พฤติกรรมการเดินทางและปัจจัยที่ส่งผลต่อความถี่ในการใช้การขนส่งแบบไม่เป็นทางการ และรถโดยสารสาธารณะในเขตเมืองของพนมเปญ

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TRAVEL BEHAVIOR AND FACTORS INFLUENCING FREQUENCY OF USING INFORMAL TRANSPORT AND PUBLIC BUS IN URBAN AREA OF PHNOM PENH

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งวนซอง เอือง : พฤติกรรมการเดินทางและปัจจัยที่ส่งผลต่อความถี่ในการใช้การขนส่งแบบไม่เป็นทางการ และรถโดยสารสาธารณะในเขตเมืองของพนมเปญ (TRAVEL BEHAVIOR AND FACTORS INFLUENCING FREQUENCY OF USING INFORMAL TRANSPORT AND PUBLIC BUS IN URBAN AREA OF PHNOM PENH) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: เกษม ชูจารุกุล, 78 หน้า.

ระบบพาราทรานสิท เช่น Motodup และ Remork สามารถเห็นได้ทั่วไปในเขตเมืองของกรุงพนมเปญเป็นเวลาหลายทศวรรษ ระบบดังกล่าวมีบทบาทสำคัญในฐานะที่เป็นระบบขนส่งสาธารณะหลักสำหรับผู้เดินทางในท้องถิ่น ก่อนที่จะมีรถประจำทางที่วิ่งให้บริการในเมืองอย่างเต็มรูปแบบในปีพ.ศ. 2557 งานวิจัยนี้มีเป้าหมายเพื่อวิเคราะห์ความถี่ในการเดินทางของผู้โดยสารระบบพาราทรานสิทและผู้โดยสารรถประจำทาง โดยพิจารณาตัวแปรทางด้านเศรษฐกิจและสังคมของผู้เดินทาง ลักษณะการเดินทาง และลักษณะการดำเนินงานของรูปแบบการขนส่งแต่ละแบบ โดยใช้แบบจำลองแบบ Ordered-Probit Model ข้อมูลในการศึกษาได้จากการวิเคราะห์กลุ่มตัวอย่างจำนวน 483 ตัวอย่าง ที่ได้สำรวจในพื้นที่หลัก 4 พื้นที่ในกรุงพนมเปญ ได้แก่ เขตศูนย์กลางทางธุรกิจ (CBD) เขตสถานศึกษา เขตที่อยู่อาศัย และเขตชานเมือง ผลการศึกษาชี้ให้เห็นว่านักเรียนนักศึกษาใช้บริการ Motodup ไม่บ่อยนัก แต่จะเลือกใช้ Remork ในการเดินทางมากกว่า ค่าใช้จ่ายในการเดินทางเป็นปัจจัยหลักต่อการตัดสินใจเลือกใช้ Motodup และรถประจำทาง แต่อย่างไรก็ตาม ตัวแปรนี้กลับไม่พบว่ามีนัยสำคัญกับความถี่ของการใช้บริการ Remork แต่ประการใด ในด้านของทัศนคติพบว่า ผู้โดยสารที่ใช้ Remork และผู้โดยสารรถประจำทางให้ความสำคัญต่อความสบายและความพร้อมใช้งาน ซึ่งส่งผลต่อความถี่ในการเดินทางของรูปแบบการเดินทางดังกล่าว สำหรับรถโดยสารประจำทาง หากผู้กำหนดนโยบายต้องการส่งเสริมการใช้บริการ ก็ควรยกระดับคุณภาพของความสบายและความพร้อมในการเดินทาง เช่นเดียวกับการเก็บค่าใช้จ่ายในการเดินทางในราคาที่ต่ำเพื่อให้สามารถช่วยเพิ่มความถี่ในการใช้บริการรถประจำทางให้มากยิ่งขึ้น

ภาควิชา วิศวกรรมโยธา ลายมือชื่อนิสิต .....

สาขาวิชา วิศวกรรมโยธา ลายมือชื่อ อ.ที่ปรึกษาหลัก .....

ปีการศึกษา 2558

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KEYWORDS: PARATRANSIT / PUBLIC BUS / PHNOM PENH / ORDERED PROBIT MODEL

NGUONSONG EUNG: TRAVEL BEHAVIOR AND FACTORS INFLUENCING FREQUENCY OF USING INFORMAL TRANSPORT AND PUBLIC BUS IN URBAN AREA OF PHNOM PENH. ADVISOR: ASSOC. PROF. KASEM CHOOCHARUKUL, Ph.D., 78 pp.

For decades, paratransit modes such as Motodup and Remork can be commonly seen in the urban area of Phnom Penh. They play an important role as a major public transport for local travelers, even before the city bus was put into full operation in 2014. This study aims to analyze trip frequency of paratransit and city bus passengers by considering traveler's socioeconomic variables, trip characteristics and operational characteristics of each mode. Using ordered probit modeling, data is analyzed based on 483 samples collected from four main areas of Phnom Penh, i.e., CBD, educational, residential and suburb areas. Results indicate that students do not use Motodup frequently, but they prefer Remork. Moreover, travel cost is seen to be the major factor that reduces the likelihood of using Motodup and city bus, but this variable is not found significant in determining the frequency of using Remork at all. In terms of attitudes, Remork and city bus passengers perceive comfort and availability importantly. The more important they value these two factors, the more frequent they would use such modes. Since city bus is a highly promoted public transport, policy makers should enrich the quality of comfort and availability as well as keep the travel cost low in order to increase the usage frequency.

Department: Civil Engineering Student's Signature .....

Field of Study: Civil Engineering Advisor's Signature .....

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Chapter 1
INTRODUCTION

1.1 Study Background

Phnom Penh is the capital and the busiest city of Cambodia. It is the center of economic, politics and culture of the country with roughly 2 million inhabitants. Population growth and the active economical activities are one of the main reasons causing the traffic in the city become worse. The investment on transportation infrastructures such as road and flyover constructions has been arisen lately in order to relieve the traffic congestion in the city. However, this seems not to be the long-term solution, while public transportation needs to put into account. Currently, public transportation in Phnom Penh mainly depends on paratransit and public bus, which was just put into full operation in 2014.

