aged family member and senior. For the quantitative data, there were 252 respondents in total and half of the respondents were young and had low household income. The collected data were analyzed using the multinomial logit model (MNL) and found out that most of the adoptive users were the students and the public transport users while public transport was the dominant modes in the service package. The private car users were limited in consideration about changing the transportation mode, using the public transport instead (Ratilainen, 2017).

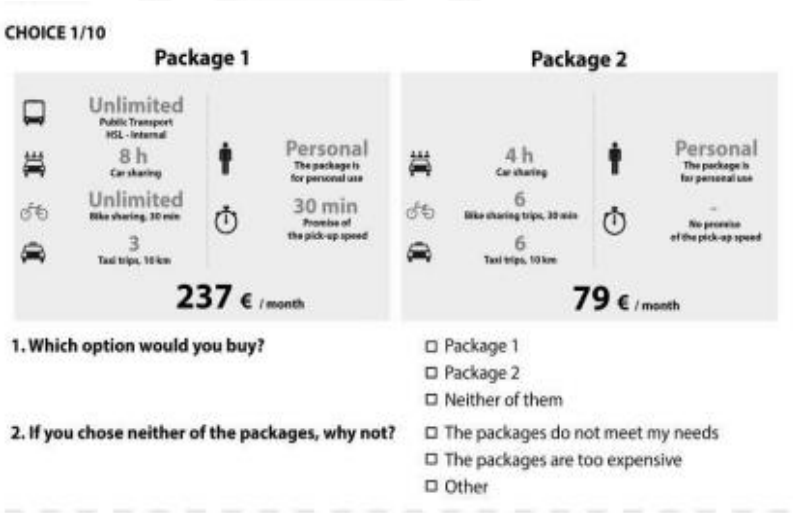


Figure 4: Example of Fixed Package (Ratilainen, 2017)

As seen in Figure 4, the predesigned package includes the bundle of the services and features. Mostly this kind of package is offered at the discounted price relative to the individual feature price (Bakos & Brynjolfsson, 1999). The monthly package service is a prepaid service and the customer can buy the extra service easily through an app.

2.4.2 Case Study in Landon

Another type of package is flexible package which the operators will provide the menu option type service choice and customers can select the number of trips or kilometer of travel on individual modes. The app will calculate the service fees automatically and show up the price after choosing the service. It is like the customized package type which would meet the traveler's needs. Furthermore, there will be more add-on service features like transferability, the un-used trips or the remaining kilometer will be able to transfer to the next consecutive month.

Matyas and Kamargianni (2018) explored about the features and modes which appeals the users to shift to MaaS service and what kind of package plan that people were interested in. The study was conducted in London using mixed-method approach in order to get the quantitative data (online survey about the stated preference experiment) and the qualitative data (in-depth interviews). Researchers tracked and recorded how each of the respondent travel in his or her daily life and the service packages generated based on his or her mobility records. Not only the fixed packages but also the flexible packages type (menu options) were provided in the choice set for the respondents to choose when the fixed packages did not meet their travel demand or desirable services. The data collection process lasted for 6 months, from November

2016 to April 2017 and there were 1,138 participants answering the questionnaire. The multinomial logit modeling method was used to understand the user preferences on the MaaS plan.

The result showed that less than 20% of the respondents are less likely to choose the flexible package option as the package's price is higher than the fixed packages. The high-income respondents are more likely to choose the flexible option while the respondents, however, participants under the age of 30 and low household income, think that the predetermined fixed bundle plan is preferable than the personalized option.

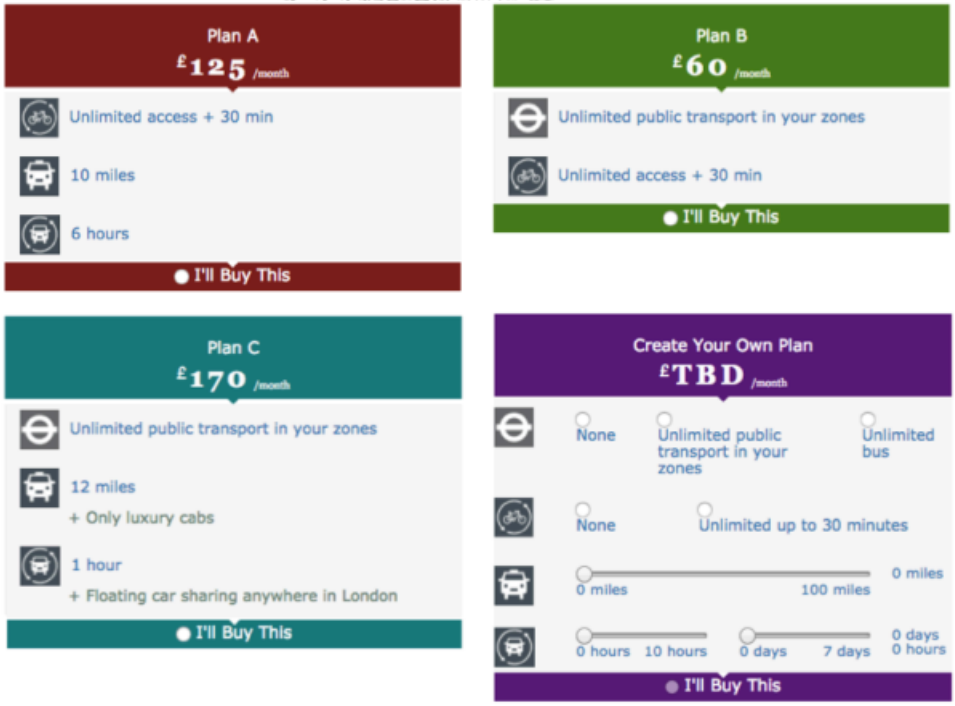


Figure 5: Example of Flexible Package (Matyas and Kamargianni, 2018)

2.4.3 Case Study in Sydney, Australia

In a study by Ho et al. (2018), the pay-as-you-go package type was considered when designing the survey questionnaire to explore the potential market of MaaS and how the individual item included in the package could affect the users' choices. In this package, the operators offer the discounted unit price for some services (e.g. Car2Go). For some partnering services, the operators offer the special discount for every single trip that the traveler makes. By subscribing this type of the package, the user can get discount according to the package they buy and travel cheaply.

For this study, data were collected using Computer-Assisted Personal Interview method in three shopping centers. Each respondent was asked to watch video explaining about MaaS service and later got into the interview section. There were 252 participants in the interview for the period of 18 days. Following that, data was analyzed using conditional multinomial logit regression to understand the potential market of MaaS. The result showed that most of the respondents prefer to the pre-design fixed package type.

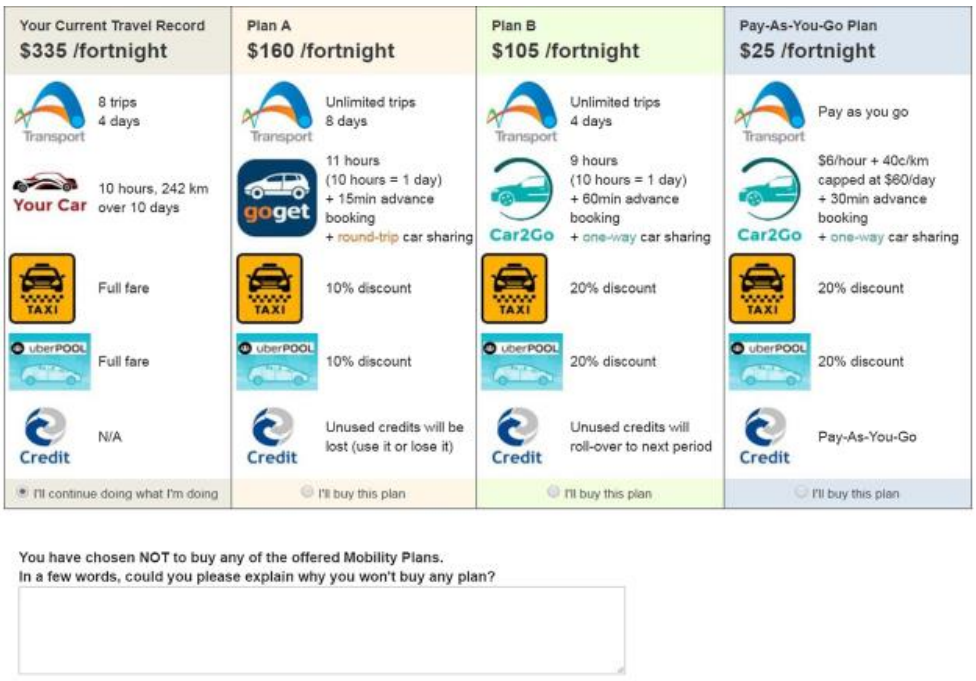


Figure 6: Example of pay-as-you-go package (Ho et al., 2018)

2.5 Chapter Summary

From the related literature reviews, the definition of MaaS is summarized. Key features in MaaS include integrated services of payment, information, bundling of services, and the coordination service providers. Case studies are presented to exemplify the past attempts to investigate details on MaaS development, such as user preferences, MaaS plan (offering) types, package design.

To design the MaaS service package, prior knowledge about the travel behavior of the users and the monthly demand of transport should be known before designing the service packages. It can be clearly seen from above studies that most of the respondents in different countries have more potential to buy the fixed type package plan rather than the other types of plan. It can be concluded that the good design of predetermined package plan can still meet the users' requirements and it

can bring the simplicity and convenience to the users. For the further study in this thesis, the fixed plan service package will be considered to explore the acceptance level of the students from Chulalongkorn University and encourage them to use shared mobility. The following chapter will discuss about the methodology that will be applied for gathering data from the samples and statistical analysis on the collected data.

CHAPTER 3
RESEARCH METHODOLOGY

This chapter outlines the overall research framework. After the concepts related with this work are reviewed, this chapter explains the survey method will be employed in this study. Details are elaborated on how the questionnaire would be designed in order to obtain the effective data, detail about the data collection method, target group for this study and statistical treatment of the data which includes multiple linear regression, mixed logit analysis and validation of the model. The models are used to understand the respondents' characteristics and their decision making among the provided scenarios.

3.1 Stated Preference

3.1.1 Contingent Valuation

Contingent valuation (CV) is widely used to elicit the monetary values, specifically maximum willingness to pay, associated with the change in quality or quantity of public goods or non-market goods. When designing, CV questionnaire, special consideration on these three facts are required. Firstly, the respondents have to imagine the change of the goods in term of quality and quantity and consider how can it affect them. Secondly, the respondents might not be familiar with the hypothetical situation and could result unreliable data. Lastly, willingness to pay for the change of goods would be asked in questionnaire (Bateman et al., 2002). To elicit the economic value of goods, some special techniques are used in the questionnaire such as open-ended elicitation, bidding game elicitation, payment card elicitation, single-bounded dichotomous choices, and double-bounded dichotomous choice.

Open-ended elicitation is a very straightforward technique in asking willingness to pay for a goods. The drawback of this technique is that the result may be unrealistic or unreliable as there may be zero answer. However, there are many studies using open-ended technique to get monetary values of a goods (Alvarez-Farizo, 1999; Langford et al., 1998). In this thesis, open-ended approach will be used to explore willingness to pay for each shared mobility mode in CU (specifically, Ha:mo and Muvmi) under the stated scenarios in the first questionnaire.

3.1.2 Discrete Choice Modelling

Discrete Choice Modelling (DCM) is another method to perform analysis on the stated preference questionnaire. Unlike Contingent valuation, this approach is used for determining the values of characteristics and attributes of goods. There are four approaches to do discrete choice modelling such as choice experiments, contingent ranking, contingent rating and paired comparisons. The choice experiments approach is widely used in many studies about MaaS (Ho et al., 2018; Kamargianni et al., 2015; Ratilainen, 2017), and in health care studies (Sever et al., 2019). Each alternative contains the bundle of different levels of three or four attributes to test the weight of each attribute that affects the bundle of service. The level of each attributes should be ranged carefully and realistically (Bateman et al., 2002).

3.2 Structure of Questionnaire

A good questionnaire is a critical component of the study and it helps the researcher, in this matter, to understand better about the relationship between current travel pattern and respondents' decision when the service packages are provided. The

questionnaire can be separated into three parts: respondents' socio-demographic characteristics, travel behavior of individual including monthly transportation expenses and the designed scenarios.

This study plans to have two rounds of survey data collections. The internal mobility demand questionnaire was designed to capture travel behaviors in association of person and travel characteristics, and willingness to pay for some shared mobility services. The shared mobility package questionnaire was designed to explore the preference of travelers on designed mobility packages.

Initially, socio-demographic characteristics are important to understand the factors that influence the decision of respondents in the latter parts of the first survey. The personal information: gender, age, level of study, personal income, and whether the respondents have driving license or not, were asked in the first part of the questionnaire survey. The income is the vigorous explanatory factor for the travel pattern (Borgoni et al., 2002), and might have significant impact on the demand for different MaaS service packages. Similarly, Borgoni et al. (2002) also mentioned that gender and age are important demographic characteristics that acquire for explaining travel behavior.

In addition, travel pattern of students on campus was asked in the consecutive section of the questionnaire. Moreover, the amount of money that they currently spent for going around CU was explored for designing service packages which included the new innovative modes; Ha:mo and Muvmi in the last part of the questionnaire.

Based on the data collected and analysis results from the internal mobility demand survey, the questionnaire for shared mobility package were created. Similar

to the first questionnaire survey, socio-demographic characteristics of respondents were asked initially in the first part. Next, current mode choices and amount of usage for each mode (i.e; CU Pop Bus, CU Bike, Ha:mo, and Muvmi) were recorded as they could be used as explanatory variables along with other variables such as income and current travel behaviors.

The final part of the questionnaire was about the proposed service packages which included the combination of different transportation modes attributes (Ha:mo and Muvmi) and non-transportation modes attributes such as incentives (i.e. offer free rides to membership for some specific route in non-peak hours), transferability (i.e. users can carryover the unused trip to the next consecutive month), and others features were offered in mobility package (bundling) to respondents. Using the advantage of stated choice experiment, the stated scenario would be explained clearly, so that, all the respondents could realistically imagine their amount of trips around CU and could state their desirable package under a clear condition that "You can buy any monthly service package that you prefer from each scenario and you can use it for going within and nearby Chulalongkorn University. It lasts for a month starting from the day you purchase". It took around five minutes for each respondent to complete the questionnaire. Richardson et al. (1995) mentioned that the respondents' interest in answering the questionnaire will decrease generally when the survey is too long.

As fixed type of service package was to be designed, the approximate amount of money that the students would spend for going around CU per month and the usage of each mode should be known first in order to create a more realistic package design

which meet the students' needs. The various methods to create the mobility package and detail of the experimental design will be presented in next chapter.

3.3 Survey Method

In this section, how the questionnaire survey will be contributed to the respondents to obtain the required data, the place where survey will be conducted and the focus group for this study will be discussed in detail.

3.3.1 Instruments for Data Collection

The complete questionnaire was created using the online platform such as google form, which is user-friendly platform and can be distributed through various channels. The online survey, the electronic platform, is the easiest and fastest way to get people participate in answering the questions and the cheapest method for the surveyor to get the large sample size. Richardson et al. (1995) also supported that online survey method is inexpensive compare to the costly paper survey and other data collection methods.

Initially, a full instruction was provided for the respondents, so that, they could complete survey by themselves. In transportation field, most of the survey is done alone by the respondents without assistance of a surveyor. Consequently, the interviewer effect does not influence on data from the respondents and they do not have pressure while completing the questionnaire. However, the respondent rate may be lower compared to personal interview.

3.3.2 Determination of Sample Size

The first survey, survey for current internal mobility demand, was conducted to obtain the reliable information about users, preferences, and willingness to pay, the

study chose the method of sample size determination based on willingness to pay. Gunatilake et al. (2007) proposed the determination based on the amount of population and desirable significant levels. From Table 2, the open-ended question for willingness to pay is considered continuous data and the required sample size when the population size is greater than 10,000 is 119 sample. Nonetheless, some of preference questions are categorical (rating), and thus the study planned to collect 370 samples.

Table 2: Determining number of sample size based on population size (Gunatilake et al., 2007)

Population Size	Continuous Data (Margin of error =0.05)	Categorical Data (Margin of error =0.05)
	α=0.05, t=1.96	α=0.05, t=1.96
1,000	106	278
1,500	110	306
2,000	112	323
4,000	119	351
6,000	119	362
8,000	119	367
10,000	119	370

For the second survey, which focused on discrete choice experiments, there were some rule of thumbs that could apply for calculation the minimum sample size required. According to Johnson and Orme (2003); Orme (1998), Sever et al. (2019), the required sample size depends on three factors: 1. the main effects depends on the number of choice task (t), 2. the number of alternatives in each choice task (a) and 3. the largest number of levels for any of the attributes when considering the main effects (c).

For this study, there were seven attributes in total while each of them had the same levels (two levels). In questionnaire, there were total eight pairs of choice tasks and the respondents were asked to choose one alternative from each pair.

$$N > \frac{500c}{t \times a} \quad (1)$$

$$N > \frac{500\ x\ 2}{8x2}$$

$$N > 62.5\ samples$$

Therefore, a minimum 62.5 samples from the target population group was required for this experiment. It was noted that various methods of sample size determination were proposed by many researchers and some methods can result in larger sample sizes. For instance, Hensher et al. (2005) suggested that the sample size can be calculated from the number of attributes in practice that are used to create bundling package. Another sampling approach for choice base experiment is that 50 samples are required for one attribute. However, in many MaaS studies, namely Ho et al. (2018); Kamargianni et al. (2015); Ratilainen (2017), approximately 250 samples in total were collected and used for choice modelling. Therefore, 250 samples were planned in this study for choice modelling purpose.

3.3.3 Study Area

Even though more than four modes are available for users in university campus area, only four main modes (CU Pop bus, CU bike, Ha:mo and Muvmi) were considered in this study (excluded modes included motorcycle taxi, regular for-hire taxi, ride hailing taxi, etc.,). The detail for the study area can be seen clearly in the Figure (7). All the trips using shared mobilities provided in campus and generated in this study area were considered, covering all access trips and circulation within the

area. It might include the shopping trip to and from MBK, Sam yam Mirtown, Siam area and BTS station as well.