Paratransit is considered an informal transportation that is available in many cities of developing nations. However, there are many kinds of paratransit including the motorized and the non-motorized modes. Their characteristics are quite different from country to country (Phun & Yai, 2015). Due to this reason, it is quite difficult to give an exact definition that represents the characteristics of paratransit modes in general. For instance, Cervero (2000) defines this term as a transportation service that mainly serves low-income people. However, it seems not to be the case for some cities such as Phnom Penh due to the fact that paratransit is absolutely rich in amount in urban area. That is why paratransit tends to be referred to motorcycle taxi (Motodup) and Remork for Cambodia(Phun et al., 2015a), small-sized converted pickup truck (Silor Lek or Ka-por) for Thailand (Choocharukul & Sriroongvikrai, 2011), Angkot for Indonesia (Joewono & Kubota, 2005), Rickshaw for Bangladesh (Hossain & Susilo, 2011) and resident's coach for Hong Kong, China (Loo, 2007).

In Phnom Penh, both motorized and non-motorized paratransit including motorcycle taxi, Remork, long-tailed Remork and Cyclo (Phun et al., 2015a) still exist. However, the

common ones that are found in urban area of Phnom Penh are only motorcycle taxi and Remork, while long-tailed Remork is mostly available in the suburb area as a transportation made for garment factories workers, and Cyclo is only found in some part of Phnom Penh mainly serve for tourists. The presence of public bus has competed the existing paratransit modes. Nonetheless, paratransit is still a major public transportation although public bus was introduced to the public with lower fare. This is due to the fact that it provides door-to-door service and the extensive availability across the city, while public bus is only available on the arterials.

1.2 Problem Statement

Paratransit and public bus play an important role as public transportation in urban area of Phnom Penh. However, the management of paratransit and service quality for public bus remain low provoking an ineffective public transportation service. Although most paratransit drivers (mainly Remork drivers) are bunched together under several associations in a picture of informal sector, those associations do not have any critical influences on the operation. Thing is that most drivers own the operated vehicles, and they only need associations to help them to negotiate for parking space at the high-demand places. However, there are also paratransit drivers who do not involve in any associations. Because of this reason, it is a big challenge to identify the accurate number of paratransit fleets and to observe the trend of increasing or decreasing of paratransit in the city.

Public bus, on the other hand, has been operated by municipality of Phnom Penh. Service quality is still low leading to long waiting time and long in-vehicle travel time. Fare of using public bus is affordable for general passengers (1500 KHR/Trip), but the operation does not basically attract passenger for daily use. With the government subsidy, the service is provided for free to some group of passenger (e.g. students, senior citizen), but in fact public bus itself also needs to earn sufficient profit to keep the operation sustainable.

An effective public transportation would contribute immensely in enhancing the traffic situation in the city. However, until now the characteristics of passengers who use

paratransit and public bus have not been identified yet. The information from users' perspective would provide insight on their trip characteristics, and what are the factors influencing the frequency of using paratransit and public bus. By knowing this, we can propose measure to increase passengers' frequency of using public modes.

1.3 Scope of the Study

The study mainly observes the characteristic of paratransit and public bus passengers in urban area of Phnom Penh. The study would focus on only demand/passengers side. Three common public modes including Motodup, Remork and public bus are put into account. Since the usage of paratransit and public bus may differ by type of land-use, the study considers four main study areas in Phnom Penh, which are central business district (CBD), educational area, residential area and suburb area.

1.4 Research Objectives

The objectives of this study are:

- To analyze trip characteristic of various group of passengers to the different operational locations of paratransit and public bus.
- To investigate the factors influencing the usage frequency of passengers toward paratransit and public bus.
- To suggest the appropriate transportation policies that would promote the usage of public bus, resulting in better sustainable transportation planning.

1.5 Expected Outcomes

The operation of paratransit and public bus functions importantly as public transportation in urban area of Phnom Penh. Their presence provide variety choices of transportation for passengers, not only for the present time but also for the future. The results from this study is expected to benefit transportation planning in the city in various ways such as:

- Provide characteristic information of passengers who use public transportation. This would be a useful piece of information that transportation planning could hit the target group of users.

- Reveal passengers' perception toward the operation of paratransit and public bus so that the improvement can be made according to the strengths and weaknesses we observed.
- The analysis of trip frequency shows the factors influencing paratransit and public bus usage. The results from this could potentially be used to fluctuate the usage of public modes so that the optimal supply-demand can be reached.

1.6. Report Organization

The report of this study is organized by six chapters.

Chapter 1 provides background of the study, problems statement, objectives of the study and expected outcomes.

Chapter 2 gives the overview of current urban transportation in Phnom Penh, and the literature reviews. The reviews are divided into two main parts – the previous studies related with informal transportation in Asian countries and the previous studies that use the procedure of ordered probit model to apply in transportation field.

Chapter 3 shows the methodology of the research. In this chapter method of data collection and main framework of data analysis are discussed.

Chapter 4 summarizes the descriptive statistics obtained from data collection. Those descriptive results mainly consist of passengers' socioeconomics, trip characteristics and their perception on the operation of Motodup, Remork and public bus.

Chapter 5 provides two main scopes. Initially, there is a discussion on theory, model specification and modeling procedure. These subsections are connected to modeling results, which are provided subsequently.

Chapter 6, which is the last chapter, summarizes the main ideas of the study, and conclusions are drawn accordingly. In this chapter, there is also a discussion on policy implementation and the recommendation for future study.

Chapter 2

LITERATURE REVIEWS

2.1. Profiles of Phnom Penh

Phnom Penh is known as the capital city of Cambodia providing homes to roughly 2 million people (Municipality of Phnom Penh, 2015) out of 14.86 million (UN data, 2012) across the country. Land area of Phnom Penh is 678.46 Km^2, and population density is reported to be 2,213 inhabitants/Km^2 (Municipality of Phnom Penh, 2015). Within the last 5 years, population annual growth rate was found to be 1.8%, while urban population growth rate reaches 2.1% (UN-Data, 2015). GDP per capita of Cambodian was estimated to be USD 769 in 2009, but USD 820 for each Phnom Penh citizen in 2005 (Municipality of Phnom Penh, 2015).