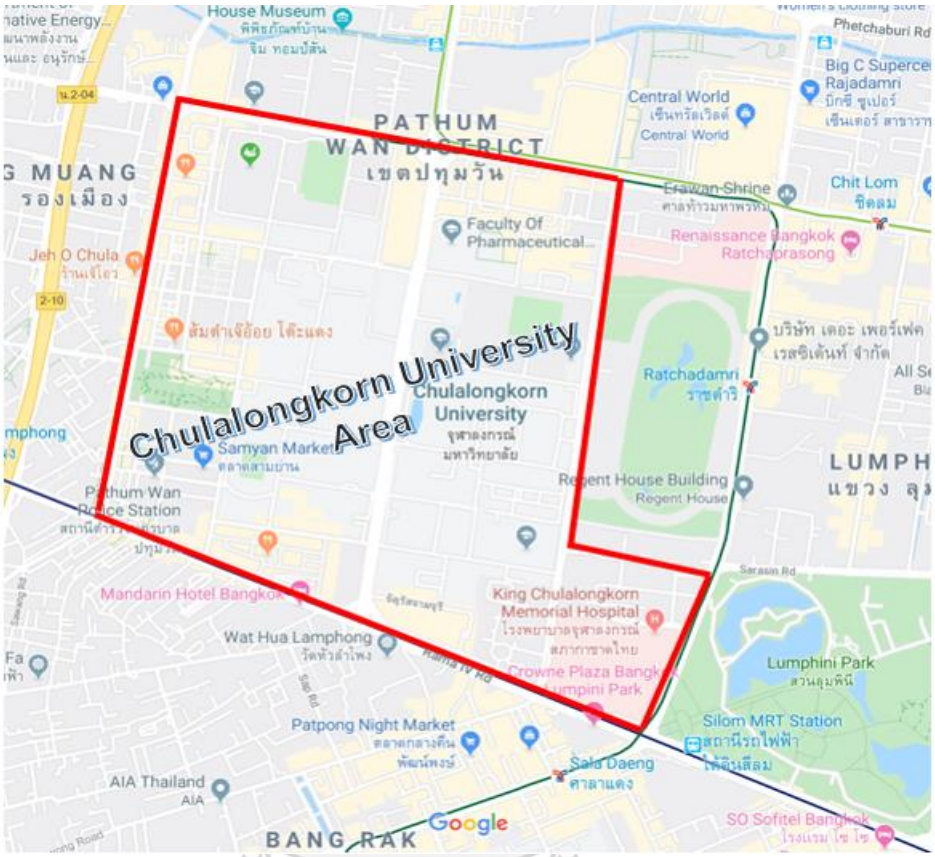


Figure 7: Study Area (Chulalongkorn University Campus)

3.4 Statistical Treatment of Data

This section explains the statistical methods that were utilized to treat collected data to understand the travel behavior of the users and factors influencing the decision making and willingness to pay.

3.4.1 Multiple Linear Regression Analysis

Regression analysis is statistical tool to study about the significant correlation between dependent variable and at least one independent variable (explanatory

variables). Moreover, the strength of impact (explanatory power) of independent variables, in the other word, the significance of the regressor, on the dependent variable can be evaluated with Welch's t-test. The relationship between dependent variable (the number of usages on each mode) and independent variables (i.e., demographic characteristics of the respondents, qualitative variables: satisfactory level of each modes, and quantitative variables: price reduction and frequency of usage of each mode currently) would be seen using multiple-linear regression analysis. In general, the equation for multiple linear regression model can be written as follows.

$$Y=\beta_0 + \beta_1 X_1+\beta_2 X_2+\ldots\ldots+\beta_\kappa X_k+u \quad (2)$$

where;

Y = dependent variable

$X_1, X_2, \ldots, X_k$ = explanatory variables

β_0 = the intercept value (constant term)

$\beta_1, \beta_2, \ldots, \beta_\kappa$ = coefficient of the independent variables

u = error term

Overall significant of the model can be explained using F-test for the regression. In addition, R-squared from the model can say goodness of fit of the model as well. The higher R-squared, the better the model. The multicollinearity, interaction effects between the independent variables, should be tested. The explanatory power of the model can decrease when two regressors from the model are highly correlated.

3.4.2 Logistics Regression

Logistic regression approach can be utilized for modelling a dichotomous dependent variables, which is 0 or 1 (Bewick et al., 2005). In this study, different scenarios (service packages) will be presented to each individual respondent and investigated whether they would like to buy the service packages or not. In general, logistic regression function with more than one explanatory variable can be written as follow;

$$P = F(Z) = \frac{1}{1+e^{-z}} \quad (3)$$

$$Z = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots\ldots + \beta_i X_i \quad (4)$$

where; P = predicted probability of choosing a package

Z = a function of explanatory variables

$X_1, X_2, \ldots\ldots, X_i$ = explanatory (independent)variables

β_0 = the intercept value (constant term)

$\beta_1, \beta_2, \ldots\ldots, \beta_\iota$ = coefficient of the independent variables

3.4.3 Mixed Logit

Mixed logit (ML) approach is appropriate method for the repeated choices by the same respondent as it allows the parameters associated with each observed variables (coefficient) to vary across respondents randomly (Revelt & Train, 1998). In discrete choice experiment, a respondent faces eight different scenarios and chooses a desirable one out of two packages from each scenario. The preference of package A over package B can be modelled by mixed logistic regression under the utility framework. ML method can be utilized for modelling a dichotomous dependent

variable, which is 1= chosen package, 0= unchosen package. In this study, various combination of attributes levels (packages) will be presented to each individual respondent and investigate the factors influence the choice situation (package A or package B). The utility function for a n^{th} respondent choosing j alternative package from s choice situation can be written as below.

$$U_{njs} = \beta'_n X_{njs} + \varepsilon_{njs} \quad (5)$$

Where U_{njs} is the utility of the package j while the package j from s choice situation is chosen by individual n, X_{njs} is a vector of observed attributes for alternative j (i.e., the level of attributes in the package), coefficient vector β_n is unobserved for each n respondent and varies in the population with density $f(\beta|\theta)$ where are the true parameters of the distribution, ε_{js} is an unobserved error term which assumed to be independently and identically distributed. Conditional on βns are known, the standard logit formula for the probability that a respondent n chosen alternative j in s choice scenario can be denoted as follow:

$$L(j,s|\beta_n) = \frac{e^{\beta n\, Xnjs}}{\sum_{j=1}^{J} e^{\beta' n\, Xnjs}} \quad (6)$$

If y_n is the chosen alternative in all choice situations for individual n: $y_n = (y_{n1}, y_{n2}, \ldots\ldots y_{ns})$, and the probability of these choices condition on β_n is

$$L(y_n|\beta_n) = \prod_s \left(\frac{e^{\beta n\, Xnjs}}{\sum_{j=1}^{J} e^{\beta' n\, Xnjs}}\right) \quad (7)$$

While β_n is unknown, the unconditional probability of choosing y_n is the integral of standard logit probability over all possible values of β_n is

$$P(y_n|\theta) = \int L(j,s|\beta_n) f(\beta|\theta) d\beta \quad (8)$$

Mixed logit model could relax the assumption of independence of irrelevant alternative and capture the heterogeneous consideration of each individual by assuming the distribution of random parameters such as log normal, normal, uniform, triangular and etc. For this study, the random parameters are assumed to be normally distributed as it is commonly used in mixed logit study and has no restriction of sign for random coefficient.

3.4.4 Validation and Significance of Data

For testing and validation of the data, the resulting P value from the model will be used to find the variables that are statistically significant and can explain more about the dependent variable, the mobility package. When the P value of independent variable is less than 0.05 for 95% confident interval, it means that variable is statistically significant.

The statistical measure mentioned above is only for testing of the explanatory variables, when it comes to test the goodness of fit of the model, MacFadden's Pseudo R^2 can be used for the study that has large sample size (more than 250 samples). The equation for calculating Pseudo ρ^2 can be written as below;

$$\rho^2 = 1 - LL(\beta_{MLE}) / LL(0) \quad (9)$$

$$\rho^2_{adj} = 1 - [LL(\beta_{MLE}) - p] / LL(0) \quad (10)$$

$LL(\beta_{MLE})$ = maximum log-likelihood value

$LL(0)$ = log-likelihood value at zero

ρ = the number of estimated parameters

Analogous to the linear regression model, the higher value of R^2, the more useful in predicting dependent variable.

3.5 Research Framework

Figure (8) presents the overview of the methodology that was employed in this research. Detail about the design experiments and choosing attributes and attributes levels will be discussed in the later chapters in this thesis.

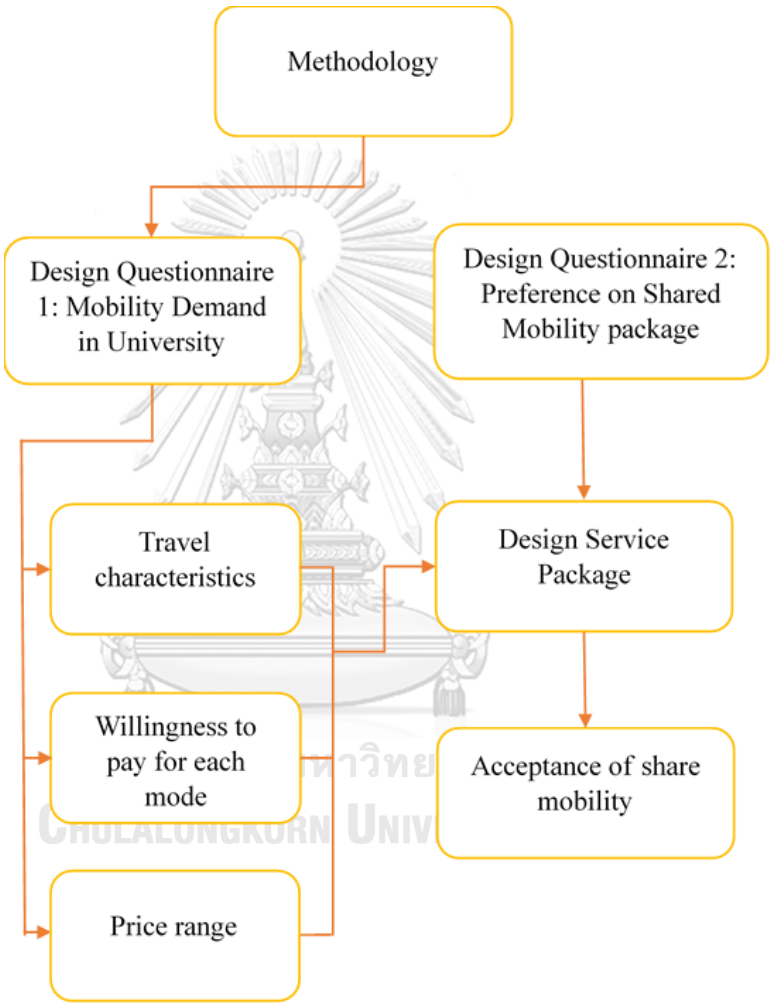


Figure 8: Overview of Methodology

3.5 Chapter Summary

This chapter presents the methodologies that were employed in this study. The study planned to organize two data collection, in which the first data collection captured the basic travel behaviors and preference of the usage of the

current modes. The willingness to pay for the paid shared mobility services; Ha:mo and Muvmi, were collected using open-ended questions. The discrete choice experiment was formulated so that the decision on mobility package selection was captured in the second survey. The data from the first survey were analyzed by descriptive analyses as well as multi-linear regression analysis. The data from the second survey were analyzed and modelled using logistic regression and mixed logit approach, so that the preferences on service mobility packages were investigated.

CHAPTER 4
DATA COLLECTION AND ANALYSIS FOR MOBILITY IN UNIVERSITY CAMPUS

4.1 Data Collection for Mobility in University Campus

In this section, questionnaire design and the actual data collection procedure, that were employed to obtain sufficient data from the target population, were presented. The characteristics of the respondents who took part in this survey were also described below.

4.1.1 Questionnaire Design for Determining Current Mobility Services

The questionnaire was separated into three parts: 1) respondents' socio-demographic characteristics, 2) travel behavior of individuals including the monthly transportation expenses and satisfaction on current mode services, and 3) preferences on mode improvement including willingness to use of each modes if the price has changed. Initially, the socio-demographic characteristics of each respondent were collected as these factors might influence the decision of respondents in the latter parts of the survey. The personal information: gender, age, level of study, personal income, and possession of driving license were collected. It is noted that the users need driving licenses to register for the car sharing service (Ha:mo). The income is the vigorous explanatory factor for travel pattern and might have significant impact on the demand for each particular mode. Similarly, gender and age are important demographic characteristics for explaining travel behavior. Next, the respondents were asked to rate service quality of each mode using a five-point Likert scale. Moreover, the amount of money that they currently spend for going around CU was

explored. The respondents were asked for expected additional amount of travel would have been made if the price of these new innovative modes was reduced.

4.1.2 Research subjects and Survey Instruments

Even though there are a lot of faculty members and other employees working in Chulalongkorn University, this study considered only the students who currently studying in the main campus as our target group. It included both undergraduate and graduate students in the main campus as they perceived and used modes of service around CU main campus. For this questionnaire, both students with and without driving license were considered. These students were counted in the target group as they would understand or have had experience on the limitation of services and the reason behind not choosing to use any of these services even though they were able to choose them.

The survey was initially designed in google form and distributed to the students through various platforms and groups via online. Unfortunately, the rate of online survey participation was not satisfying and unpromising. Firstly, online survey was conducted for five days starting on Monday, 25 November 2019 to Friday, 29 November 2019. Data collection period was closed to the university exam period and this might also be one of the reasons why participation rate was not high as expected. In order to obtain reliable and sufficient data during designated data collection period, paper questionnaire approach was employed.

To capture data from different respondents, actual survey date was randomly selected, and data collection was performed between 9:00 to 16:00. The interviewers

went to different faculties and randomly invited students to participate in answering questionnaire. The invited students could choose whether they would like to participate on-site survey or not. Initially, interviewers briefly explained about the questionnaire to the respondents to avoid misunderstanding and unreliable information. Most of the data collection were done in the libraries and co-working spaces because students always gather in those places.

On-site interview was more reliable and received the higher respondent rate than online interview even though it was time-consuming and needed more human resources. Moreover, the advantage of on-site interview was that the interviewer could give explanation while the respondents had any question and it could even reduce the non-response answer. During five days of data collection period, a total of 400 respondents were sampled and 30 samples were eliminated due to reliable data and outlier issue. The total of 370 samples from this questionnaire would be used for further analysis.

4.2 Socio-demographic Characteristics of the respondents

Out of 370 samples, the percentage of female participating in this survey (64%) was higher than male respondents (36%). According to the university census report (2015), CU has 59.5% of female and 40.5% of male. Compared to the actual population on campus, the proportion of female was slightly over-represented. When faculties were grouped into two: humanity (education, law, fine and applied arts, psychology, communication arts, etc.) and science (medicine, dentistry, sport science, engineering, etc.), 45.1% of respondents were from humanity faculties. The sample proportion was resembled to the population proportion of students studying in those

faculties (44.7%), reported by Chula facts and stats (2019). Generally, the collected data could represent the true population of the students studying in CU. Details of the demographic profile of the respondents can be seen in Table (2).

Table 3: Socio-demographic characteristics of the respondents (N=370)

Characteristics	Frequency	Percentage(%)
Gender		
Male	133	35.9
Female	237	64.1
Faculty		
Art	167	45.1
Science	203	54.9
Level of Study		
1st year	150	40.5
2nd year	76	20.5
3rd year	64	17.3
4th year	52	14.1
>4th year	3	0.8
postgraduate	25	6.8
Spendable amount of Money		
<2000 baht	16	4.3
2000-4000 baht	68	18.4
4001-6000 baht	87	23.5
6001-8000 baht	62	16.8
8001-10000 baht	71	19.2
10001-12000 baht	30	8.1
12001-14000 baht	14	3.8
>14000 baht	22	5.9

By looking at the level of study of the respondents, first-year students were more active and participated more in the on-site interview, 40.5%, while the response rate from second-year students were below half of the first-year students. The students from senior years had the lowest respondent rate, or 14.9%. Income is another important variable. The amount of money that each student could spend might be related to the modes that they might choose to go around CU campus area. Thus, the spendable amount of money could be used to correlate it with the preferable mode by

students. According to the collected data, 41.9% of students could spend 2,001-6,000 THB per month while 36% of students could spend between 6,001 THB and 10,000 THB for transportation and daily expenses. Less than 20% of students had spendable amount of money for living over 10,000 THB per month.

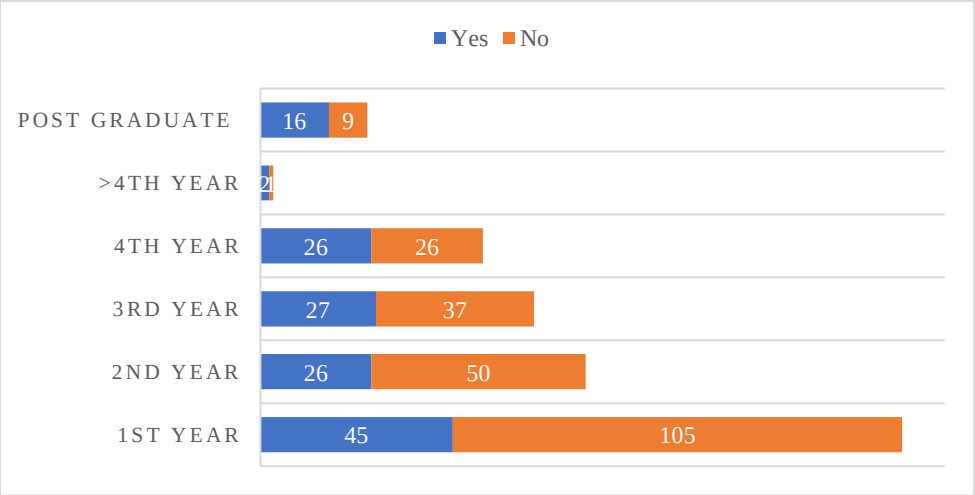


Figure 9: Proportion of Students having driving license

Among 370 of total respondents, only 38% of the students had driving license while the rest 62% were not able to drive and had limitation for using Ha:mo, in which users need driving license to make registration. For those who did not have the driving license would not be able to use this specific mode. According to Figure (9), the percentage of students who did not have driving license were higher than those who had the driving license in every level of study except graduate student level. This was commonly related to the age of students, as most of the first to third year students were still under the age of 20 and had not taken a driving test yet.

4.3 Descriptive Statistics of respondents

In this section, descriptive statistics of many variables were summarized and presented in Table 4.

Table 4: Descriptive Statistics

	Variables	Unit	N	Minimum	Maximum	Mean	Std. Deviation
1	Personal Income	baht/month	370	3750	21250	9519.8	4722.864
2	Spendable amount of money	baht/month	370	1000	15000	6891	3521.845
3	Days come to CU	days/week	370	1	5	4.13	1.098
4	Weekly expense going around CU	baht/week	370	100	900	279.29	229.532
5	Current usage of CU Pop Bus	times/week	370	0	12	5.81	3.835
6	Current usage of CU bike	times/week	370	0	5	0.16	0.611
7	Current usage of Ha:mo	times/week	370	0	5	0.13	0.64
8	Current usage of Muvmi	times/week	370	0	9	0.85	1.478
9	WTP of Ha:mo	baht/ride	370	0.5	20	15.925	4.6561
10	WTP of Muvmi	baht/ride	370	2	25	16.75	4.1761
11	Total times tend to use CU Bike	times/week	370	0	13	1.8	2.373
12	Total times tend to use Ha:mo	times/week	370	0	14	1.12	1.924
13	Total times tend to use Muvmi	times/week	370	0	18	2.83	3.121

The respondents' income per month and the amount of money that they spent for going around Chulalongkorn University area (i.e., internal trips in campus, trips to/from BTS stations and shopping trips) were shown. It ranged between from 3,750 THB to 21,250 THB. On average, a person had personal income around 9,500 THB per month which might include money for accommodation and other living expenses. In order to know the actual amount of money that they could spend per month, excluding amount of money of accommodation, respondents were asked again. The questions on income and spendable amount of money per month were sensitive, therefore the possible ranges were provided in questionnaire. From the data on the spendable amount of money per month, a person could spend at least 1,000 THB and the highest amount was 15,000 THB with an average of 7,000 THB per month for

transportation and other living expenses. This is an important variable as it could reflect to their mode choice to going around CU.

According to Table (4), students came to university four days a week on average. This confirms that most of the respondents (93%) were undergraduate students as they had lecture classes nearly every day. The average spending for travel around campus was 280 THB per week while some students spent up to 900 THB per week.

When separating four modes in two groups: free service mode (CU Pop Bus and CU Bike) and paid service mode (Ha:mo and Muvmi), it can be seen that the average number of times that students used CU Pop Bus in one week (Avg=5.81, SD=3.835) was significantly the highest. Even though the service was provided for free, CU bike usage was very low (Avg=0.16, SD=0.611) compared to CU Pop Bus. In the same way, current usage of Ha:mo in one week (Avg=0.13, SD=0.64) was less than Muvmi usage (Avg=0.85, SD=1.478). In general, CU Pop Bus was the most popular mode among four modes.

As Ha:mo and Muvmi are paid service, service fee and available money to be spent for travel by students can be a determinant of the service usage. A direct question was asked about the preference of the service fee and expected additional time (frequency) of usage was recorded. This was an open-ended question for willingness-to-pay (WTP) for these paid services. As CU bike is free to most students (free for the first hour), it was exempted from the willingness analysis. From Table (4), most students were willing to pay around 16 THB per ride for both Ha:mo and Muvmi services.

4.4 Satisfactory level of current service quality

Service quality is one of the important factors that influence user's mode choice and user's behavior. Moreover, it is the key driver for the service provider business and survival (Charbatzadeh et al., 2016). In this questionnaire, students were asked to rate their satisfaction level on a five-point Likert scale (1= very dissatisfied to 5= very satisfied). The study focused on transportation services around the area, in which students could normally make within and around campus. The following discussion would be about the level of satisfaction from the user point of view, as a result of questionnaire analysis.

CU Pop Bus

As mentioned before, CU Pop Bus is a free shuttle bus service provided by CU. The service runs as schedule and connects to many dominant places within and nearby campus such as student dormitories, BTS stations and shopping areas. Not only the students but also other faculty members rely on this free shuttle bus service in their daily commuting around CU campus.

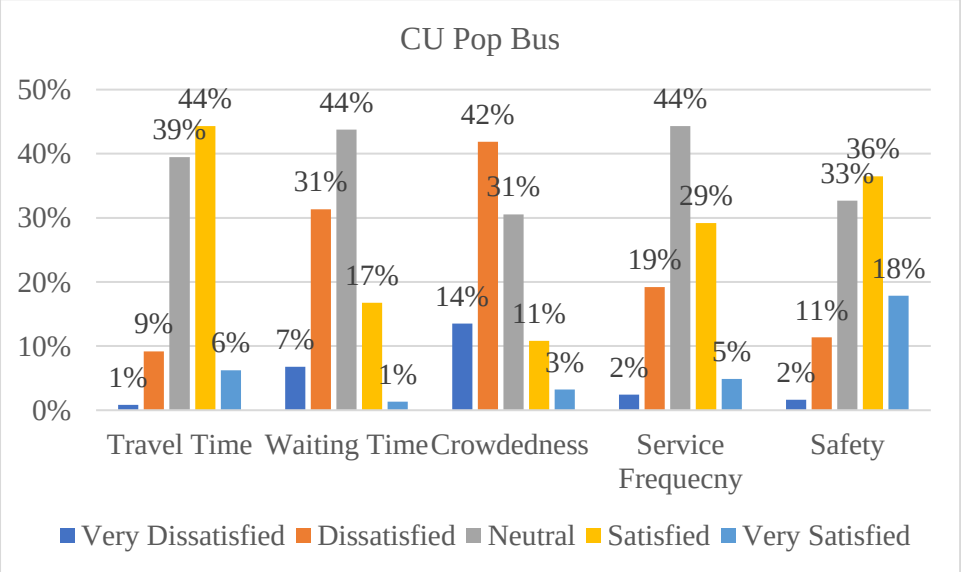


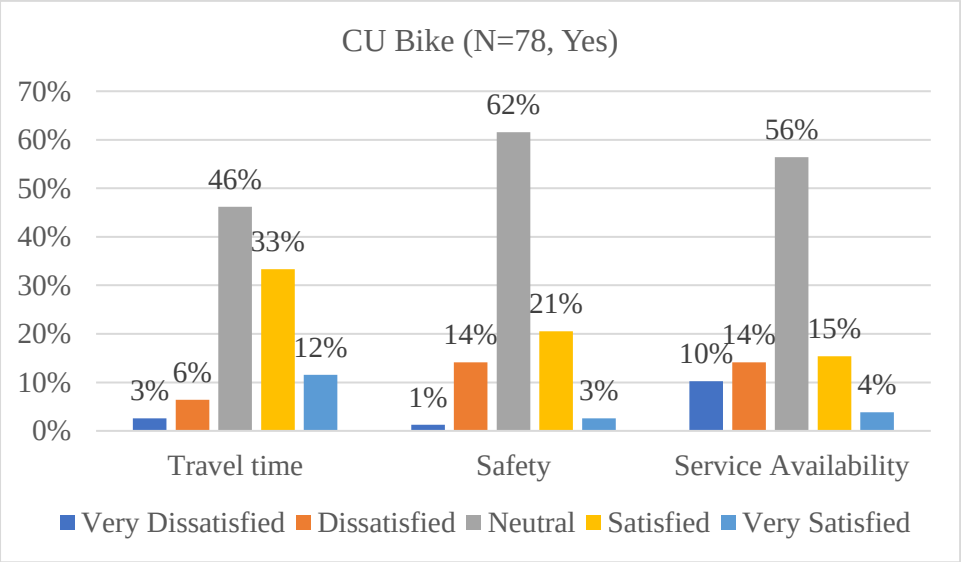
Figure 10: Satisfactory level of CU Pop Bus (N=370)

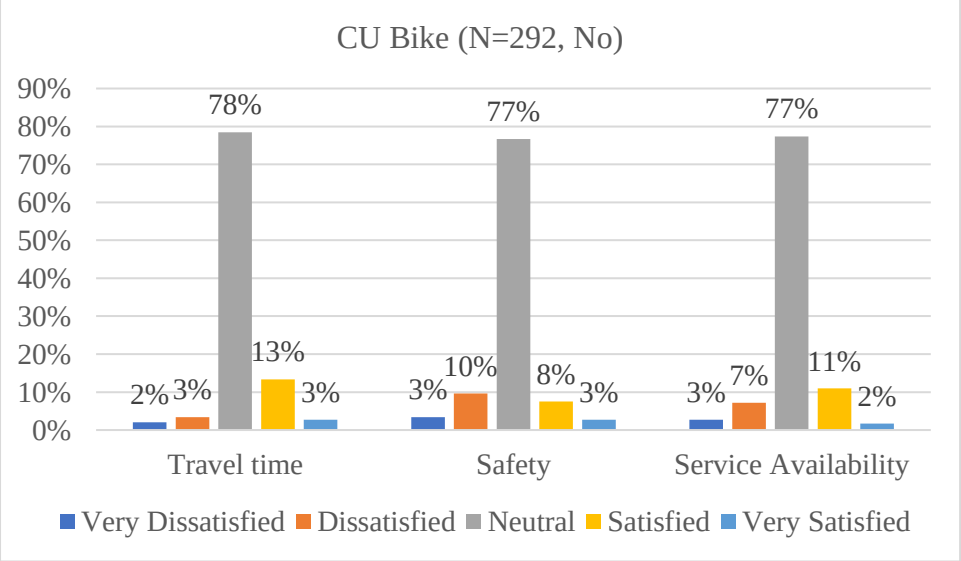
The survey shows that almost all the students had tried and used it before. Figure 10 presents the level of satisfaction of all respondents on CU Pop Bus. Looking at the satisfaction of service quality aspects, 50 percentage of respondents were satisfied with the travel time, perhaps because this service runs with fixed schedule and the users can check the location of the bus through app. The waiting time (38%) is not quite satisfied for students especially during the morning and evening peak hours as it takes longer waiting time than normal. Similarly, students were not satisfied with crowdedness on bus (56%) especially during peak hours. The demand of shuttle bus was over the limit of bus capacity and this causes inconvenience to users. For the safety aspects, 54 percent of users felt safe to use the shuttle bus. The service runs from 7:00 in the morning to 22:00, it is more convenient for some users who leave campus in late hours. However, students are pleased with overall service quality and have a very high demand.

CU Bike

CU bike, shared bicycle service, is provided for free for the first one hour of usage which is enough time for users to go around CU. Thus, CU bike can be assumed as another service that CU provides for free. In the questionnaire, we had questions about whether they had any experience of this service or not. For CU bike, only 78 respondents, 21% of total respondents, had used CU bike before. In order to explore the satisfactory level based on user experience, data from 78 participants were considered and presented in Figure 11. Considering the satisfactory level of CU bike in three aspects, it was found that 24 percent of the respondents complained about service availability of CU bike at the dissatisfactory levels. Students could not find

bike easily nearby their current location as there are limited number of docking stations around campus. Regarding to safety aspect, only 18 out of 78 respondents (24%) had positive opinion while the rest of respondents were not really satisfied with current service quality.





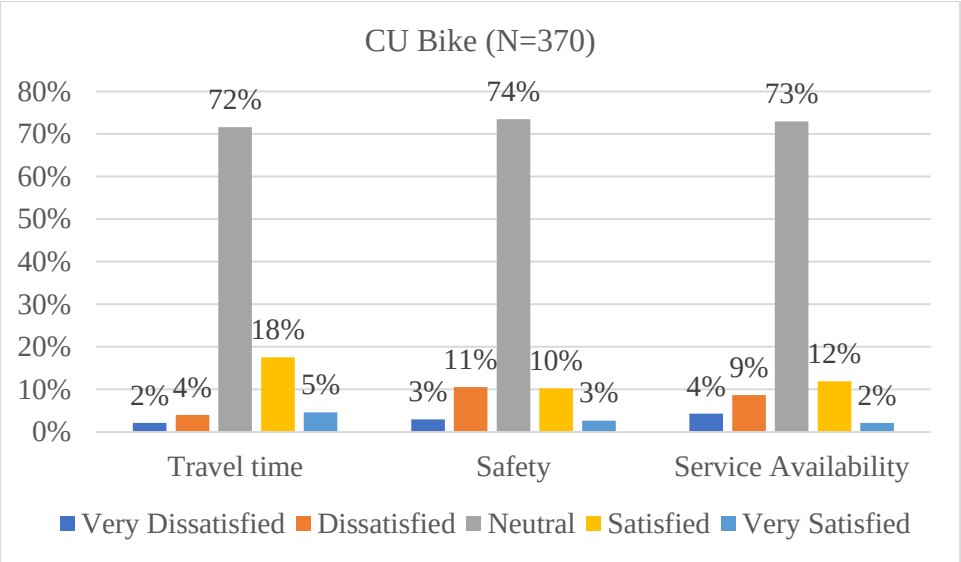
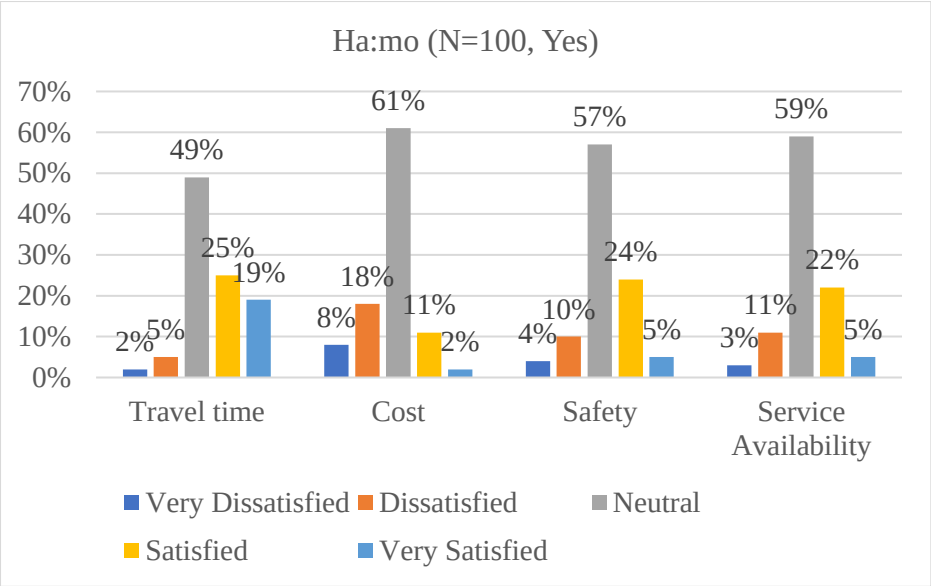
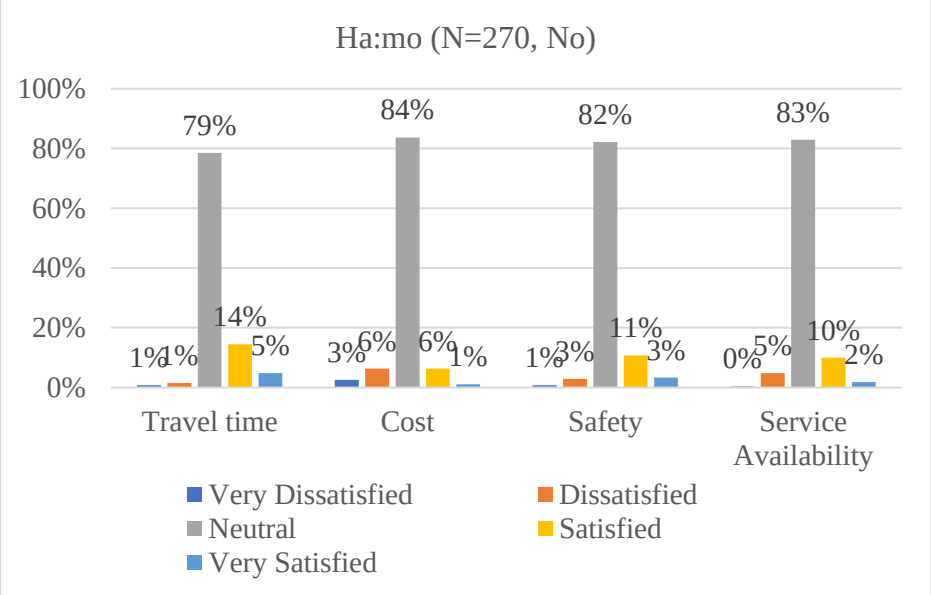


Figure 11: Students' satisfaction on CU Bike service

Ha:mo

Similar to CU bike, satisfactory level from actual users were considered in order to get more realistic and practical result. From Figure 12, the number of users who had positive experience with Ha:mo, paid car sharing service, was the highest in all service attributes except cost attribute, among four modes available in CU. For the users who had experience of Ha:mo service before, the highest satisfaction was on travel time (44%) while cost factor (13%) was the lowest. However, this kind of service provides flexibility and privacy to the user. One can see the trade-off between cost and other service attributes. The satisfaction level of safety and service availability aspects are having similar proportion (29% and 27%) respectively. As Ha:mo service has a separate mobile app which is convenient for users to find available vehicle near by their current location and book parking slot in advanced at their destination point.


Ha:mo (N=100, Yes)
70%
60%
50%
40%
30%
20%
10%
0%
2%
5%
49%
25%
19%
8%
18%
61%
11%
2%
4%
10%
57%
24%
5%
3%
11%
59%
22%
5%
Travel time
Cost
Safety
Service Availability
Very Dissatisfied
Dissatisfied
Neutral
Satisfied
Very Satisfied


Ha:mo (N=270, No)
100%
80%
60%
40%
20%
0%
1%
1%
79%
14%
5%
3%
6%
84%
6%
1%
1%
3%
82%
11%
3%
0%
5%
83%
10%
2%
Travel time
Cost
Safety
Service Availability
Very Dissatisfied
Dissatisfied
Neutral
Satisfied
Very Satisfied

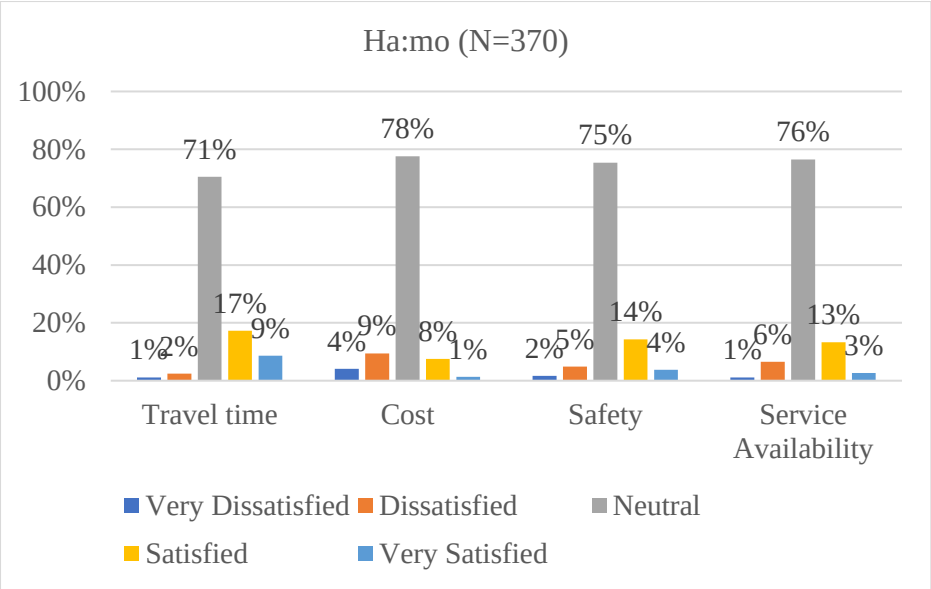


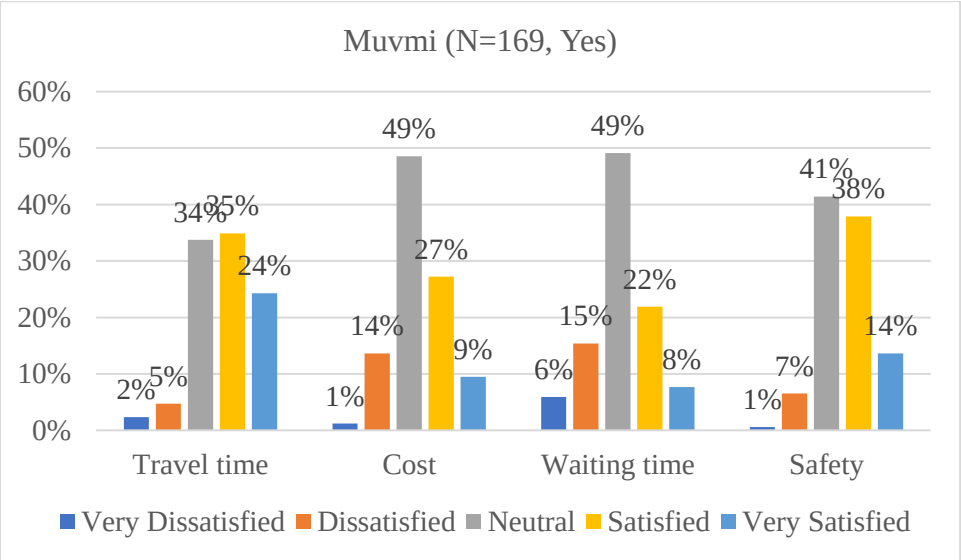
Figure 12: Students' Satisfaction level on Ha:mo Service

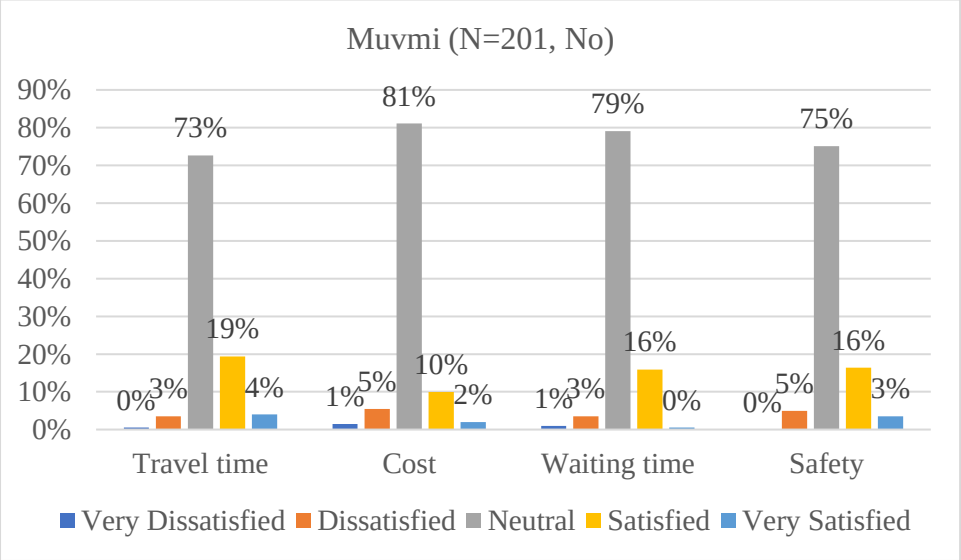
For non-users, cost is the prominent factor that causes students not choosing this mode. At the same time, students also have free option(s), especially CU Pop Bus which is the (most) competitive mode for this service.