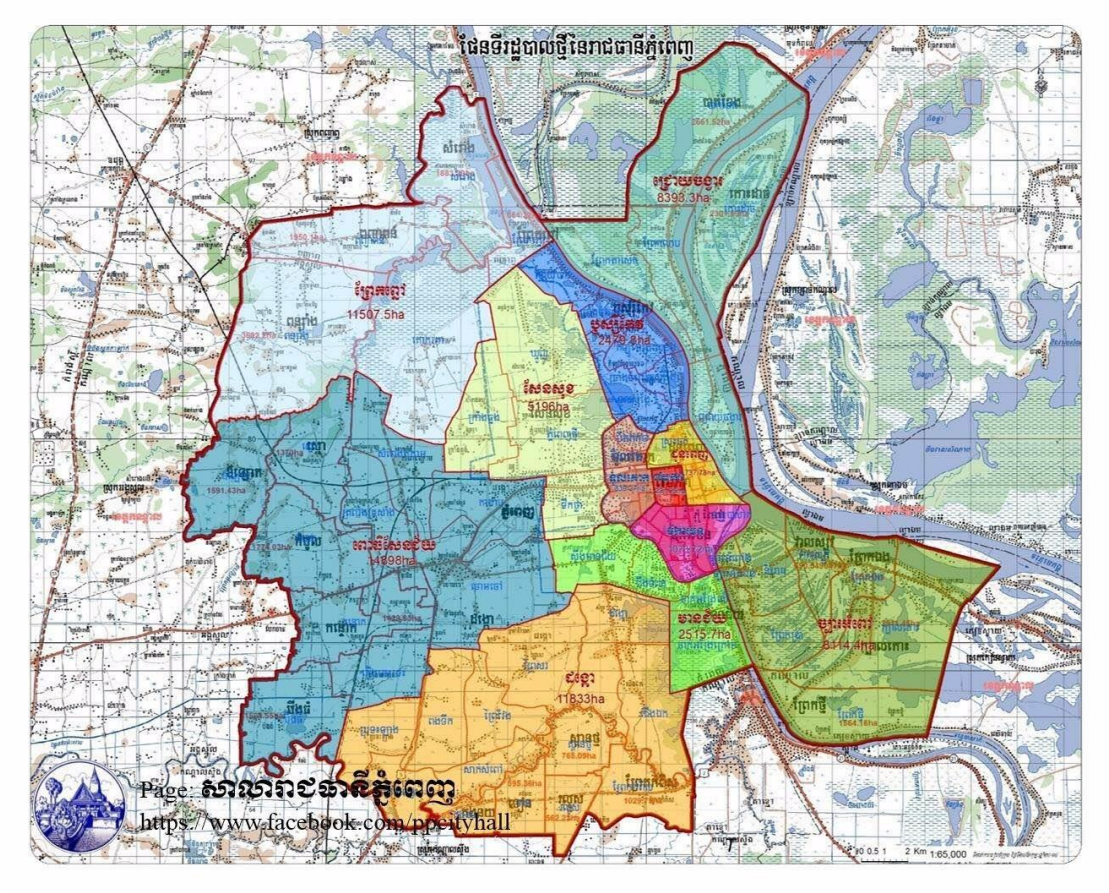


Figure 2-1 Map of Phnom Penh (Municipality of Phnom Penh, 2016)

Because of population growth, Phnom Penh is becoming denser that land area of the city need to be expanding to the neighboring provinces. According to Phnom Penh Capital Hall, the city boundary has been modified into four stage:

- Stage 1: Add up Dangkor District
- Stage 2: The creation of Khan Russey Keo
- Stage 3: The integration of 4 villages from Kanthork Commune to Phnom Penh territory
- Stage 4: The integration of 20 communes from 5 Districts (Ponnhear Leu, Mok Kampoul, Khien Svay, Kandal Steung, Angsnoul) of Kandal Province to Phnom Penh.

As of 2016, Phnom Penh consist of 12 districts (see Figure 2-1), all of which are 7-Makara, Chamkarmon, Chbar Ampov, Chroy Changva, Dangkor, Doun Penh, Mean Chey, Por Sen Chey, Prek Pnov, Russei Keo, Sen Sok and Tuol Kok. Phnom Penh citizens are categorized by occupations into four groups – civil servant, staff and worker, service provider and farmer (Municipality of Phnom Penh, accessed on May 26, 2016). The proportion of each occupation is shown in Figure 2-2.

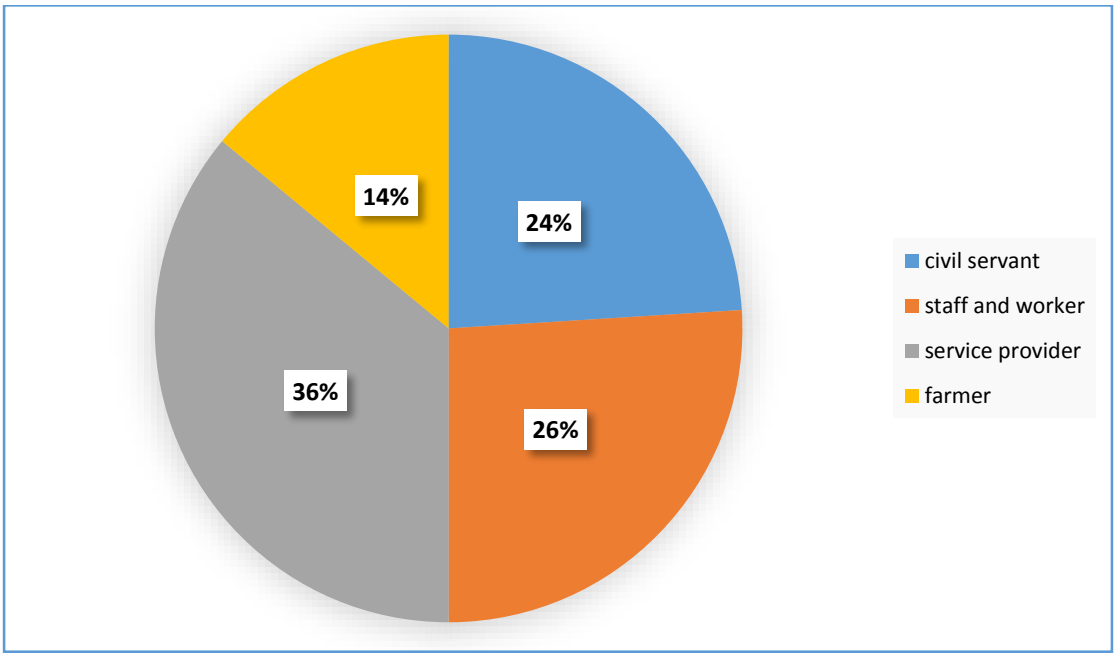


Figure 2-2 Occupational group of Phnom Penh inhabitants (Municipality of Phnom Penh, 2016)

2.2. Urban Transportation in Phnom Penh

Traffic in Cambodia mixes up with several kinds of vehicle fleets. As of 2012, registered vehicle in Cambodia was reported to be 2,172,000, excluding mopeds (OECD/ITF, 2014)), while Phnom Penh alone shares 670,091 (Municipality of Phnom Penh, 2015). Among all modes, motorcycle shares 80%, and this mode also contributes the most in road accident – accounting 68% of total casualties (OECD/ITF, 2014). A big difference of modal shared in terms of size and speed has created couples of problems, and this has put the pressure upon motorcycle mainly (Kov & Yai, 2009). In other word, motorcyclists have been blamed for having a bad driving behavior that is responsible for 95% of accident causing by motorcycle (Kov & Yai, 2011).

Table 2-1 Number of registered vehicles in Phnom Penh
(Municipality of Phnom Penh, 2015)

No	Type of Vehicle	Number registered
1	Sedan	94,782
2	Truck	8,213
3	Motorcycle	562,623
4	Tricycle	1,137
5	Motorcycle with cart / Trolley	3,336

2.2.1. Public Bus

As of 2014, the operation of public bus in Phnom Penh came to action again after the failure in 2001 (Phun et al., 2015a). Currently, 45 buses run along three lines across the main areas of the city. As of early September 2014, the length of operational routes were extended to 19km, 19km and 13.5km for line 01, line 02 and line 03 respectively (Phun et al., 2015a). The operation starts from 5:00am and ends at 8:30pm with fare set 1500 KHR (roughly 0.37 USD) per trip per person. However, this fare charge is excluded senior citizens, disable people, monks and students. The total bus stop was reported to be 184, composed by 67 stops from line 01 (A), 68 stops from line 02 (B) and 49 stops from line 03 (C). Each line operates along the fixed routes as follow:

- Line one started to operate on September 1st, 2014. It departs from Kilometer No 9 on National Road No 05 directly to the Old Stadium Monument. Then it goes down to Monivong Boulevard, Monivong Bridge, and then runs along National Road No 1 until Boeung Chhouk Bus Station.
- Line two started to operate on September 7th, 2014. It departs from the Night Market on the Preachsisovath Boulevard to Chroy Changva Bridge, and then pass by the Old Stadium Monument, street No 70, street No 273, Toul Kork Channel, Kim El Soung Boulevard, Bokor Traffic Light, Monivong Blvd, and straight to National Road No 2 until Takao roundabout.
- Line three started to operate on September 15th, 2014. It departs from the Night Market on the street 106, then goes on Norodom Boulevard, street No 130, Phsar Thmey Market, Kampuchea Krom Boulevard, across the 7 Makara Flyover Bridge, Russian boulevard, Phnom Penh-International Airport, and stops at Choam Choa roundabout.

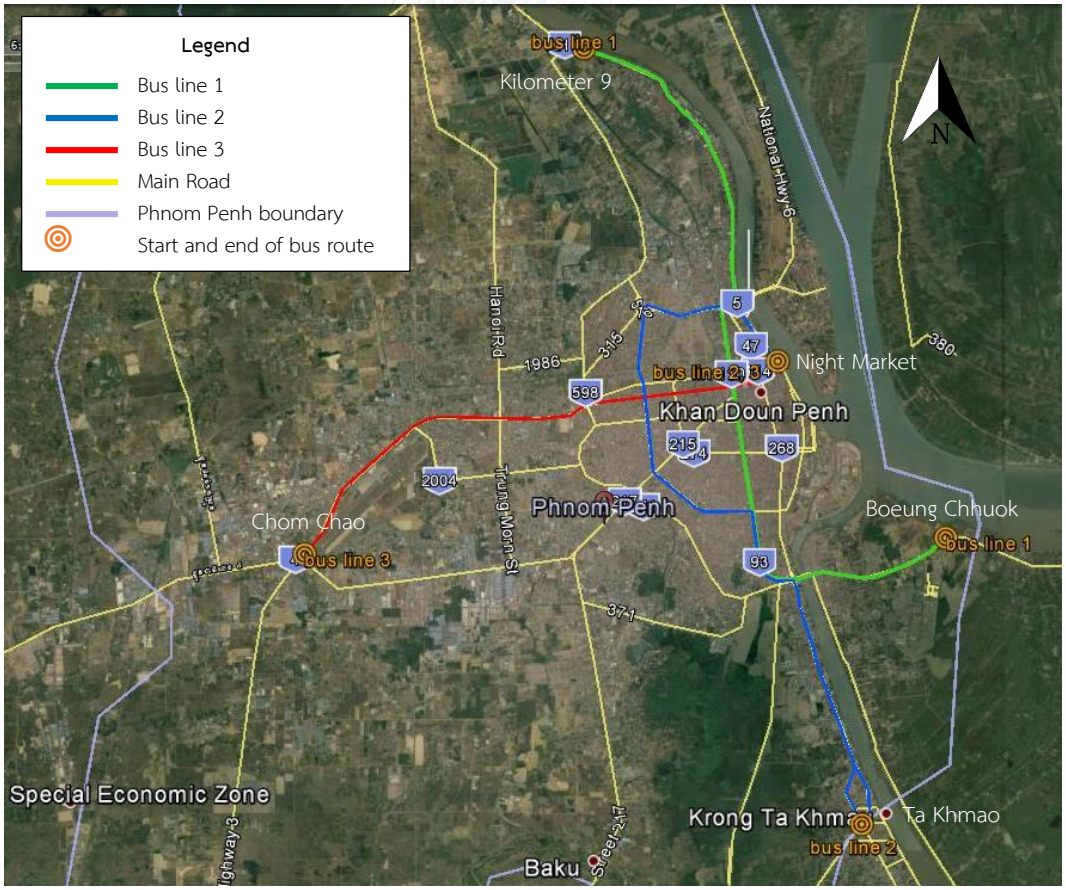


Figure 2-3 Map of bus routes

(a) Public bus

(b) Bus stop

(c) Inside the bus

(d) Bus ticket

Figure 2-4 Phnom Penh Public bus

2.2.2. Paratransit

Getting around urban area of Phnom Penh, Motorcycle Taxi and Motorcycle-rickshaw (known as Motodup and Remork respectively in local language) are the two common paratransit modes that operate extensively across the city. The number of Remork was reported to be 6,000 in 2012, but that of Motodup cannot be identified since everyone can be a Motodup driver (Phun et al., 2015a). Paratransit serves for public. Vehicle can accommodate one passenger for Motodop and at least four passengers for Remork. Paratransit drivers often wait for their passengers at the high-demand places such as market, hospital and airport. Market for this kind of job is quite competitive, that is why we usually see paratransit drivers wave for passengers instead of passengers go for them. Basically, Remork charges more expensive than Motodop due to the capacity it can accommodate. Charging criteria is based upon several aspects including distance,

capacity, part of the day (peak or off-peak hour), but it is completely negotiable. Drivers and passengers often negotiate with the price in advance before departure.