Muvmi

Muvmi is another paid sharing service available in CU starting from 2018. The result from survey about Muvmi is shown in Figure 13. Regarding to four attributes: safety, waiting time, cost, travel time, the biggest proportion of users (48%) were satisfied with the current service quality in general. Travel time factor had the highest satisfaction level (59%), followed by safety (52%). The waiting time attribute was the lowest satisfaction level (30%) as it takes around 10 to 15 minutes on average to pick up a passenger. Despite the fact that the waiting time is a bit long, it is at the acceptable level to the students.

In general, Muvmi had a large number of users compared to the other two services: Ha:mo and CU bike. It is on demand service and runs flexibly, the user can easily add pick up and drop off point in app. It becomes popular among the students.





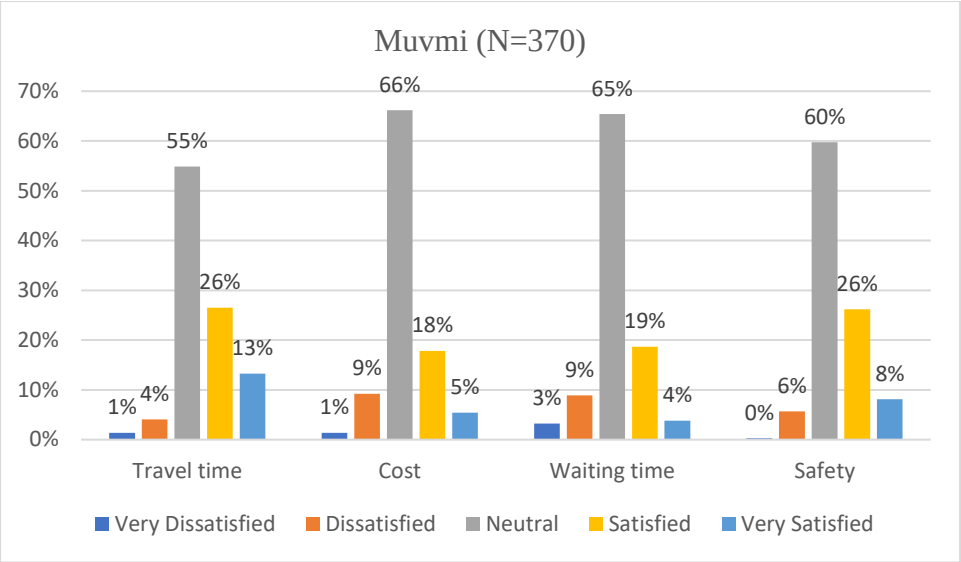


Figure 13: Satisfactory level of Muvmi

The result in Figure 14 confirmed that the free shuttle bus, CU Pop Bus, stands highest (36%) at the satisfied level as expected and followed by Muvmi (31%), Ha:mo (17%) and CU bike (16%). Among the paid sharing services, Muvmi has a large number of users compared to Ha:mo. It is popular because of the user-friendly application, users can easily add pick up and drop off point in app and this service operates as on demand service.

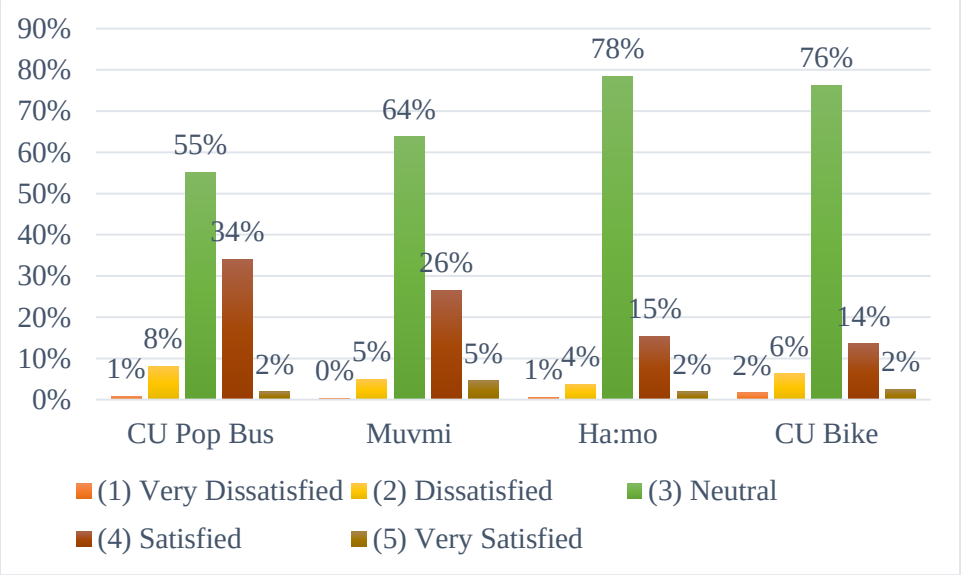
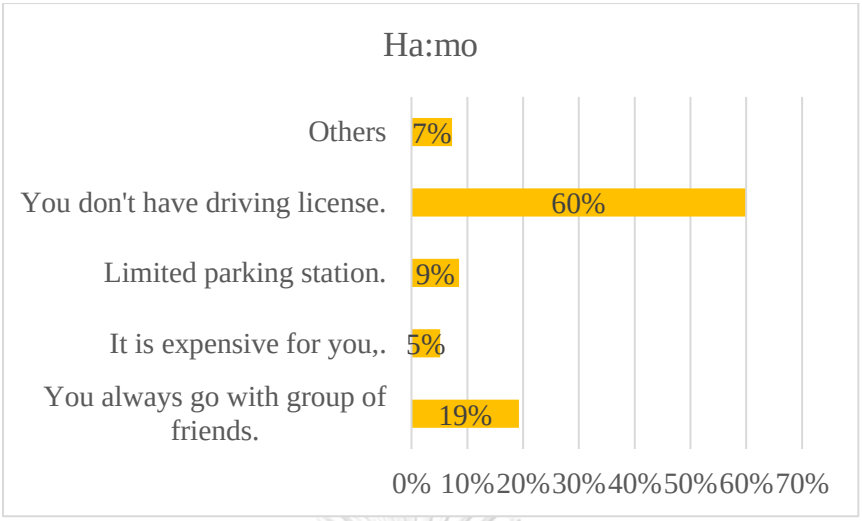


Figure 14: Overall satisfactory level of all modes in CU

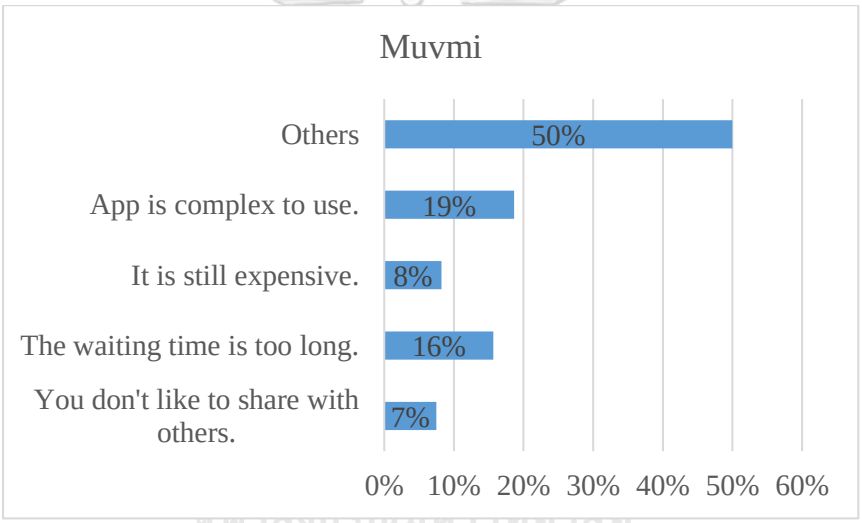
4.5 Reasons behind why students are not preferring to use

Different people have difference opinions on the provided services and different preferences. This section discussed the reasons why students still say “No” to different modes even though the price is reduced. These might be concerned with the service quality, the environment, and their personal preference.

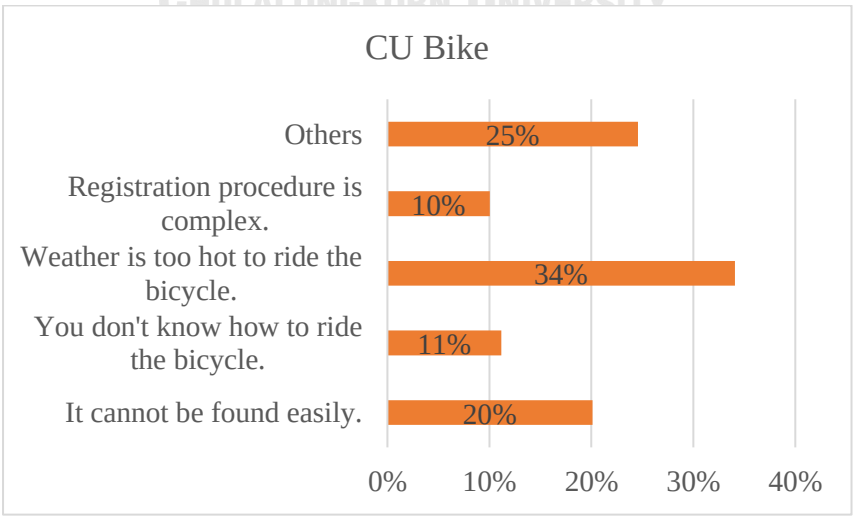
Firstly, looking at Ha:mo, 140 students out of 234 had limitation to register Ha:mo because they did not have a driving license even though some of them could drive. Driving license is a primary requirement for registration.


Ha:mo
Others
7%
You don't have driving license.
60%
Limited parking station.
9%
It is expensive for you,.
5%
You always go with group of friends.
19%
0% 10% 20% 30% 40% 50% 60% 70%

(a)


Muvmi
Others
50%
App is complex to use.
19%
It is still expensive.
8%
The waiting time is too long.
16%
You don't like to share with others.
7%
0% 10% 20% 30% 40% 50% 60%

(b)


CU Bike
Others
25%
Registration procedure is complex.
10%
Weather is too hot to ride the bicycle.
34%
You don't know how to ride the bicycle.
11%
It cannot be found easily.
20%
0% 10% 20% 30% 40%

(c)

Figure 15: Reason behind why students are not interested to use
(a) Ha:mo (b) Muvmi (c) CU bike

Moreover, Ha:mo is a one-seater sharing vehicle service, which it is not suitable for those who travel with friends. Out of 234, 45 respondents (19%) said that they always went with friends and Ha:mo was not their choice in this case. Currently, Ha:mo have had around 30 designated packing lots for vehicles around CU but it still does not cover many places, and therefore limited number of parking station was another reason which made this service unattractive.

When it turned to Muvmi, most of the students unliked it for other reasons even they did not mention a specific reason. The reason “complexity of the App” and “waiting time is too long” stood at the second and third rank why it was unappealing to users. Now, Muvmi charges from 15 baht to 25 baht depends on the distance travel, 8.3% of respondents still felt that it was still expensive, and they preferred to choose other inexpensive mode such as CU Pop Bus.

The weather in Bangkok is too hot and active mobility such as bicycling and walking are not attractive to users. Among 176 respondents who said they did not want to use bicycle, large proportion of respondents, 34% students, stated that they were not interested to use it because of weather. CU has only five docking stations around the campus so that limited number of docking stations probably make the mode unattractive and students preferred to choose more convenient and comfortable modes.

CHAPTER 5
DEVELOPMENT OF SHARED MOBILITY DEMAND MODEL

5.1 Introduction

To find the influential factors that have significant effect on the total number usages that students tend to use for each mode provided in Chulalongkorn University campus, regression analysis was used. Regression analysis is a statistical tool to study about the significant correlation between dependent variable and at least one independent variables (explanatory variables). Moreover, the strength of impact (explanatory power) of independent variables, the significance of the regressors, on the dependent variable could be evaluated. For those studies to formulate the linear equation between dependent variable and more than one independent variables, multiple linear regression analysis was utilized. The following equation (2) is a general formula for multiple linear regression analysis.

$$Y= \beta_0 + \beta_1 X_1 + \beta_2 X_2 + .. + \beta_\kappa X_k + u \quad (2)$$

In this study, several independent variables (see in Table 5), namely spendable amount of money that students could spend in a month, driving license, satisfactory levels relating to each attribute, number of days normally travelling to campus, initial awareness of each mode before survey, current frequency of usage, weekly expenses for transportation going around CU and willingness to pay for each modes, were used to explore the effect on total number of times that a user tends to use in the future for each paid shared mobility mode, especially for Ha:mo and Muvmi service.

Before analyzing the data and discovering the significant effect of explanatory variables on dependent variable, the data should satisfy with the following

assumption. The assumptions for linear regression model are (1) normality (2) linearity (3) homoscedasticity and (4) absence of multicollinearity.

Table 5: Explanatory Variables in Regression Model

Variables	Variable Description	Unit
Independent Variable (Dummy variables)		
Gender	Gender	if Female=1, otherwise=0
Faculty	Faculty	if Science=1, otherwise=0
Edu	Education	if Graduate=1, otherwise=0
DL	Driving License	if Yes=1, otherwise=0
SL	Satisfactory Levels for each service attributes	if Satisfied or very satisfied=1, otherwise=0
Mode_Know	Awareness of mode before	if Yes=1, otherwise=0
Independent Variables (Quantitative)		
W_exp	Weekly expense for going around CU	Baht
D_CU	No. of days come to CU	Days
Mode_PR	Price reduction for each mode	Baht
Mode_usage	Current usage of each mode	Times
Mode_moretimes	Additional trips tend to use in future	Times
SM	Spendable amount of money per month	Baht

5.2 Testing Linear Assumptions for Ha:mo Demand Model

As mentioned before, the four assumptions were explored initially. Normality was checked whether the residuals of the regression are normally distributed or not. This could be investigated from predicted probability (P-P) plot, if the residuals distributed along the normality line, it could be said that the disturbance terms of the regression were distributed normally. As seen in Figure 16, there was a bit deviation

from the normality line. However, we can assume that the residual meets the normality assumption as there is no extreme deviations.

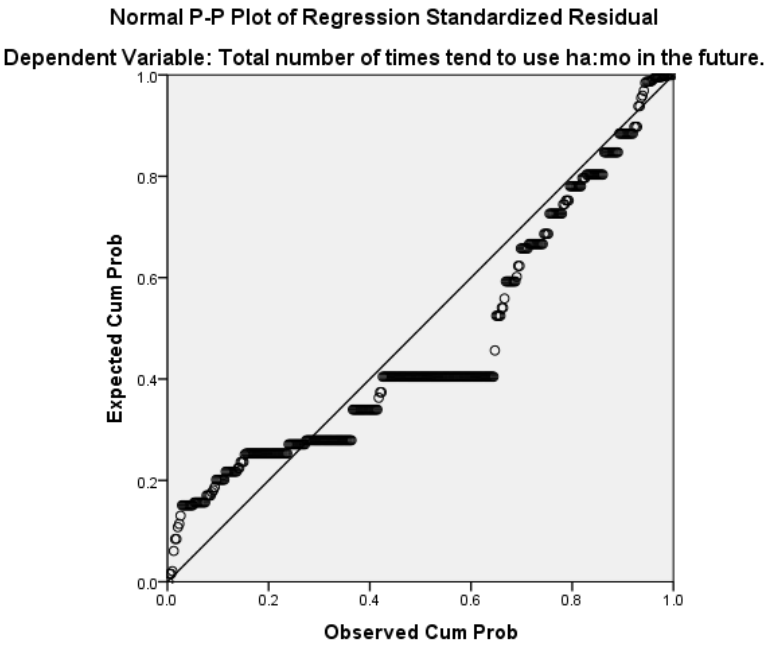


Figure 16: P-P Plot for Checking Normality Assumption for Ha:mo

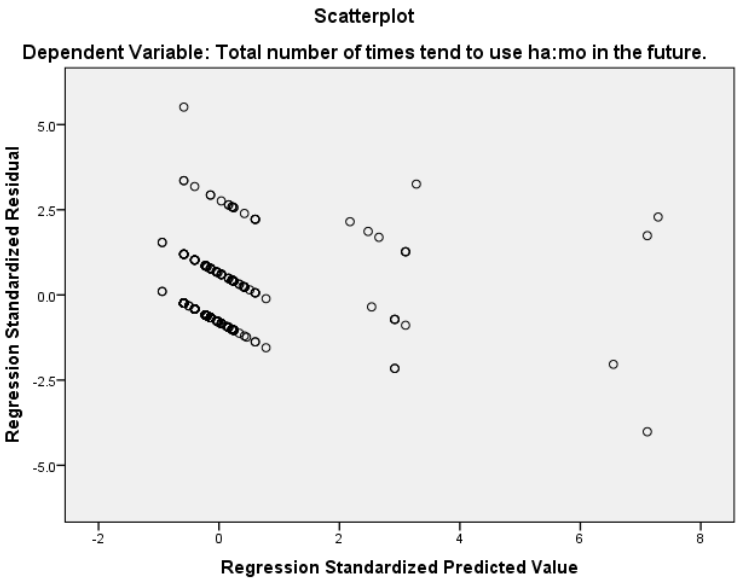


Figure 17: Scatter Plot for testing Homoscedastic assumption for Ha:mo

Multicollinearity test: checking the correlation between independent variables, the relationship among independent variables should be absent in order to generate the best model that could predict the dependent variable. Multicollinearity can be checked from correlation coefficients or variance inflation factor (VIF) values. According to a rule of thumb, the absence of multicollinearity assumption meets when the tolerance values should be greater than 0.1 and VIF value should be under 10 (Miles, 2014). According to Table 6, collinearity statistics table, all the tolerance values were greater than 0.1 and VIF values were less than 10. Therefore, one could say that there was no correlation between independent variables.