(a) Motodup

(b) Remork

Figure 2-5 Common paratransit modes in Phnom Penh

2.3. Previous Study of Paratransit in Asian Cities

The nature of informal transportation is well recognized due to fleets operated and the service offered (Cervero, 2000). Each mode of paratransit has different service characteristic that a term to define it cannot be drawn. As an example to this, Motodup is operated freely without both fixed schedule and roads, while converted pickup truck or Songtaew in Thailand runs on a particular route but non-fixed schedule. Since the operators own the vehicles, this mobility service is completely in a form of self-employed business where fare is set by the operators.

2.3.1. Bandung, Indonesia

Angkutan Kota is a very common paratransit mode in Bandung, Indonesia. As of 2005, Joewono and Kubota conducted a research in order to investigate the characteristics of paratransit, specifically, Angkutan kota and non-motorized transport (NMT) in Bandung by focusing on operation, finance, commuter perception, and willingness as well as ability of users. After analyzing the data gotten from survey, some conclusions were drawn. The target users of NMT are mainly women, students and low-income people, and at the same time, service providers are virtually amateurs and low-educated people. In addition, both paratransit and NMT are still useful for the community. From demand side, users are positive with the quality of service offered.

Interestingly, they are able to pay for service even more than the price fixed (Joewono & Kubota, 2005).

Later on in 2007, another research of Joewono and Kubota was published. The study tries to measure paratransit user satisfaction. In case it's not good enough, suggestion to enhance the service quality is made. Likewise, paratransit mode considered in the study is Angkutan Kota. The methodology of this research followed factor loading (Multiple-fit indices) and structural equation model. The results addressed that up to 84.6% of paratransit users do not feel satisfied with current service. However, they still need to use it. It can be inferred that people tend to change their public mode once the better public transport is available. According to the hypotheses testing, the price that paratransit charges does matter to users. Therefore, some actions relating to this should be taken in order to balance the quality of service and the fare (Joewono & Kubota, 2007).

In 2013, there was another research done by Weningtyas, Fujiwara and Zhang. They tried to seek whether or not life quality of paratransit drivers was enhanced after improving paratransit service. The study scoped out mainly on Angkutan kota which is a common paratransit mode in Bandung. To analyze the data, researchers used Bi-level optimization model to incorporate the optimized results of paratransit and used simultaneous-equation ordered probit model. The results show that most paratransit operation is a private-own, and although the level of service has been increase, it does not make any positive change in life quality. The reason is that life quality of paratransit drivers rely strongly on their own performance. Users will notice it once they obtain an unsatisfied service. In contrary, there is no reason that paratransit drivers need to offer better service if service improvement does not enhance their quality of life, unless there is a involvement from the government to control the entire operation (Weningtyas et al., 2013).

Figure 2-6 Angkutan Kota (Jabarsatu, accessed 2015)

2.3.2. Bangkok, Thailand

Tangphaisankuna and Nakamura (2009) investigated the impact of commuter toward paratransit functioning as a feeder of mass transit system in Bangkok. Using structural equation model, the results reveal the fact that commuters are optimistic with the role of paratransit as a feeder to mass transit system. However, the quality of informal vehicles is still limited that the enhancement of transport policies or any actions related must be made (Tangphaisankun et al., 2010).

Another case study of paratransit in Bangkok was conducted by Choocharukul and Sriroongvikrai (2011). They looked through the problems that high population had been accompanying Bangkok to experience severe traffic congestion, and that the present of both formal and informal transport is necessary. Nonetheless, the study was interested in informal sector and focused on small-sized converted pickup truck (Silor Lek). Researchers tried to get into detail of current Silor Lek operation in urban area of Bangkok. The results from descriptive statistics indicate that Silor Lek has been seen to operate in main residential areas, but not in CBD. Service is made with unparticular stops. In other word, it picks up and drops off passengers along the operational route routinely although there is loading and unloading depot. Actually, it is possible to use Silor Lek as a feeder to main public transport, yet most passengers prefer it as door-to-door transport instead. Comparing this mode to other informal modes such as

motorcycle taxi, and converted pickup truck (Songtaew), it is neither good nor bad. In terms of fare, Silor Lek is cheaper than motorcycle taxi but more expensive than Songtaew due to capacity share. In terms of time saving, Silor Lek is noticed to be less advantageous than Motorcycle taxi but does better than Songtaew because of vehicle size. For safety, Silor Lek provides safer service than motorcycle taxi but somehow similar to Songtaew. Recently, there are 8 major cooperative in charge of Silor Lek operation in Bangkok under the regulation of Department of Land Transport of Thailand. Nevertheless, illegal operations still arise due to the fact that 88 routes are operated without permission (Choocharukul & Sriroongvikrai, 2011).

(a) Motorcycle taxi (b) Tuk-Tuk

(c) Songtaew

Figure 2-7 Common paratransit modes in Bangkok, Thailand

2.3.3. Dhaka, Bangladesh

It is common to see rickshaw—a commonly non-motorized paratransit mode, operates across the city of Dhaka which is a capital city of Bangladesh. Hossain and Susilo was conducted a research in 2011 with an interest to observe the characteristics of rickshaw and its impacts to the society, while it has been prohibited to operate on the 8 major roads. The study did not intend to involve in any actions that oppose to the policies of rickshaw operational limitation, yet to reveal the importance of this paratransit mode in daily life of various groups of Bangladeshi. Descriptive and multivariate analyses were used to explore the social impacts of rickshaw on different group of society. The results showed that rickshaw played an essential role as a major public transport for the variety of purpose. Firstly, this kind of paratransit mode was seen to be the best option for the traveling during the rainy season which often caused flood. Secondly, rickshaw was the only mean of transport where up to 90% of housewife relied on. The reasons were that it provided low fare, privacy of travelling, convenience (available everywhere) and safety. Safety here not only included the possibility of having accidents, but also encountered personal safety while women might face a difficulty of getting commuted in a crowded public bus (mostly full of men) for restrictions from society and religion. Further analysis showed that even though one day rickshaw was not available, public transport such as bus was still not an option. In other word, passengers would prefer either auto-rickshaw or taxicab (Hossain & Susilo, 2011).

Figure 2-8 Rickshaw in Dhaka, Bangladesh (webpage of Aljazeera, 2015)

2.3.4. Ho Chi Minh, Vietnam

A study conducted in Ho Chi Minh City by Tuan and Mateo-Babiano (2012) investigated the nature of motorcycle taxi service, its influences on socioeconomics and its future function in urban transport system. Data from a survey of 400 users, 100 operators and 20 stakeholders were used to analyze via descriptive statistics. The results show that most of motorcycle taxis are individual-owned, and the drivers come from less educated group. Majority of motorcycle taxi users are workers and students who come from low and middle-income family. They use it mostly for the distance approximately 6km, and 70% of them use it very less frequent (once a month). Moreover, users agree that motorcycle taxis provide a flexible service; however, in terms of safety and reliability, it needs to be improved. It is seen further that motorcycle taxis will role as a feeder of public transport which is not accessible to the local road in urban area (Tuan & Mateo-Babiano, 2013).

2.3.5. Hong Kong, China

Although Hong Kong is considered as a modern city, present of paratransit is still necessary. For the case of Hong Kong, paratransit refers to residents' coach, differently from other Asian cities. Loo (2007) conducted a research on paratransit in this city with respect to three main objectives. First, the study tried to look for factors causing residents' coach service to grow. Second, it aims to investigate the role of resident's coach service as paratransit in public transport system. Last but not least, this research tries to scrutinize whether or not residents' coach is still important while rail lines are increasing. Data gotten from survey was used for statistical testing. Unlike in the US where paratransit is mainly used for elderly and disable people, residents' coach service has increased due to the need of population growth as well as the modernization. Although mass rapid transit will be introduced for the future public transport in the CBD, informal vehicle cannot be completely ignored due to the reason that it roles as a feeder of railway. Besides, transport policies will strictly limit the number of residents' coach to enter the city center, for it is believed to be the cause of traffic congestion (Loo, 2007).

Figure 2-9 Minicoach in Hong Kong (wikipedia, 2015)

2.3.6. Phnom Penh, Cambodia

Phun et al. (2015a) provides insight analysis on paratransit characteristics in Phnom Penh and its fare. It has been known that paratransit is not under control of any official authorities leading to the poor governance with no performance accountability. The results from the study indicate that most of drivers are married, aging between 23 and 64 years old with the average age of roughly 40 years old. Paratransit drivers are found to be low educated (i.e.; lower than university level), and majority of them are not originally Phnom Penh citizen. The average working hour for paratransit drivers are reported to be approximately 12 hours. This corresponds with their monthly income of 251 USD and 176 USD for driver of Remork and Motodup respectively. Majority of drivers claims that they satisfy with their job, and it even provide them with good living condition although they have to confront with road safety and job security during the operation. In terms of fare characteristics, modeling results indicate that fare of paratransit is influenced by trip characteristics of the operation, working condition of drivers and drivers' attributes.

2.4. Reviews on Ordered Probit Model

Ordered probit model was first introduced by Bliss (1934), and it is a well-known statistical method to analyze the ordinal data. The estimation is done by using

maximum likelihood estimation, and the fast method for computing was proposed by Fisher (1935). Under the procedure of ordered probit model, it is necessary to consider three important assumptions (Daykin & Moffatt, 2002). Firstly, ordered probit model does not treat the difference between two categories the same. In other word, the difference between using a mode (Motodup or Remork or public bus) occasionally and 2-3 days/week has different rage from the difference between using a mode 2-3 days/week and 4-5 days/week. Secondly, respondents who provide the same response are not considered to have exactly the same attitude. However, because there is a range between attitudes and it is unobservable, its difference need to be put into account. This helps to reduce the biased estimation, especially in the case that the number of categories are small. Thirdly, the effect as a consequence of wording in the question should be avoided. This is due to the fact that ordered probit model does not model the responses directly like linear regression. Parameters are estimated under the underlying distribution that is why underlying distribution of population is supposed to be invariant to the wording of the question.

2.4.1. Modeling Specification

Ordered probit model is commonly used when dependent variable provides ordering outcomes. However, dependent variable cannot be observed directly linear regression that latent dependent variable needs to take the role. Under the adaptation of this statistical modeling, latent dependent variable y_i^* is written as a linear function of the explanatory variables x_i such that:

$$y_i^* = \beta x_i + \varepsilon_i \qquad \text{Eq. 1}$$

Where,

- y_i^* : Latent dependent variable
- x_i : the vector of independent variables of an individual *i,*
- β : the vector of parameters to be estimated, and
- ε_i : the error term, which is assumed to be normal distributed

The values of y_i fall between categories *j* (*j*=1, 2, … , n), and they are related with the linear function of y_i^* such that $\mu_{j-1} < y_i^* \leq \mu_j$, where μ_j is known as cut-points

or threshold parameters. The relationship between y_i, y_i^* and cut-points is shown in Eq. 2.

$$y_i = \begin{cases} 1 & \text{if} \quad y_i^* \le \mu_1 \\ 2 & \text{if} \quad \mu_1 < y_i^* \le \mu_2 \\ 3 & \text{if} \quad \mu_2 < y_i^* \le \mu_3 \\ \vdots & \\ n & \text{if} \quad y_i^* \ge \mu_{j-1} \end{cases} \qquad \text{Eq. 2}$$

Like models in binary outcomes, the concerns are stressed on how changes in the predictors translated into probabilities of observing a specific ordered outcomes (Jackman, 2000). The probabilities of each outcome category is a standard normal cumulative function determined by cut-point μ_{j-1} and μ_j. The computation can be done according to Eq. 3.

$$P_i(y_i = j) = P(\mu_{j-1} < y_i^* \le \mu_j) = F(\mu_j - \beta x_i) - F(\mu_{j-1} - \beta x_i) \qquad \text{Eq. 3}$$

Where,

- $P_i(y_i = j)$: the probability of outcome category *j*
- $F(.)$: the standard normal cumulative distribution function
- μ_j and μ_{j-1} : the upper and lower cut-points for category *j*

According to a sample $(y_i, x_i, i = 1, ..., n)$, the log-likelihood, which is a sum of each log probability can be written as in Eq. 4.

$$LogL = \sum_{i=1}^{n} \log[P_i(y_i = j)], \qquad j = \{1, 2, \ldots, n\} \qquad \text{Eq. 4}$$

The purpose of log-likelihood is to get the maximum likelihood estimates (MLEs) under iterative procedures. This procedure is done based on the elements of β and the cut-points. The modeling will estimates two set of parameters – coefficients of β and cut-points. Basically, coefficients of β reflects the impact of each explanatory variable on latent dependent variable, while the values of cut-points can be informative in some ways (Daykin & Moffatt, 2002). Cut-points are expected to bunch together in the middle of the distribution once the data set expresses a strong attitude of respondents, for instant they use Motodup/Remork/public bus very frequent or very less frequent. In

contrary, if respondents do not show such a strong attitude, cut-points are expected to spread wider in the distribution. In addition to this, cut-points also provide the strength and weakness of wording the survey form. In the case that respondents find it hard to understand the questions, the middle cut-point will spread apart. The positive result of contraction between middle cut-point before and after the questions are modified will reveal the improvement survey form as well as the improvement of data set.