Table 6: Collinearity statistics for checking multicollinearity for Ha:mo

	Variables	**Collinearity Statistics**	
		Tolerance	VIF
1	Constant	--	--
2	Driving license	0.922	1.085
3	Price Reduction of Ha:mo	0.988	1.012
4	Current usage of Ha:mo	0.902	1.109
5	Ha:mo Travel Time	0.897	1.114

5.3 Calibration of Ha:mo Demand Model

All the linear regression assumptions had been checked and already met. In this step, multiple linear regression that could explain dependent variable was generated. The primary purpose of this analysis was to explore the independent variables that had effect on dependent variable, total number of times that users tend to use Ha:mo in future. A model generated using stepwise method in SPSS, Statistical Package for Social Sciences.

Before looking at details of regression model, the predictive power of the explanatory variables was checked initially. For testing whether independent variables were significant predictor of the dependent variables, the following hypothesis, F values from ANOVA Table was used and shown in Table 7.

Table 7: ANOVA Test for Multiple Linear Regression Model

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	653.809	4	163.452	84.573	.000[b]
	Residual	705.424	365	1.933		
	Total	1359.232	369			

a. Dependent Variable: Total number of times tend to use ha:mo in the future.
b. Predictors: (Constant), HM_T_dum, Hamo_PR, Driving license, No of usage of Ha:mo currently

H_0: $\beta_1 = \beta_2 = \beta_3 = ... = \beta_5 = 0$
H_1: at least one $\beta \neq 0$

As seen in Table 7, the calculated value of F from the regression model is 84.573. The critical value of F, at the significance level of 0.05 with 4 degree of freedom at numerators and 365 degrees of freedom at denominator is 2.79. While comparing two F values, the F value from Table 7 is greater than critical F value, and therefore the null hypothesis can be rejected. This means that none of the regression coefficient of independent variables are equal zero and are significantly predictive. Table 8 presents R-squared (R^2), a goodness-of-fit measure for linear regression model, that indicates explanatory power of independent variable on the total variance of dependent variable, which is the total number of times that users tend to use a specific mode. From Table 8, the value of R^2 is 0.475~0.5, and it can be interpreted that the percentage variance of total number of times that the users tend to use Ha:mo could be explained by 50 percent using those independent variables.

Table 8: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.694[a]	.481	.475	1.390

a. Predictors: (Constant), Ha:mo_PR, Number of usages of ha:mo currently, Hamo travel time, Driving license

b. Dependent Variable: Total number of times tend to use ha:mo in the future.

The model was calibrated, and the result is shown in Table 9. Based on the model, the regression equation can be written as follow:

$$Y = 0.336 + 0.589X_1 + 0.048X_2 + 1.781X_3 + 0.511X_4 \quad (11)$$

where: Y = total number of times tend to use Ha:mo in the future

X_1=driving license,

X_2=price reduction,

X_3= current usage of Ha:mo, and

X_4= Satisfaction level of Muvmi travel time.

Table 9: Multiple Linear Regression Model for Ha:mo

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	Constant	.336	.112		3.012	.003
	Driving license (1=Yes)	.589	.155	.149	3.803	.000
	Price Reduction of Ha:mo(THB)	.048	.014	.126	3.331	.001
	Current usage of Ha:mo	1.781	.120	.591	14.893	.000
	Ha:mo Travel Time (1=Satisfied)	.511	.174	.117	2.936	.004

a. Dependent Variable: Total number of times tend to use Ha:mo in the future.

Significant test for each independent variable whether it had significant correlation with the dependent variable, P values, in Table 9 was carried out. If P value is greater than 0.05, it means no significant association between dependent variable and independent variables at 95% confidence level. In such a condition, the change of independent variables would not affect dependent variable. However, in Table 9, P values of all explanatory variables were less than 0.05, thus, showing significant association with the future prediction of Ha:mo. A unit change in dependent variable can be affected by a unit change in an independent variable.

Regression coefficient (β) indicates the important order of independent variable to the dependent variable. In the above model, all the coefficients have positive sign, indicating a mean of predictor variable increases when the values of explanator variable increase. For instance, the coefficient of current usage of Ha:mo, the most important variable, is 1.781. Therefore, the mean of total number of times using Ha:mo increases by 1.781 with a unit increase in current usage of Ha:mo while the other variables are holding constant. In other word, the students who currently have experience in using Ha:mo may use it more in future, compared to those who do not have experience.

Similarly, the marginal effect of possession driving license, satisfaction on Ha:mo travel time and price reduction were 0.589, 0.511, and 0.48 respectively. The second most important variable is driving license possession. Students with driving license have higher average total usage of Ha:mo by 0.589, compared with those who do not have driving license. It makes sense that, the need of driving license is a basic requirement for registration of Ha:mo. For this mode, only users who have driving license are accessible. In the same way, travel time of Ha:mo which is attractive

attributes to Ha:mo users, as this service does not have waiting time and users can drive directly to their destination point. If users have positive experience in traveling with Ha:mo, they probably continue using it more in future. Last but not least, price reduction is another independent variable that could affect the total number of usage of Ha:mo. Mathematically, total number of usage of Ha:mo tends to increase 0.48 times while the price is reduced by ten baht.

Other independent variables were excluded from the model as they had high P values and had no significant correlation with dependent variable. Keeping these variables could reduce precision of the model.

5.4 Testing Linear Assumptions for Muvmi Demand Model

The same procedure with Ha:mo, for multiple linear regression analaysis, was applied for Muvmi, Tuk Tuk sharing service. Initially, testing the four assumptions for linear regression model were performed.

As seen in Figure 18, the error between observed and predicted values are normally distributed along the normality line. Therefore, the residual of the predictors meets the normality assumption even though little deviations can be seen in the Figure 18.

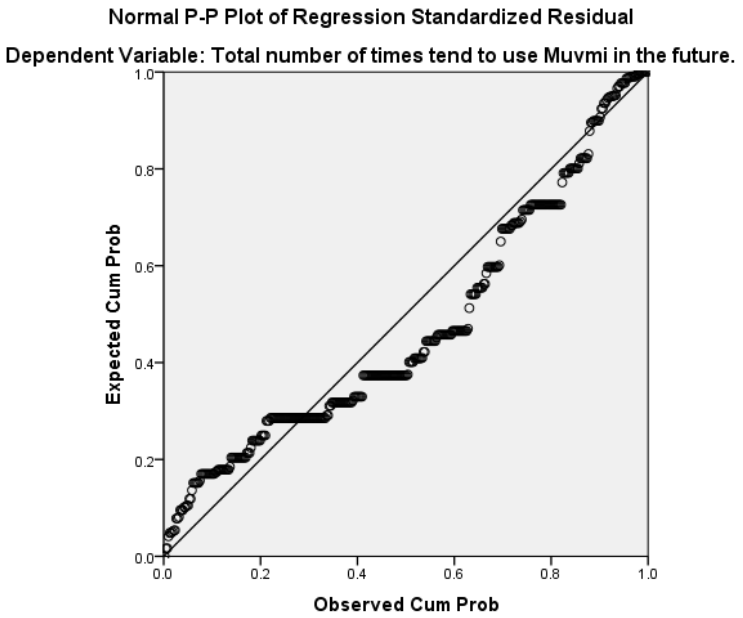


Figure 18: P-P plot for Checking Normality Assumption for Muvmi

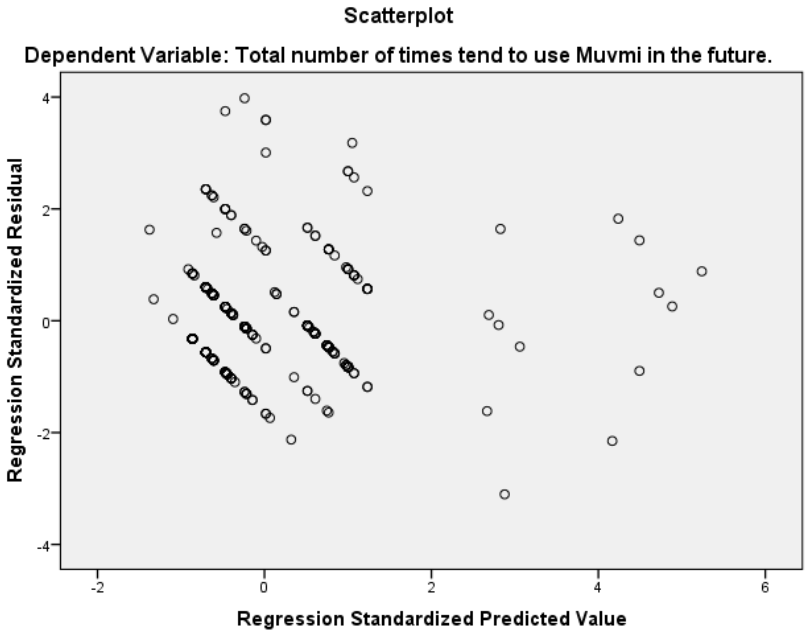


Figure 19: Scatter Plot for testing Homoscedastic assumption of Muvmi

The tolerance values, the measure of the influence of one independent variable on other independent variables and the variance inflation factors of linear regression (VIF) was used to test the multicollinearity. As mentioned before, the tolerance values of all independent variables were greater than 0.1. From Table 10, all VIF values were

less than 5. Therefore, the is no correlation between the independent variables and multiple linear regression can be performed.

Table 10: Collinearity statistics for checking multicollinearity for Muvmi

	Variables	Collinearity Statistics	
		Tolerance	VIF
1	(Constant)		
2	Current Usage of Muvmi	.908	1.102
3	Price Reduction of Muvmi	.981	1.019
4	Gender	.999	1.001
5	Muvmi Travel Time	.917	1.090

F test in ANOVA, test on goodness of fit of model, in the other word, testing whether the independent variables in model have predictive power for the dependent variable. The null hypothesis is that the coefficient of independent variables is equal zero, while alternative hypothesis is that coefficient of at least one independent variable differs from zero. From the Table 11, at the 95% confidence level, F critical values, F (4,365) is 2.79 less than F values (214.224) and P value is less than 0.05. Therefore, the null hypothesis can be rejected and all the parameters in model have significant power to predict the dependent variable.

Table 11: ANOVA for Muvmi

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2516.199	4	629.050	214.224	.000[b]
	Residual	1071.791	365	2.936		
	Total	3587.989	369			

a. Dependent Variable: Total number of times tend to use Muvmi in the future.

b. Predictors: (Constant), MU_TT_dum, Gender, MU_PR, No of usage of Muvmi currently

Another measure, R-squared also can measure the goodness of fit of the linear regression model. Theoretically, if adjusted R-square is larger than 0.5, we can say that the model is good. According to Table 12, the adjusted R-squared value is 0.698, or can say that independent variables in the model could predict 69% total variance of the dependent variable, the total number of times tend to use Muvmi in future.

Table 12: Model Summary for Muvmi

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.837[a]	.701	.698	1.714

a. Predictors: (Constant), MU_TT_dum, Gender, MU_PR, No of usage of muvmi currently

b. Dependent Variable: Total number of times tend to use Muvmi in the future.

After doing significant test of the overall model, the significance of individual regressor should be explored in the following step. In general, P value of all independent variables are less than 0.05, thus, all the independent variables have significant correlation with the dependent variable.

5.5 Calibration of Muvmi Demand Model

Table 13 presents the final calibration of Muvmi demand model. Regression coefficients of all independent variables are positive. It implies that a unit increase of the dependent variable could occur by a unit increase of one independent variable while the other variables are holding constant in multiple linear regression model. The regression coefficients of current usage of Muvmi, price reduction, gender and travel time are 1.589, 0.121, 0.418 and 0.664 respectively.

Table 13: Multiple Linear Regression Model for Muvmi

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.552	.175		3.150	.002
	Current Usage of Muvmi	1.589	.064	.751	25.026	.000
	Price Reduction of Muvmi	.121	.019	.188	6.525	.000
	Gender (1= Female)	.418	.186	.064	2.250	.025
	Muvmi Travel Time (1=Satisfied)	.664	.190	.104	3.493	.001

a. Dependent Variable: Total number of times tend to use Muvmi in the future.

Mathematical expression, the model can be written as follow;

$$Y = 0.552 + 1.589X_1 + 0.121X_2 + 0.418X_3 + 0.664X_4 \quad (12)$$

where; Y = Total number of times tend to use Muvmi in the future

X_1= current usage of Muvmi,

X_2= price reduction of Muvmi,

X_3 = gender, and

X_4= Satisfaction level of Muvmi travel time.

As seen in Table 13, those students who currently use Muvmi tend to continue using it with the average of 2.114 (0.552+1.589) times per week (with current price). Similarly, the total times tend to use Muvmi would increase by 1.21 times while the price of Muvmi is reduced by ten baht. Logically, the number of usages may probably increase when the price is decreased and may become more attractive to users. The model indicates that male students would have lower Muvmi usage and students who are satisfied with travel time tend to use it more. Likewise, if the users are satisfied with the current travel time, service attribute, the future prediction of usage could increase by 0.664. As Muvmi runs on flexible route and

can drop users at their destination point. The service also has the least travel time compared to other modes such as CU Pop Bus which runs in fixed routes.

5.6 Chapter summary

This chapter employs multiple linear regression to develop Ha:mo and Muvmi demand models. The regression analysis reveals that some factors are associated with demand, such as gender, having driving license, being the current user of services, and satisfaction on the current services (travel time). It seems that students who are currently using these services (Ha:mo and Muvmi) tend to use it more than the other group in the future. For Muvmi users, the result explains that female probably feels more comfortable to share the ride with other passengers. Comparing the results from Ha:mo, gender is not associated with the amount of usage.

CHAPTER 6
DATA COLLECTION AND ANALYSIS FOR SHARED MOBILITY PACKAGE

This chapter explores the way creating shared mobility package to test the preference of each attributes from service packages, data collection for shared mobility package questionnaire and followed by exploring socio-demographic characteristics of the respondents, their mode choice and satisfaction level on the current service quality.

6.1 Mobility Package Design

Experimental design is a vital concept of choice modeling. A discrete choice experimental design composes of several choice sets, and each choice set contains more than one alternative which is the combination of related several attributes and their levels. Discrete choice experiment is a quantitative method of this study to evaluate the value of different attributes and their levels that influence the respondent's (customer) decision. Moreover, it helps researchers to understand customers' choice decision relating with their socioeconomic characteristics. Discrete choice experimental method is very attractive for researchers and policy makers as it can weigh different factors and trade-off between them. Most of the choice set are hypothetical scenarios (products or services) and it is widely used in various fields such as marketing (Chintagunta & Nair, 2011; Louviere & Hensher, 1983; Zwerina, 1997), transportation field (Ben-Akiva & Bierlaire, 1999; Truong & Hensher, 1985; Washbrook et al., 2006), environmental studies (Hackbarth & Madlener, 2013; Hoyos et al., 2015) and health care studies (Ryan & Gerard, 2003; Viney et al., 2002).

Since hypothetical scenarios are the combination of different attributes, the number of combinations also depend on the number of attributes and their levels that researchers would like to test. For example, there are 128 possible combinations in total when there are seven attributes and having two levels each by full factorial design. It is difficult to test all the combinations as it is costly to survey administrator and could place burden on respondents, causing low respondent rate or inaccurate answers. In order to solve the above problem, fractional factorial design is popular and widely used in choice modeling as it reduces the number of combinations to test and cost effective in practice (Ryan et al., 2012).

The orthogonal design is an effective way to reduce full set of scenarios (full factorial design) to a governable level (fractional factorial design). Before generating the choice sets, the researcher might need to decide whether both main effect and interaction effect might be considered in the study as the main effect consideration only might already generate a large number of combinations as well. Orthogonal design can be generated using statistical packages such as SPSS software, Sawtooth software and Minitab software. However, there are some optimal choice design catalogues available in some studies (Bush, 2014). For this study, a choice design catalogue generated from orthogonal arrays will be used to create the package combinations and presented in Table 14.

Table 14 choice design for 7 attributes and 2 levels each (Bush,2014)

Option A							Option B						
0	0	0	0	0	0	0	1	1	1	1	1	1	1
0	0	1	1	1	1	0	1	1	0	0	0	0	1
0	1	0	1	0	1	1	1	0	1	0	1	0	0
0	1	1	0	1	0	1	1	0	0	1	0	1	0
1	0	0	0	1	1	1	0	1	1	1	0	0	0
1	0	1	1	0	0	1	0	1	0	0	1	1	0
1	1	0	1	1	0	0	0	0	1	0	0	1	1
1	1	1	0	0	1	0	0	0	0	1	1	0	1

6.2 Selection of Attributes and Their Levels

In this section, selection of attributes that might reflect to the user's choice decision on the package will be discussed. Generally, there are two type of factors: 1. package attributes (modes and their service features) 2. sociodemographic factors (age, educational level, personal monthly income, etc.,).

Level of mode attributes and service attributes should be carefully selected in order to create more realistic and attractive packages to customers. The problem of complexity for respondents can be eased while choice tasks are meaningful, understandable, and handled. From the lesson learned from previous two chapters, the service attributes that students were likely dissatisfied would be considered in the creation of the package. However, the selected attributes were considered under these conditions: 1. they should be realistic for both service providers and users, 2. they should be helpful features in students' daily mobility. The selected attributes and levels are shown in Table 15.