2.4.2. Marginal Effects

Marginal effect of an independent variable is a partial derivation of dependent variable with respect to that independent variable (see Eq. 6). Marginal effect expresses the change of dependent variable when independent variable changes. It has been known that probit model is assumed to have normal distribution, and thus

$$\Pr(y = j) = \int_{\infty}^{x} \frac{1}{\sqrt{2\pi}} e^{\frac{-x^2}{2}} dx \qquad \text{Eq. 5}$$

The marginal effects of continuous variable x_k is given by:

$$\frac{\partial \Pr(y = j)}{\partial x_k} = F(\beta x)\beta_k, \qquad j = \{1, 2, \ldots, n\} \qquad \text{Eq. 6}$$

Where,

- $F(\beta x)$ is the standard normal density function determined by βx, so

$$F(\beta x) = \frac{1}{\sqrt{2\pi}} e^{\frac{-(\beta x)^2}{2}}$$

2.4.3. Measure of Fit

Likelihood ratio index is used to measure the goodness-of-fit of the model based on the value of log-likelihood. Likelihood ratio index is represented by R^2, and it is defined as:

$$R^2 = 1 - \left(\frac{\log L(\beta_{\text{initial}})}{\log L(\beta_{\text{convergence}})} \right) \qquad \text{Eq. 7}$$

Where,

- $\log L(\beta_{\text{initial}})$ is the log-likelihood at zero iteration where model only has constant term (i.e., vector of coefficients are set to zero)
- $\log L(\beta_{\text{convergence}})$ is the log-likelihood value at convergence

The value of R^2 stays between zero and one. R^2 is equal to zero when all confidents in the model are equal to zero, but R^2 will be close to one when the goodness-of-fit is improved. The value of R^2 can be described as the percentage that model can explain more compared to the null model.

Another way to test whether or not the model is improved can be done by likelihood ratio test. This test describes how the additional variables affect the model under the procedure of hypothesis testing. The hypothesis can be stated such that:

$$H_0: \quad \beta_k = 0$$
$$H_1: \quad \beta_k \neq 0$$

Where, β_k is vector parameter of explanatory variables we added to the model.

Conclusion of the test can be drawn according to the comparison of $\chi^2_{\text{statistic}}$ and χ^2_{critical}. The value of $\chi^2_{\text{statistic}}$ can be computed by the formula shown in Eq. 8. If the value of $\chi^2_{\text{statistic}} > \chi^2_{\text{critical}}$, we are likely to reject the null hypothesis. In this case, β_k is not equal to zero, or in other word the addition of β_k improves the model.

$$\chi^2_{\text{statistic}} = -2\left[\log L\left(\beta_{\text{initial}}\right) - \log L(\beta_{\text{convergence}})\right] \qquad \text{Eq. 8}$$

2.5. Previous Studies on Application of Ordered Probit Model

Abdel-Aty (2001) observed the effect of transit information in determining the likelihood of using transit of commuters in northern California. Using ordered probit model, models were performed based on 1,000 samples obtained from telephone interview in the morning. The dependent variables was classified into ten categories; however the lowest and next lowest categories were combined together, so there were eight thresholds for the model. Explanatory variables were extracted from two sets of variables, including commuters' socioeconomics and the significant types of transit information. The results indicated that service frequency, number of transfers, seat availability, accessibility to the station and fare information were significant in determining the acceptance of transit in commuting trip. On the other hand, commute

time, income, education and dummy variable of carpooling also contributed in likelihood in using transit.

Quddus et al. (2002) used ordered probit model to investigate the factors influencing motorcycle injury severity and motorcycle damage severity. Data was obtained from 27,570 database of motorcycle accidents, which were reported by Singaporean police within nine years period (1992 – 2000). Two dependent variables were of interest for this study. First dependent variable is the severity of injury associated with motorcycle accidents. The outcome of this dependent variables were classified into three categorical levels: (1) fatal, (2) seriously injured and (3) slightly injured. The second dependent variable is the severity of motorcycle damage in accidents. It was categorized into four levels: (1) total wreck, (2) extensive damage, (c) slight damage and (4) no damage. Many sets of explanatory variables were considered i.e., time of the day, seasonal effects, type of locations, road engineering, type of traffic, type of road, speed limit, nature of lane, road surface, collision type and socioeconomic variables. The results showed the factors that increase the probabilities of severe injuries and severe motorcycle damage i.e., foreigner drivers, increased engine capacity and so forth. It was also found that the level of severity of both dependent variables increased over time. The detail of this was discussed in (Quddus et al., 2002).

Jang et al. (2010) applied the procedure of ordered probit model in order to determine the factors affecting the level of injury in pedestrian crashes in the city of San Francisco. The study obtained data from Statewide Integrated Traffic Records System (SWITRS) for six-year period (2002 – 2007) of pedestrian-involved crashed recording. The level of severity were classified into five categories,

where (1) Property Damage Only (PDO),
(2) Slightly injury (complaint of pain or injury 1),
(3) Visible injury (other visible or injury 2),
(4) Severe injury (extended hospitalization or injury 3), and
(5) Fatal

Models were performed under the effects of four sets of explanatory variables, including pedestrian characteristics, driver characteristics, environmental characteristics and crash characteristics. The results indicated that explanatory variables that were extracted from these four set of variables were significant in the model (i.e., alcohol involvement, cellphone use and so forth). Modeling results were useful in understanding the risk factors that had impacts on level of severity of pedestrian crashes. This would lead to the effective policy implementation that benefited transportation planning in various way.

PHUN et al. (2015b) used ordered probit model to assess the performance of newly introduced public bus service in Phnom Penh. 1,100 samples were obtained from on-board survey with public bus passengers. The assessment was done based on five categories of dependent variables, where (1) very bad performance, (2) bad performance, (3) moderate performance, (4) good performance and (5) very good performance. The study considered five sets of explanatory variables, including personal characteristics, previous travel modes, access and egress distance, subjective evaluation scores on bus attributes and lastly free opinion. The results showed that the performance of public bus was likely to be improved by focusing on bus attributes itself (i.e., speed, comfort, safety, fare) and by considering the concerns addressed by passenge

Chapter 3

METHODOLOGY

3.1. General

In order to achieve the objective, the study follows the research framework as shown in Figure 3-1. The study initiates with literature reviews of paratransit in Asian countries as well as the public bus in Phnom Penh. Questionnaire was designed to consist of 3 main parts – socioeconomics, trip characteristics and attitudinal statements. Data collection was conducted in Phnom Penh. Descriptive statistics from the survey were performed to observe the characteristics of paratransit and public bus passengers. Moreover, statistical modeling was run under the effects of socioeconomics, trip characteristics, passengers' perception toward operational characteristics and passengers' criteria when choosing public transportation. Lastly, there were discussion and conclusion on data analysis and modeling.