Table 15: Attributes and their levels for bundling package

Attributes	Attribute levels
Ha:mo	5, 10
Muvmi	5, 10
Carry-over unused trips	Yes, No
Having priority for Ha:mo	Yes, No
Faster pickup speed for Muvmi	Normal, Pickup within 10mins
Free ride per month	Yes, No
Package price	Normal Price, 20% Discount

Service Attributes

Ha:mo: Car sharing service, Ha:mo, is the second least popular mode in Chulalongkorn University. This might be because of the driving license requirements and some students might not know how to drive especially for the first-year students. So, current access to Ha:mo is limited for students. However, a group of students presently prefer to use Ha:mo as it is private and fastest mode. From the previous chapter(s), students use Ha:mo approximately five times per week in maximum which is equal to 20 times per month. Thus, attribute level five rides per month and ten rides per month are appropriate to be chosen for later study.

Muvmi: Ride sharing service, Muvmi has become popular among students as it is targeting to every student in CU as it does not need special requirement such as driving license, as Ha:mo. Generally, students use Muvmi nine times per week in maximum equating to 36 times per month. However, the same level as Ha:mo service, five rides and ten rides per month are considered.

Service Attributes

Carry-over: The users can transfer the unused trips to the next consecutive month when they buy too many trips in their package (or use less in a particular month). The minimum number of trips included in the package are ten trips which might be more than actual usage for some package users. Thus, this kind of service feature is beneficial for the users as they do not need to worry for the remaining trips.

Having Priority for Ha:mo: This feature refers to giving priority to the users who buy monthly subscription package than normal pay-per-ride users whenever they book for vehicles. The current Ha:mo users are less satisfied with the service availability as seen from the answers of the first questionnaire in the Chapter 4.

Pick-up Speed: This refers to the time it takes for a vehicle to reach to user pick-up point after booking for a trip. Normally, Muvmi service takes ten to fifteen minutes to gets a vehicle due to high demand and limited number of vehicles. Once the users subscribe the mobility package, the user can get this special feature once includes in package. It may help users to reduce waiting time whenever users place booking.

Price: This is monthly subscription price of the packages which includes all rides and special incentive features in the package with special discount than users. The results of questionnaire analysis in Chapter 4 indicated that students could spend a minimum 400 THB per month for transportation in case of going around Chulalongkorn campus area. Therefore, the range of package price was set between 160 THB to 400 THB to cover all students.

A total sixteen optimum package among 128 combinations with various attributes were selected using the optimum choice design in Table 14. In the final arrangement, each respondent had eight different scenarios which consisted of two alternatives. The respondents chose one alternative which they preferred the most or alternative that nearly met their mobility needs. The example of the package design can be seen in below.

Features	Package A	Package B
	5 times	10 times
	5 times	10 times
Carryover	X	√
Muvmi Pickup Speed	X	√
Free Trip	X	√
Ha:mo Priority	X	√
Package Price	200 THB	320 THB
	Normal price >200 THB	Normal price >400 THB

Figure 20: Example of Monthly Package Design

6.3 Questionnaire Design for Shared Mobility Package

Final survey consisted of three parts: firstly, personal socio-demographic characteristics (i.e., gender, education level, personal income, student's accommodation and driving license) as the location of accommodation was expected to have influence on the mode choice; in other words, students who lived in dormitory or within 2km from Chulalongkorn University were expected to use shared mobility (Ha:mo and Muvmi) more compared to students who stayed more than 2km away

from CU. Secondly, their travel characteristics, mode choice and their satisfaction level on Ha:mo and Muvmi services was assumed to be based on the current service quality and price. Later on, a short description about the service package with special incentive that users would get, how the integrated app would work for the service, and how it would help in daily mobility were mentioned in order to make sure respondents understand clearly before going to the third part. Sixteen different combinations were provided in eight scenarios with no opt-out (neither choice) option. Lastly, respondents were asked whether they still would like to choose the service package or not if they had pay per ride option in hand. It could be seen the preference or the interest on the additional feature of the service package. Detail of the questionnaire survey can be found in Appendix B.

6.4 Data Collection and Socio-demographic Characteristics of respondents

The total of 343 respondents were obtained for mobility package questionnaire, while 17 respondents were eliminated as they were non-students from Chulalongkorn University. Hence, the total response of 326 samples were used for further analysis. This data was collected using online approach, in which the questionnaire was distributed in various platforms to reach to CU students starting from 1st April to 30th April 2020 for first round and 2nd July to 10th July 2020 for second round.

In this questionnaire survey, various questions about socio-demographic characteristics were asked individually. As the target group of this study was the students from Chulalongkorn University, thus it included not only undergraduate

students but also graduate students. Table 16 shows that more than half of the respondents were male (56.7%) while the rest (43.3%) were female. Comparing the actual proportion of population, the sample of male respondents were over-represented as CU has only 40.5% of male and 59.5% of female respectively as mentioned in section (4.2).

For the education level, the data was separated into two groups: undergraduate students and graduate students. In a further analysis, these two groups were expected to have different travel characteristics and preference on the mobility package as most of the graduate students were less likely come to campus compared to the undergraduate students. In term of percentage, 73.6% of sample came from undergraduate students while 26.4% were from graduate students.

Table 16: Socio-demographic characteristics of the respondents (N=326)

	Frequency	Percentage (%)
Gender		
Male	185	56.7
Female	141	43.3
Education		
Undergrad Students	240	73.6
Graduate Students	86	26.4
Accommodation		
CU dormitory	63	19.3
Place within 2km away from CU	65	19.9
Place more than 2km away from CU	198	60.7
Driving License		
No	154	47.2
Yes	172	52.8
Personal Income		
<5000 THB	71	21.8
5000-10000THB	160	49.1
10001-15000THB	56	17.2
15001-20000THB	10	3.1
>20000 THB	29	8.9

Another socio-demographic variable is personal income which is essential variable in transport related studies as it is more likely to influence on the decision making in daily mobility. It was expected that high income students would be more likely to have more options to choose (Ha:mo and Muvmi) which were paid service. In other words, it was predicted that the packages might be more attractive to the high-income students. However, it is clearly that nearly half of the students (49.1%) had their spendable amount of money in the range of 5000 THB-10000 THB per month for their living which was nearly the same proportion in the previous survey, while only 12 percent of the population could spend over 15000 THB per month for their expenses.

Another variable, the location of the students' accommodation, is compulsory as it can explain the chosen mobility service available in CU. As mentioned in previous chapter, the services provided by CU are only available in specific subareas in the campus. Thus, students who stay in university dormitories or within 2km away from CU campus were predicted to have high probability on the usage on the shared mobility service for commuting from/to and within CU. Currently, over 50% of the respondents, exactly 61%, lived more than 2km away from CU. It is not certain, however, that the rest of students (40%), who stay in student dormitory and residents within 2km from CU, would completely choose the paid service as their mode choice options also include CU Pop Bus (free service) and other available means in CU.

In the previous chapter, driving license is a variable which is highly related with the accessibility of Ha:mo, since it requires driving license for registration. Given that most of the respondents were undergraduate students, so it was not

surprising that 47.2% of the sample did not have a driving license. However, the questionnaire used a stated preference approach and assumed that everyone had driving license and had Ha:mo service option in hand. Every respondent was answering the questionnaire under the same condition. Therefore, all the data would be utilized for modeling in the coming section.

6.5 Mode Choice and Satisfaction Level of Respondents

Mobility characteristics of the CU students were explored in the section. Regrading to their commuting modes to and from Chulalongkorn University, the majority of samples used Bangkok Mass Transit System (BTS sky train), Mass Rapid Transit (MRT subway), respectively, as CU is located in the central accessible area that can be accessed by both metro systems. As stated in previous section, majority of samples in this study stayed more than 2km away from CU, hence it was not surprising to see the highest number of usages of BTS and MRT. Minority of students (15% of respondents) came by bus. It is noted that the bus service is the cheapest mode among all public transport and the most affordable mode for students. The most important finding was that most of the students also relied on the service provided by CU for daily mobility.

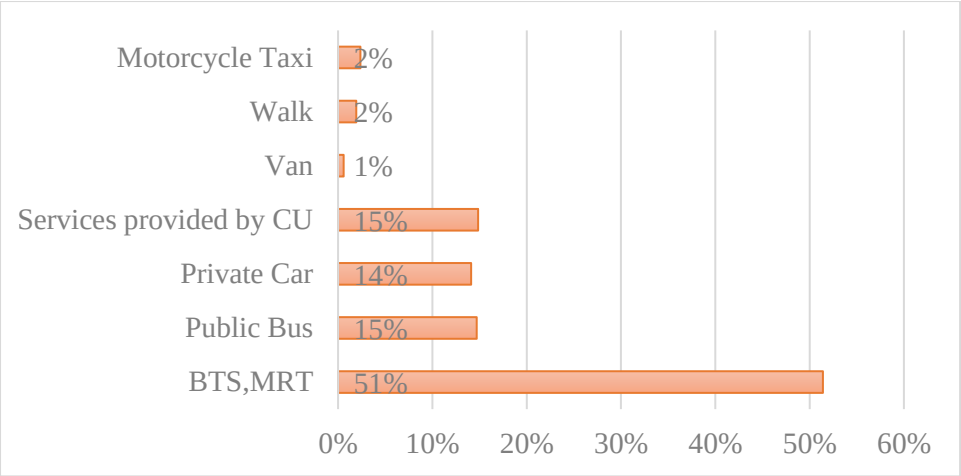


Figure 21: Mode Choice of Students for going to and from Chulalongkorn University

Considering the trips that students went around CU campus area, we could clearly see that free shuttle bus was the most popular mode among all provided services and had the highest percentage of usage by students. From the survey, highest proportion of students (48.5%) were using CU Pop Bus more than 8 times in a month. Very low percentage (5.2%) of respondents had never used the CU Pop Bus before while over 70% of respondents had never used the shared mobility modes. On the contrary, above 7% of respondents used Ha:mo and CU Bike twice a month while nearly 17% had used Muvmi one or two times a month.

However, less than 10% of the respondents used Ha:mo, Muvmi, and CU Bike more than two times per month. As explained in the previous chapter, some modes were less popular due to longer waiting time and driving license limitation to access the mode.

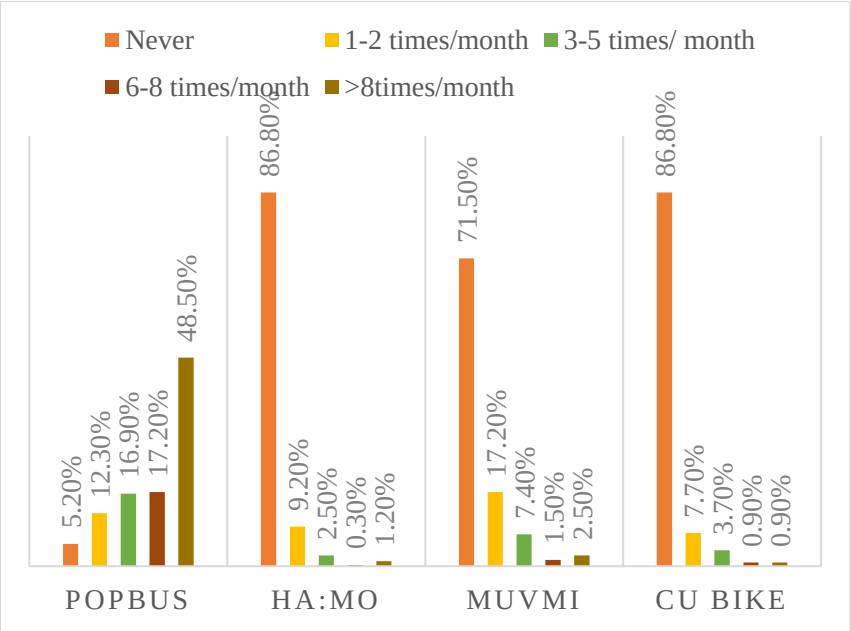


Figure 22: Mode usage for going around CU campus area

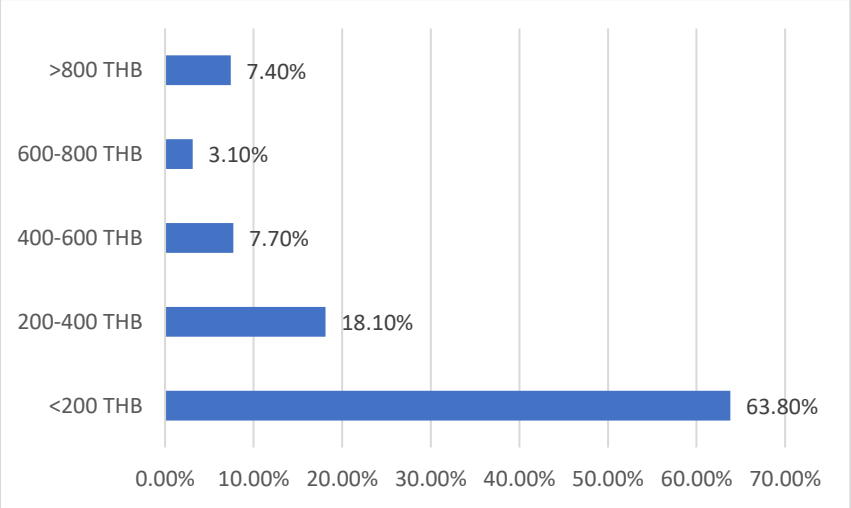


Figure 23: Amount of money spend for internal mobility service

Figure 23 shows the amount of money that students spent for mobility service in CU for going around the campus. Personal income was asked in the previous questionnaire, and the result shows that students spent around 1000 THB per month on average for traveling in and around CU. Therefore, this question was repeated in this second questionnaire to confirm again. The above figure shows that over 60% of

students spent less than 200 baht per month and around 82% of students could spend up to 400 THB per month. It is consistent with the package price which was 150 to 400 THB per month. The results assure that the proposed mobility package prices are within the affordable price range for the students.

Table 17: Descriptive Statistics of Mode Usage of Students

	Variables		N	Minimum	Maximum	Mean	Std. Deviation
1	Personal Income	baht/month	326	2500	22500	8911.45	5561.1
	Current Usage of Shared Mobility provided by CU						
2	Pop Bus	times/month	326	0	18	12.727	5.63525
3	Ha:mo	times/month	326	0	18	0.7699	2.52602
4	Muvmi	times/month	326	0	18	1.9877	3.80605
5	CU Bike	times/month	326	0	18	1.0521	2.86524
6	Expense for going around CU	baht/month	326	100	900	244.17	238.869

From Table 17, we could see the average usage of each mode in one month and average expense for going around CU as well. When service separate into two groups: free service mode (CU Pop Bus and CU Bike) and paid service mode (Ha:mo and Muvmi), it can be seen that the average number of times that students used CU Pop Bus in one month (Avg=12.727, SD=5.64) was significantly the highest. Even though the service was free, CU bike usage was very low (Avg=1.0521, SD=2.865) compared to CU Pop Bus. In the same way, current usage of Ha:mo in one month (Avg=0.7699, SD=2.526) was less than Muvmi usage (Avg=1.99, SD=3.806). In general, CU Pop Bus was the most popular mode among four modes. In addition, students could spend around 250 THB per month for going around CU while they are getting money around 8900 THB per month in average.

6.6 Correlation between explanatory variables

Figure 24 shows Pearson correlation between socio-demographic characteristics of the respondents and their interest in the service packages. It is noted that only the correlation between two variables that are significant at 0.1 level are shown. A positive correlation indicates a unit increase of one variable would make a unit increase in the corresponding variable. As seen in the Figure 24, the correlation value between education level and person income is the highest (0.5) and it is positively correlated. This implies that senior year students get higher income than other junior class students. For the interest in package, expense for transportation going around CU is 0.1 and positively correlated. It means that the more the students spend for transportation, the more they are interested in service package. It is logical in that the frequent travelers tend to prefer more discounted price and other privilege service features to normal services. Another important consideration is the association between accommodation and usage of internal service. They are negatively correlated, and it can be implied that those students living more than 2km away from CU less likely use internal mobility service provided by CU. In the other words, they seem rely on the other public transport such as BTS, MRT and buses.

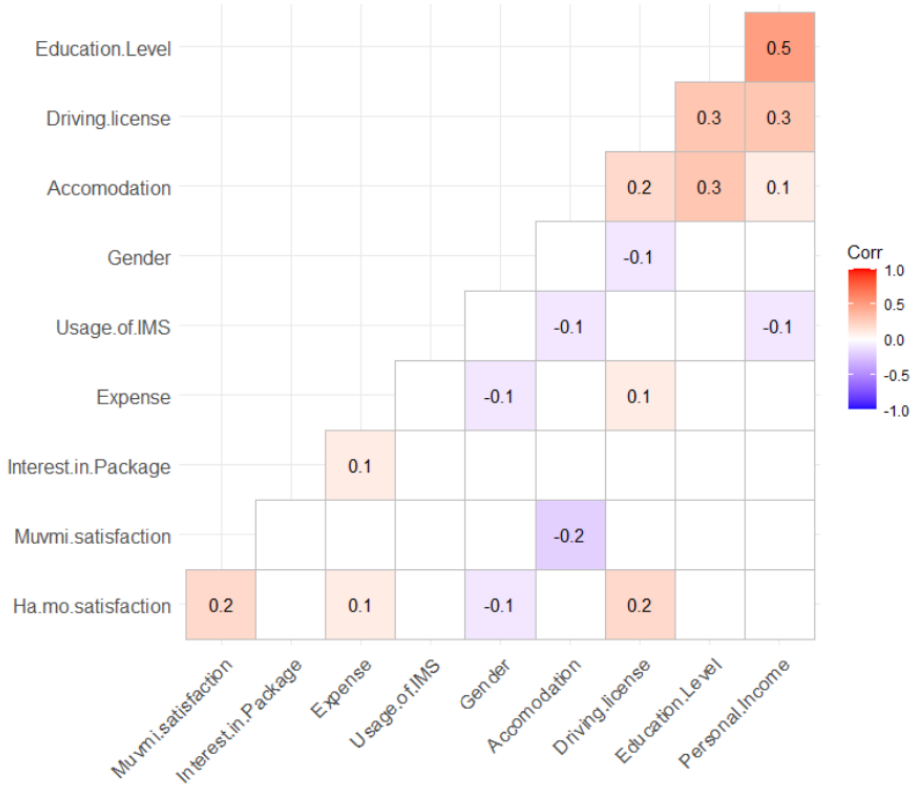


Figure 24: Correlation between socio-demographic characteristics and interest in package

CHAPTER 7
DEVELOPMENT OF SHARED MOBILITY PACKAGE MODEL

This chapter discusses mainly about development of package demand models for shared mobility services which would be the answer for the final objective: determine the attributes of the shared mobility package which have effect on student's decision. Binary logistic regression and mixed logit analysis were used to find factors or attributes influencing on their preference of service packages. In previous chapter, we have investigated various variables and the correlation between them. For upcoming model analysis, service package attributes and some socio-demographic variables which had significant effect on choice decision were selected. Table 18 shows quantitative and qualitative explanatory variables that would be used in model.

Table 18: Explanatory Variables for Mixed Logit Model

Variables	Variable Description	Unit
Independent (Quantitative) Variables		
Hamo	Number of trips of Ha:mo in package	Trips
Muvmi	Number of trips of Muvmi in package	Trips
Price	Service package price	THB
Income	Individual monthly income	THB
Independent (Qualitative) Variables (Dummy Variables)		
Carryover	Transferable unused trip to next consecutive month	=1 if Yes, = 0 if No
Priority	Priority for Ha:mo service	=1 if Yes, = 0 if No
Pickup Speed	Pickup Speed for Muvmi service	=1 if Faster pickup speed,= 0 if Normal pickup speed
Free Trip	Offer free trip on selected routes and time	=1 if Yes, = 0 if No
Gender	Gender	= 1 if Female, otherwise= 0

7.1 Calibration of Shared Mobility Package Model by Logistic Regression

Assuming that the respondents were answered the binary response (Yes, No) for each package, the collected data was analyzed using logistic regression to explore the significant of each package attributes on the decision making of students. The probability of choosing each individual package can be written as

$$P = F(Z) = \frac{1}{1+e^{-z}} \quad (3)$$

while z is the utility of each package. The estimated coefficient of logistic regression analysis for each variable can be seen in Table (19).

Table 19: Estimation of Logistic Regression Model

Attributes	Estimated coefficient	Std. Error	Z value	Pr(>|Z|)	
Intercept	0.80669	0.14352	5.621	1.90E-08	***
Ha:mo	0.01798	0.0213	0.844	0.39861	
Muvmi	0.06029	0.02144	2.813	0.00491	**
Carryover	1.68714	0.06457	26.129	<2e-16	***
Pickup Speed	0.36637	0.0631	5.806	6.40E-09	***
Priority	0.32023	0.06339	5.052	4.37E-07	***
Free Trip	0.35341	0.06295	5.614	1.98E-08	***
Price	-1.02303	0.10237	-9.993	<2e-16	***
Number of Observation	5216				
Null Deviance	7230.9				
Residual Deviance	6146.8				
R square	0.149				
Adjusted R square	0.148				

Significance : 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’1

As seen in Table (19), the number of trips of Ha:mo in the package has a positive coefficient which means the increase of trips of Ha:mo in packages could increase the utility of the package. However, it is not significant, so that, we cannot certain whether it influence on respondents’ decision nor not. Similarly, the

coefficient of number of trips of Muvmi in the package is positively significant. Therefore, the number of trips of Muvmi in the package has a significant influence on the decision making. The coefficient of other service package attributes, such as carryover of unused trips to next consecutive month, priority of using Ha:mo, faster pickup speed for Muvmi and getting free trips are 1.68714, 0.3202, 0.3663 and 0.35341. Those attributes are positively significant on the utility of the package as well. In the other word, having one of these service attributes in the package could increase the utility of choosing the package. In general, we could say that the respondents prefer to have these privilege features of the service in packages once they buy the monthly integrated service package. For the price of service package, the estimated coefficient is -1.023 which is negatively significant. The increase of the package price could decrease the utility of the package.

7.1.1 Marginal Effects

Marginal effect could express the change of probability of choosing the package while one of the attributes in the package change by one unit. Table (20) shows the marginal effect of each service attributes.

Table 20: Marginal effects of Service Attributes in Package

Attributes	Marginal Effect
Ha:mo	0.0225
Muvmi	0.0752
Carryover	0.3984
Pickup Speed	0.0913
Priority	0.0799
Free Trip	0.0881
Price	-0.2558

A unit increase in number of trips of Ha:mo in the package could increase the probability of choosing package could be increase by 0.0225. For the number of trips

of Muvmi in the package, a unit increase of it could increase the probability of the package by 0.0752. The marginal value of carryover feature is 0.3984 which is the highest among all other attributes. Probability of choosing the package with carryover service attributes is higher 0.3984 times compare to the probability of the package without carryover feature in package. Having pickup speed feature for Muvmi in the package could increase the probability of choosing package by 0.0913 while the other attributes are holding constant. The marginal value for priority of using Ha:mo and getting free trip when buying package are 0.0799 and 0.0881. For price, the marginal value is -0.2558 which means a unit increase of package price could decrease the probability of choosing the package by 0.2558 times.

7.2 Calibration of Shared Mobility Package Model by Mixed Logit

A model was developed to explain the package preference using Mixed Logit (ML) or Random Parameter Logit (RPL) method which allows high level of flexibility and reveal heterogeneous preference of the sample population. In mixed logit, it is necessary to assume distribution of random parameters such as normal, log normal, uniform, triangular, etc. For this study, the coefficient of number of trips of Ha:mo, number of trips of Muvmi, special features: carryover, priority, pickup speed and free trip could be both negative and positive sign, so that, these random parameters were assumed to be normally distributed. Random parameters with normal distribution are popular and commonly used in mixed logit studies. However, price coefficient is assumed to be fixed as price coefficient with the normal distribution could probably generate the wrong sign. This model used data from all respondents (326 samples) who answered the questionnaire except some outliers. There are eight games, two packages in each game, so that, total 5216 observations were be used. The

model included alternative attributes of the packages: number of trip of Ha:mo, number of trip of Muvmi and other special privilege features such as carryover of unused trip, having priority for Ha:mo service, faster pickup speed, number of free trip and discounted package price. The definitions and explanations of these attributes appear in the previous Chapter. Table 21 presents the model estimation result with normally distributed random parameters such as Ha:mo, Muvmi, priority, pickup speed, free trip and carryover.

Table 21: Estimation of Mixed Logit Model with Normal Distribution

	Mean Coefficient	(SD)	Std. Error	Z-value	P value
Ha:mo	0.0196	(0.1608)***	0.0197	0.9941	0.3201
Muvmi	0.0477	(0.1309)***	0.0202	2.3605	0.0182*
Carryover	1.1696	(1.0566)***	0.0834	14.0315	<2.2e-16***
Pickup Speed	0.2537	(0.0029)	0.091	2.7859	0.005**
Priority	0.2154	(0.0010)	0.0593	3.6338	0.0002***
Free Trip	0.2384	(0.0021)	0.0909	2.6226	0.0087**
Price	-0.7311		0.1018	-7.1783	7.059e-13***
Gender	-0.2638		0.1083	-2.4375	0.0147*
Income	0.0176		0.0069	2.5586	0.0105*
Number of respondents	326				
Number of observations	5216				
Log-likelihood	-1464.5				

Significance : 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’1

As seen in above table, most of the package attributes are statistically significant at 95% of confident level and affect the probability of choosing service package. However, estimated coefficient of number of Ha:mo trips is not statistically significant in the model as P value is greater than 0.05, but logically the signs are realistic.

By looking at the mode service attributes: number of trips of Ha:mo and Muvmi, both attributes have positive sign, which means a unit increase of the

attributes could increase the utility of the package. In other words, the positive coefficient means having these feature in the package would be more attractive for customers. However, the coefficient of Ha:mo service attribute (0.0195) is not significant at 95% , which means that the presence of Ha:mo service in the package does not have a significant effect on their decision making, while the offering of Muvmi service attribute (0.0477) does impact the decision making of purchasing the mobility package. Additionally, significant standard deviation explains heterogeneous consideration of parameters among the population. The standard deviation of Muvmi (0.1309) is statistically significant, so that, the decision considering Muvmi service vary individually. Generally, this could imply that students prefer Muvmi service more than Ha:mo service in considering the mobility package. This result is also consistent with the previous discussion.

Other service attributes which have positive signs for the estimated coefficients and the values are statistically significant (i.e., 1.169, 0.2537, 0.215, 0.2384 for carryover, pickup speed for Muvmi, priority for Ha:mo service and free trip respectively). In addition, the standard deviation of carryover (1.0566) is significant statistically, so that, the decision of individual respondent is vary relating with carryover of the package while standard deviation of the rest three attributes (pickup speed, free trip, priority) are not significant, so that, it explains every respondent has homogeneous consideration or weight on those attributes. In general, it implies that the package buyers would like to have some privilege service; in other words, these service features could attract users to purchase the package rather than pay per ride. A unit increase of either one of these attributes could increase in utility of mobility package.

The price attribute coefficient (-0.7311) is negative and statistically significant. This means that the service packages may less attractive when the price is getting higher. In the same way, it could be explained that students prefer a small size package rather than a large size one. As students have limited income and limited spendable amount of money per month, a small package would be more appropriate for this user group.

Another socioeconomic variable, income, is statistically significant at 95% level and has an estimated coefficient 0.0176. By looking at coefficient, one could say that the higher income, the higher the utility of the package. The probability of choosing of service package is influenced by income of the respondents. We can assume that they are willing to pay at one time for the mobility package rather than pay per ride. The estimated coefficient of gender, dummy variable, is -0.2638 which is significant negatively. According to the result from model, the package is less attractive to female customers. If the customer is female, the utility of choosing package is decreased.

Using the mean value and standard deviation value from Table (19), the shared of population is calculated. For the special feature of the package, carryover option, had a significant standard deviation and 86.7% of population were above zero while the rest 13.3 were below zero. It could imply that this attribute was preferred by 86.7 % of respondents and they would like to have this privilege feature. For another feature, pickup speed did not have a significant standard deviation which mean they skewed on one side. While calculating the shared population, it proved that 99.99% of population were above zero, in another word, they had the same

consideration for having pickup speed feature in the package. Similarly, standard deviation of free trip and priority were insignificant and 99.99% of population were having the same consideration.

For the goodness of fit of model, hit rate could be used to validate the generated shared mobility package model. Hit rate, percentage of correct prediction, is a measure to compute the goodness of fit of model. Prediction choice probability from mixed logit model is compared with actual choice of each respondents. For this study, percentage of correct prediction is 68.21% which means the model is fit to predict respondent's choice.

7.3 Application of Logistic Regression Model

The generated logistic regression model was applied to test the preference of the packages that were used in the second questionnaire. From this we could investigate the combination of service attributes that could the attract the respondents the most. Table (22) shows the probability of each package could be chosen. Detail package design and calculation of probability of choosing individual package can be found in Appendix C.

Table 22: Probability of Choosing Each Individual Package

Package Scenarios	Probability
1	30%
2	74%
3	87%
4	16%
5	44%
6	56%
7	74%
8	26%
9	38%
10	62%
11	71%
12	29%
13	14%
14	83%
15	39%
16	56%

As seen in Table (22), the probability of choosing packages 3 is 87% which has the highest chance to be chosen. The package 3 includes five trips of Ha:mo, five trips of Muvmi and includes all other attributes such as carryover, pickup speed, priority and free trip, but with normal package price without any discount. Secondly, the probability of choosing package 14 is 83% which is the second highest. This package comprises of five trips of Ha:mo, five trips of Muvmi, having carryover option, priority of using Ha:mo service and with discounted price. Generally, we probably could say that students prefer to get privilege service once they purchase the package. The respondents seem prefer small package (10 trips in package) to large package (more than 10 trips). Moreover, respondents seem prefer to have carryover service attribute in package as they would like to make sure that they could spend all the trips that they have bought since they subscribe the package. Logically, price is a sensitive attribute, it could decrease the probability of choosing the package while price increase.

CHAPTER 8
CONCLUSION AND RECOMMENDATIONS

8.1 Research Summary

Shared mobility is a transportation strategy that have an impact on travel behavior and reduce environmental problems. Shared mobility service has been practicing in many places and Chulalongkorn University is also one of them. CU locates in CBD area and has various accessible modes nearby the campus: public bus, Bangkok Mass Transit system (BTS) sky train and Metropolitan Rapid Transit (MRT) subway. To connect to public transport, CU offers free shuttle bus service for all. However, it takes longer waiting time than normal due to traffic congestion occurs in some route and overcrowded during the peak hours. Aiming to bring a convenient and comfortable mobility for students and solving limited parking space problem in campus, CU collaborates with other private companies and offer another options, shared mobility, in the campus area.

Even though shared mobility services, Ha:mo and Muvmi, have been offering for a certain period of time, they are still less popular and have limited number of users compared to CU Pop Bus. This study aims to explore the reason behind why they are less popular and explore an alternative way improving the service quality. The concept of bundling mobility service is utilized. Before creating bundle package, it is mandatory to understand the satisfaction of the students on the current service quality and current demand on those modes.

Two phases of questionnaires had been conducted and the primary objective of the first questionnaire was to explore the current travel characteristics, satisfaction

of students based on the existing service quality and the factors influencing on the number of usage of shared mobility services in the future.

The result from internal mobility demand questionnaire indicates that students are not really satisfied with the current quality of the service. To come up with an example, students feel unsafe to use bicycle, CU bike, as there is no specific lane for them to ride safely around the campus. Another reason is that bicycles are not available at some docking stations and has limited number of docking station around the campus which make students feel inconvenient to use the service. A very small portion of the students (0.21%) uses shared bicycle service.

For Ha:mo, car sharing service, driving license is a mandatory requirement to get access to this mode which is a huge barrier for student. Most of the first or second-year students are less likely owning a driving license. For ride sharing service, a longer waiting time for Muvmi service is undesirable for students even though the number of customers of Muvmi service (45%) is much higher than Ha:mo service (27%). Moreover, it is obvious that a common factor in both services, price, around 20 THB per ride is less attractive for students since students have limited spendable amount of money per month. Comparing four modes provided by CU, unsurprisingly, CU Pop Bus is the most popular one while Muvmi gets higher demand among paid mobility service. For the current usage of Ha:mo service, there are some students using it up to five times a week while Muvmi having nine times maximum usage in one week.

The demand models for shared mobility services were generated using multiple-linear regression method. In Ha:mo demand model, it can be clearly seen

that current experience of the service is the primary factor that influence future demand, means the current users tend to continue using the service when the service quality has been improved. Secondly, follow by driving license which is essential for accessible for this service. While using contingent valuation for calculating the willingness to pay of the students, monetary value for Ha:mo service is less than normal price range (around 16 THB), price reduction is also another significant attributes in model that could attract the non-current users and maintain loyalty of current users. By reducing the service price and improve service quality, the utility of shared mobility could increase which means the demand of shared mobility service could increase significantly.

From demand model for Muvmi service, it is noted that female students prefer more Muvmi than male students. They feel safe to share with other students during the ride while male students are worried for privacy. Similar to Ha:mo, primary experience of Muvmi plays the most important role while predicting future demand of this service. However, price reduction is the least influent factor for utility of Muvmi service. The average willingness to pay for this service is approximately 17 THB per ride.

The unsatisfied service quality that need improvement and current demand of shared mobility were explored in the first phase, the hypothetical scenario (service package) testing was done in the second phase. The objective of this latter phase was to investigate the attributes of the shared mobility package which have effect on students' decision. Different combination of mode attributes and service attributes related with price were offered as a package to students in order to explore what kind

of factors could influence their decision and their preference on package. The data collected in the second phase was analyzed by logistic regression and mixed logit method.

From generic model for all respondents, number of trips for Muvmi in package is statistically significant and influence on utility of service package. Moreover, it explains that students are desirable to pay for package which have privilege features: faster pickup speed for Muvmi which could reduce their waiting time, having priority for Ha:mo (i.e., advanced booking), randomly getting free trip in every month and carryover (transferable unused trips to next month). Carryover feature option is the most vital attribute for integrated package as buyers would like to make sure that they could use all the trips they have bought. It is notable that monthly income is another factor that has effect on decision making. The utility of package seems to be high for high income students. Higher income group of students are willing to pay for all rides at one payment, buying package.

8.2 Policy and Recommendation

The result of this study could reveal the weakness of the current qualities of all services and some factors that should be taken into consideration. For CU Pop Bus, service frequency could be improved by providing more vehicles specially during peak hours. It could probably solve not only unsatisfied service frequency problem but also over crowdedness on bus. For CU bike, specific bike lane or facilities that could improve service safety and frequency should be provided. As CU is located in central business district area, safety for bike user should be prioritized. Moreover, accessibility of CU bike is another that should be considered in order to get more

users. Providing more docking stations likely improve accessibility of service and would be more convenient for all users. For Ha:mo, driving license is the barrier for students to use. Price is common barrier for both Ha:mo and Muvmi. These modes could be another option for students in their daily mobility around campus if the service providers could offer the price range approximately 15 THB per ride.

In the first part of study, we also found out that mobile application seems to be complex for some users. Another thing should be noted is that students are lack of detail information about the shared mobility service especially for fresher, the first-year students. Even though they see vehicles on campus, they still lack off information how to pay or use these specific services. So that, service promotion should be done more often. From demand model of Ha:mo and Muvmi, it is obvious that experience users tend to continue using it in the future as well. The first impression or service experience is virtual for getting more loyal customers. More than that, users are lack of sharing experience and not willing to pay for the services. Offering one or two free trips for new users could probably be a good strategy that could get more users. If both service providers could offer cheaper rides during non-peak hours, students may interest to use it. The users may probably tend to use it in future once they have positive experiences from using them.

Another alternative way is that operators could collaborate, come up with package and promote as an integrated service, it could save some marketing expense for both service providers. Therefore, preference of service package and factors or attributes that influence on choosing package have been studied. Having privilege feature in package seems to make it more attractive. Without any privilege feature

seem no different from pay per ride option, thus, students may unwilling to pay for all ride at the same time. Having carryover in the package seem to be an advantage for users and it could attract more attention from customers.

Before promoting the service, service provider should support enough vehicles to accommodate demand. Reliability of the service in terms of waiting time, service availability might be main concern for users. In order to appeal service package buyers, improvement of both services are needed especially for service reliability. Without a reliable service, users would not be willing to pay for the service. Some service quality improvement should be considered. Last but not least, pricing is a sensitive factor for both users and service provider. Appropriate pricing of package could grow the utility of package, if not, people would ignore it.

8.3 Research Limitation and Future Research

In this study, sample frame included both experience users and non-experience users of the service, so that, it could cause bias in the models. If data were collected only from experience users from both services, it might probably could give a more precise models for this study. Related with service attributes that asking for satisfaction of the students were limited. As this study mentioned only some of the most possible attributes, there might be other service factors that they are either satisfied or unsatisfied.

The modes considered in the integrated package included only paid services: Ha:mo and Muvmi and most of the factors that influence on customer choice were non-mode attributes. Obviously, the number of trips of Ha:mo and Muvmi have correlation with package price. The increase in number of total trips, increase the

package price as well. Moreover, each scenario in questionnaire had force choices, two package options, not include pay-per-ride option, so that, it seems to be unrealistic as actually users have another pay per ride option in hand.

To offer integrated service, many stakeholders should highly collaborate and work together. As this study is mainly explore or study from user point of view (demand side), study on supply side (service providers) could be an interesting or challenging issue for further research as well. Moreover, another sophisticated approach for finding the probability of the mobility service package using mixed logit method could be an interesting topic. It may probably could provide a more precise prediction on probability of choosing package as it counts heterogeneous consideration of the population.

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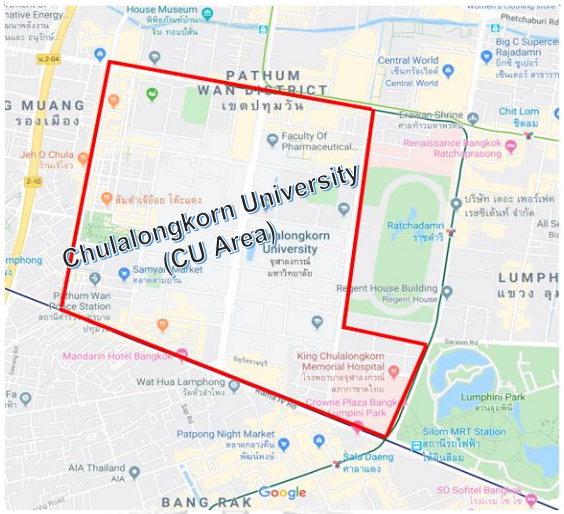
Appendix A

Questionnaire 1: Demand for shared mobility service

This study aims to explore the students' satisfaction on the current transportation modes provided in Chulalongkorn University campus area. The figure below shows CU campus area, all the trips going within this area are taking into consideration for this study. It might include your shopping trip (to/ from MBK, Sam yam Mirtown, Siam area) and (to and from BTS stations) as well.



Part 1: **General information**

1. Gender ☐ Male ☐ Female
2. Faculty ……
3. Level of study ☐ 1st year ☐ 2nd year ☐ 3rd year ☐ 4th year ☐ >4th year ☐ Graduate Student
4. Personal Income (including pocket money in baht)
   ☐<5000 ☐ 5000-7500 ☐ 7501-10000 ☐ 10001-12500 ☐ 12501-15000 ☐ 15001-1750 ☐ 17501-20000 ☐>20000
5. Your spendable amount of money for a month (e.g. Exclude your accommodation or apartment expense)
   ☐<2000 ☐ 2000-4000 ☐ 4001-6000 ☐ 6001-8000 ☐ 8001-10000 ☐ 10001-12000 ☐ 12001-14000 ☐>14000
6. Driving License for Car ☐ Yes ☐ No

Part 2 Satisfactory level for every mode available in CU

1. How satisfied are you with **CU pop bus service** in Chulalongkorn University currently?
   Please rate your satisfactory level with the following aspects.

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied
Travel time	1	2	3	4	5
Waiting time	1	2	3	4	5
Crowdedness	1	2	3	4	5
Service frequency	1	2	3	4	5
Safety	1	2	3	4	5
Overall rating	1	2	3	4	5

2. How satisfied are you with **Muvmi service** in Chulalongkorn University currently?
   Please rate your satisfactory level with the following aspects.

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied
Travel time	1	2	3	4	5
Cost	1	2	3	4	5
Waiting time	1	2	3	4	5
Safety	1	2	3	4	5
Overall rating	1	2	3	4	5

3. How satisfied are you with **Ha:mo service** currently?
   Please rate your satisfactory level with the following aspects.

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied
Travel time	1	2	3	4	5
Cost	1	2	3	4	5
Safety	1	2	3	4	5
Service availability	1	2	3	4	5
Overall rating	1	2	3	4	5

1. How satisfied are you with **CU bike service** currently?
   Please rate your satisfactory level with the following aspects.

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied
Travel Time	1	2	3	4	5
Safety	1	2	3	4	5
Service Availability	1	2	3	4	5
Overall rating	1	2	3	4	5

Part 3 Travel characteristics of respondents

1. How many days in a week do you come to Chulalongkorn University?
   ☐ Daily ☐ 3-4 days ☐ 1-2days

2. How do you normally come to Chulalongkorn University?
   ☐ Motorcycle (self-driving) ☐ Private Car (self-driving) ☐ Private Car (drop-off) ☐ Public Transport
   ☐ Modes provided by CU (CU pop bus, CU bike, Ha:mo & Muvmi)

3. Currently, how much do you spend for transportation going within Chula area **in one week**?
   ☐ <200baht ☐ 200-400baht ☐ 400-600baht ☐ 600-800baht ☐ >800baht

4. Currently, how many times do you normally use **CU pop bus** going in Chulalongkorn University area **in one week**?
   ☐ Never ☐ 1-3 times ☐ 4-6 times ☐ 7-9 times ☐ 10-12 times ☐ >12 times

5. **In one day**, how far do you normally walk around CU?.....km

Part 4 Willingness to pay for each mode (CU bike, Ha:mo & Muvmi)
(In this section, please tell me the price you would like to have for each modes and the frequency that you will use based on the price you mention.)

The registration fee is 100 baht and it is free for the first one hour per ride. The vehicle needs to return to the docking station.

1. Do you know the price condition of CU bike before?
   ☐ Yes ☐ No

2. Currently, how many times do you normally use **CU bike** going in CU campus area **in one week**?
   ☐ Never ☐ 1-3 times ☐ 4-6times ☐ 7-9 times ☐ >9 times

3. What kind of service condition would encourage you to use more CU bike?
   I would use more often when……..
   - ☐ a. When docking station is available in many places.
   - ☐ b. When registration can be done through app.
   - ☐ c. When there is no registration fee.
   - ☐ d. Others.

4 If we improve the condition you mentioned above, **how many more times** you tend use CU bike **in a week**?
   ☐ 0 time (I don't want to use it more.) ☐ 1-3 times ☐ 4-6times ☐ 7-9 times ☐ >9 times

If you tick 0 time continue question no.5, otherwise continue question no.6.

5. Please give me the reason why you are not interested to use it.
   - ☐ a. It cannot be found easily.
   - ☐ b. You don't know how to ride the bike.
   - ☐ c. Weather is too hot to ride the bicycle.
   - ☐ d. Registration procedure is complex.
   - ☐ e. Others.

6. Which modes would be replaced by **CU bike** for the additional trips that you will make?
   ☐ CU pop bus ☐ Walking ☐ I will travel more and won't replace any other modes.

Ha:mo

Ha:mo fare starts at 20 baht for the first 15 minutes and then charge additional 2 baht per minutes when students use more than 15minutes.

1. Do you know the price condition of Ha:mo before?
   ☐ Yes ☐ No

2. Currently, how many times do you use **Ha:mo** going in CU campus area **in one week**?
   ☐ Never ☐ 1-3 times ☐ 4-6 times ☐ 7-9 times ☐ >9 times

3. Please mention the price per ride you would like to have for **Ha:mo** to use it more often? (Currently, 20 baht for 15minutes)
   ……baht

4. With the price you mentioned in question above, how many **more times** you tend use Ha:mo **in one week**?
   ☐ 0 time (I don't want to use it more.) ☐ 1-3 times ☐ 4-6times ☐ 7-9 times ☐ >9 times

If you tick 0 time continue question no. 5, otherwise continue question no.6.

5. Please give me the reason why you are not interested to use it.
   - ☐ a. You always go with group of friends.
   - ☐ b. It is expensive for you.
   - ☐ c. Limited parking station.
   - ☐ d. You don't have driving license.
   - ☐ e. Others.

6. Which mode would be replaced by Ha:mo for the additional trips that you will make?
   ☐ CU pop bus ☐ CU bike ☐ Walking ☐ I will travel more and won't replace any other modes.

Muvmi

Students can call through app. The fare varies (15, 20, 25 baht) depends on the distance you travel.

1. Do you know the price condition of Muvmi before?
   ☐ Yes ☐ No

2. Currently, how many times do you normally use **Muvmi** going in Chulalongkorn University area **in one week**?
   ☐ Never ☐ 1-3 times ☐ 4-6 times ☐ 7-9 times ☐ >9 times

3. Assume currently Muvmi price is 20 baht per ride, please name the price you would like to have **for Muvmi** to use it more often?
   ……baht

4. With the price you mentioned in question above, how many **more times** you tend use **in one week**?
   ☐ 0 time (I don't want to use it more.) ☐ 1-3 times ☐ 4-6times ☐ 7-9 times ☐ >9 times

If you tick 0 time continue question no. 5, otherwise continue question no.6.

5. Please give me the reason why you are not interested to use it.
   - ☐ a. You don't like to share with others.
   - ☐ b. The waiting time is too long.
   - ☐ c. It is expensive.
   - ☐ d. App is complex to use.
   - ☐ e. Others

6. Which modes would be replaced by Muvmi for the additional trips that you will make?
   ☐ CU pop bus ☐ CU bike ☐ Walking ☐ I will travel more and won't replace any other modes.

Thank you for your effort and participation.

Appendix B

Questionnaire 2: Preference on Shared Mobility Package

Questionnaire survey about shared mobility service in Chulalongkorn University

1. Are you a student who is currently studying in Chulalongkorn University?

☐ Yes ☐ No

2. General Information

2.1 Gender ☐ Male ☐ Female

2.2 Level of study ☐ Undergrad Student ☐ Graduate Student

2.3 Personal income ☐ <5000THB ☐ 5000-10000THB

☐ 10001-15000THB ☐ 15001-20000THB ☐ >2000THB

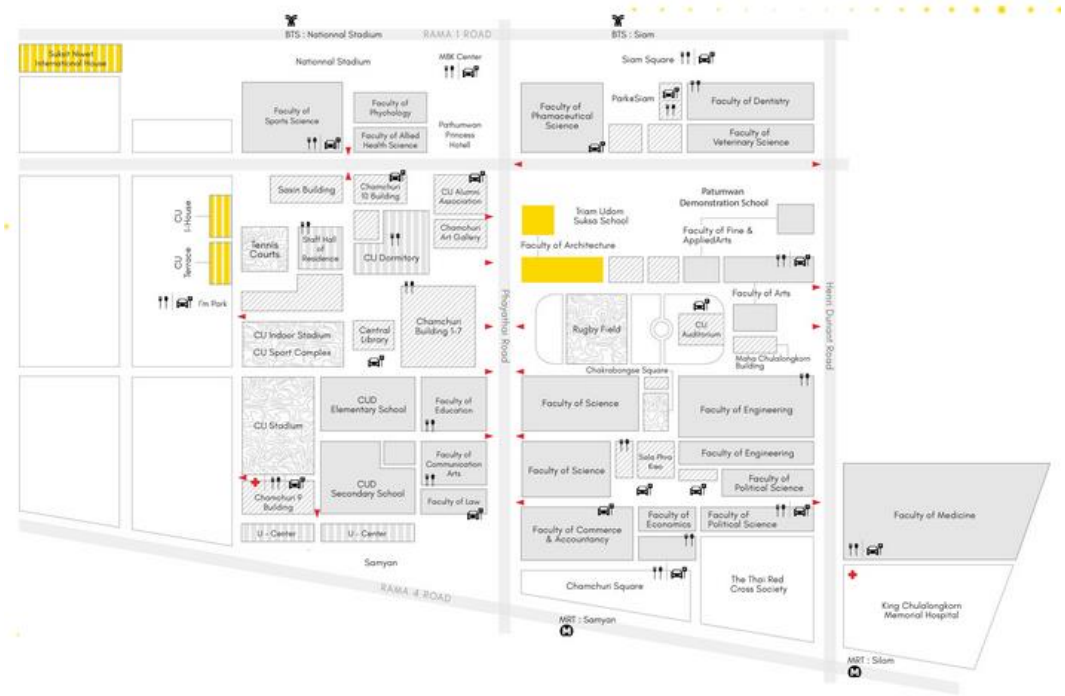
2.4 Accommodation

☐ CU dormitory ☐ within 2km away from CU ☐ more than 2km away from CU

2.5 Driving license ☐ Yes ☐ No

3. Mode choice and satisfaction level on the services

The following question is only about traveling in Chulalongkorn University campus area, which is the area that Ha:mo and Muvmi serve (students generally travel in this area during the day) as in the picture below.



3.1 Normally, how do you travel to and from Chulalongkorn University? (can choose more than one mode below).

☐ Private vehicles ☐ BTS & MRT ☐ Bus ☐ Service provided by CU ☐ Others

3.2 How often do you use the following modes from your place to faculty in CU?

	Never	Rarely (1-2times/Month)	Sometimes (3-5times/Month)	Often (6-8times/Month)	very often (>8times/Month)
Pop Bus	☐	☐	☐	☐	☐
Ha:mo	☐	☐	☐	☐	☐
Muvmi	☐	☐	☐	☐	☐
CU bike	☐	☐	☐	☐	☐
Others	☐	☐	☐	☐	☐

3.3 How often do you use the following modes for going around CU campus area?

	Never	Rarely (1-2times/Month)	Sometimes (3-5times/Month)	Often (6-8times/Month)	very often (>8times/Month)
Pop Bus	☐	☐	☐	☐	☐
Ha:mo	☐	☐	☐	☐	☐
Muvmi	☐	☐	☐	☐	☐
CU bike	☐	☐	☐	☐	☐
Others	☐	☐	☐	☐	☐

3.4 Currently, how much to you spend for mobility expense for going around CU campus area in one month?

☐ <200THB (<50THB per week approximately)

☐ 200-400THB (50-100THB per week approximately)

☐ 400-600THB (100-150THB per week approximately)

☐ 600-800THB (150-200THB per week approximately)

☐ >800THB (>200THB per week approximately)

3.5 Please rate your satisfaction level on service quality of Ha:mo and Muvmi.

	Satisfied	Neutral	Dissatisfied	Never used
Ha:mo	☐	☐	☐	☐
Muvmi	☐	☐	☐	☐

3.6 Please rate your satisfaction level on Cost of Ha:mo and Muvmi.

	Satisfied	Neutral	Dissatisfied	Never used
Ha:mo	☐	☐	☐	☐
Muvmi	☐	☐	☐	☐

4. Service package for shared mobility in Chulalongkorn University

Before continues to service package, please read the following information carefully.

Feature of the service

App gives you everything
- Plan your trip
- Give notification of optimum service nearby your location (real-time)
- Online Payment – no cash
- Cool features such as personalized record.
- Notification of emergency, major incident such as accidents, breakdown.

Privilege of members
- Receive special discounts
- Awards on points collected
- Priority of the services
  - Book Ha:mo in advance
  - Inform available Muvmi and Ha:mo around in real time
- Know and alert your discounted trip in real-time
- Personalized Assistant on your trip
- Getting some free rides on some routes at the specific time.

Discounted Price
- Pay per month is cheaper than normal pay per ride.
- Option on Carry-over the unused rides to next consecutive month.

Seamless
- Find and offer a proper mode that suits your need (you can personalize your daily travel)
- Direct you to available modes (Muvmi or Ha:mo)
- Shorter walk, shorter wait, shorter travel time

Price : Monthly price of package (discount price)

Ha:mo : Single seater car-sharing service provided in Chula

Muvmi : Six-seaters ride-sharing service in Chula

Carry-over : The remaining trips in this month can be used in the next consecutive month.

Pick-up speed : Once you subscribe the package, Muvmi driver will pick you up within 7minutes (normally 15 minutes)

Priority : Get priority on Ha:mo Advanced Booking

Free trip : Offer FREE trips on selected route and time (1-3 times/ month)

4.1 Please choose the package that is the most suitable for your travel.

Features	Package A	Package B
	5 times	10 times
	5 times	10 times
Carryover	X	√
Muvmi Pickup Speed	X	√
Free Trip	X	√
Hamo Priority	X	√
Package Price	200 THB	320 THB
	Normal price >200 THB	Normal price >400 THB

☐ Package A

☐ Package B

4.2 Please choose the package that is the most suitable for your travel.

Features	Package A	Package B
	5 times	10 times
	5 times	10 times
Carryover	√	X
Muvmi Pickup Speed	√	X
Free Trip	√	X
Hamo Priority	√	X
Package Price	200 THB	320 THB
	Normal Price >200 THB	Normal Price >400 THB

☐ Package A

☐ Package B

4.3 Please choose the package that is the most suitable for your travel.

Features	Package A	Package B
	5 times	10 times
	10 times	5 times
Carryover	X	√
Muvmi Pickup Speed	√	X
Free Trip	X	√
Hamo Priority	√	X
Package Price	240 THB	300 THB
	Normal Price >300 THB	Normal Price >300 THB

☐ Package A

☐ Package B

4.4 Please choose the package that is the most suitable for your travel.

Features	Package A	Package B
	5 times	10 times
	10 times	5 times
Carryover	√	X
Muvmi Pickup Speed	X	√
Free Trip	√	X
Hamo Priority	X	√
Package Price	240 THB	300 THB
	Normal Price >300 THB	Normal Price >300 THB

☐ Package A

☐ Package B

4.5 Please choose the package that is the most suitable for your travel.

Features	Package A	Package B
	10 ครั้ง	5 ครั้ง
	5 ครั้ง	10 ครั้ง
Carryover	X	√
Muvmi Pickup Speed	X	√
Free Trip	√	X
Hamo Priority	√	X
Package Price	240 THB	300 THB
	Normal Price >300 THB	Normal Price >300 THB

☐ Package A

☐ Package B

4.6 Please choose the package that is the most suitable for your travel.

Features	Package A	Package B
	10 times	5 times
	5 times	10 times
Carryover	√	X
Muvmi Pickup Speed	√	X
Free Trip	X	√
Hamo Priority	X	√
Package Price	240 THB	300 THB
	Normal Price >300 THB	Normal Price >300 THB

☐ Package A

☐ Package B

4.7 Please choose the package that is the most suitable for your travel.

Features	Package A	Package B
	10 times	5 times
	10 times	5 times
Carryover	X	√
Muvmi Pickup Speed	√	X
Free Trip	√	X
Hamo Priority	X	√
Package Price	400 THB	160 THB
	Normal Price >400 THB	Normal Price >200 THB

☐ Package A

☐ Package B

4.8 Please choose the package that is the most suitable for your travel.

Features	Package A	Package B
	10 times	5 times
	10 times	5 times
Carryover	√	X
Muvmi Pickup Speed	X	√
Free Trip	X	√
Hamo Priority	√	X
Package Price	400 THB	160 THB
	Normal Price >400 THB	Normal Price >200 THB

☐ Package A

☐ Package B

4.9 If you have pay per ride option, would you still prefer to buy service package?

(prefer pay per ride) 1 2 3 4 5 (prefer package)

Thank you for your participation. ☺

Appendix C

Probability of Choosing Package by Logistic Regression Model

Attributes \ Packages	1	2	3	4	5	6	7	8
Number of trips of Ha:mo	5	10	5	10	5	10	5	10
Number of trips of Muvmi	5	10	5	10	10	5	10	5
Carryover	0	1	1	0	0	1	1	0
Pickup Speed	0	1	1	0	1	0	0	1
Priority	0	1	1	0	0	1	1	0
Free Trip	0	1	1	0	1	0	0	1
Price	2	3.2	2	3.2	2.4	3	2.4	3
Z	0.848	1.043	1.879	-1.684	-0.236	0.226	1.052	-1.061
Probability	0.300	0.739	0.868	0.157	0.441	0.556	0.741	0.257

Attributes \ Packages	9	10	11	12	13	14	15	16
Number of trips of Ha:mo	10	5	10	5	10	5	10	5
Number of trips of Muvmi	5	10	5	10	10	5	10	5
Carryover	0	1	1	0	0	1	1	0
Pickup Speed	0	1	1	0	1	0	0	1
Priority	1	0	0	1	1	0	0	1
Free Trip	1	0	0	1	0	1	1	0
Price	2.4	3	2.4	3	4	1.6	4	1.6
Z	0.494	0.484	0.886	-0.896	-1.816	1.602	-0.462	0.248
Probability	0.379	0.619	0.708	0.290	0.140	0.832	0.386	0.562

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