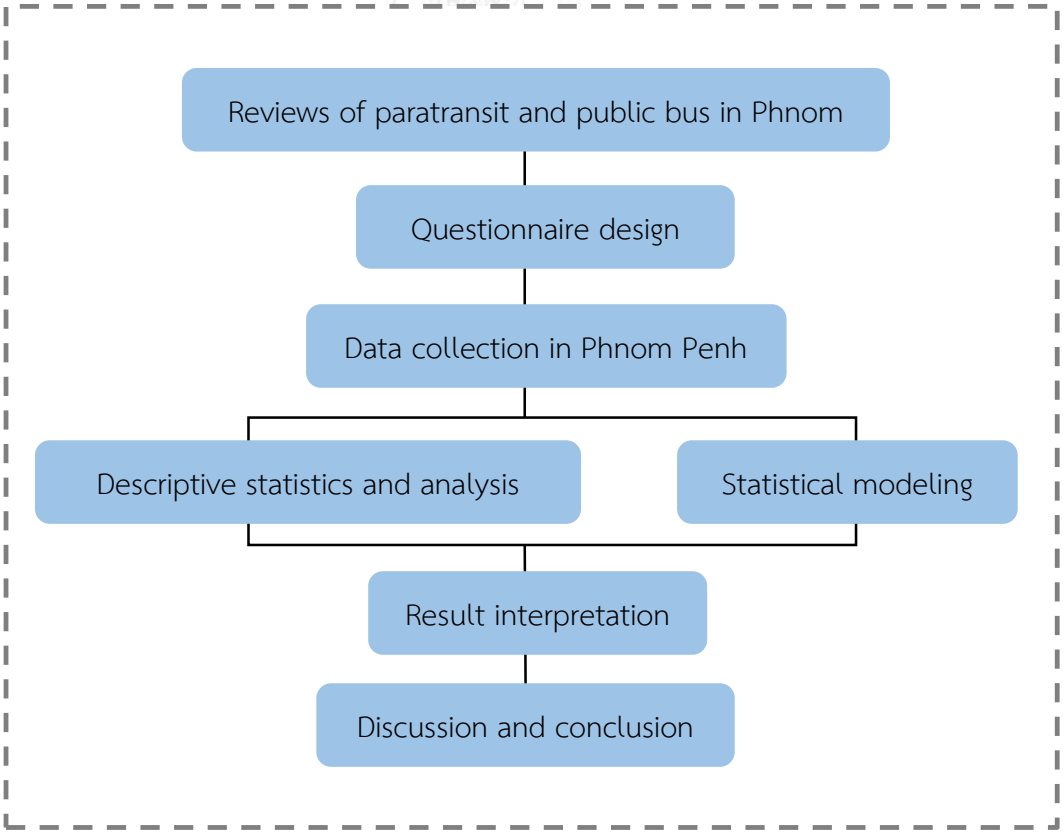


Figure 3-1 Research framework

3.2. Study Locations

Study locations are divided into 4 main areas which are Central Business District (CBD), academic area, residential area and suburb area (see Figure 3-2).

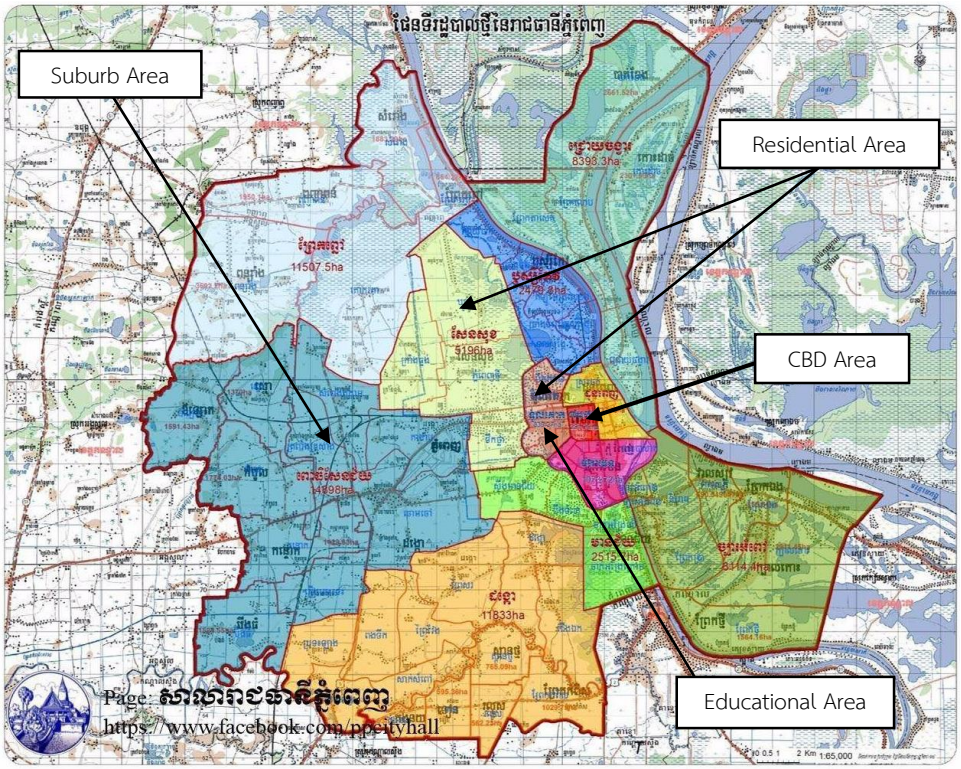


Figure 3-2 Survey locations

3.2.1. Central Business District (CBD)

The area surrounding Central Market is considered as CBD. This zone is composed of a big local market, a famous shopping center, an inter-public bus stop and also many commercial buildings. Paratransit can be found easily nearby Central Market and shopping center. Near the Central Market, it is Monivong Boulevard which is one of major streets in the city and is also a section of the public bus's route (line 01(A)). Although there are some residential buildings in this zone, those buildings function as business houses. The urbanization of this zone follows the master plan drawn in French colonization period, and its land use as a CBD exist since then.

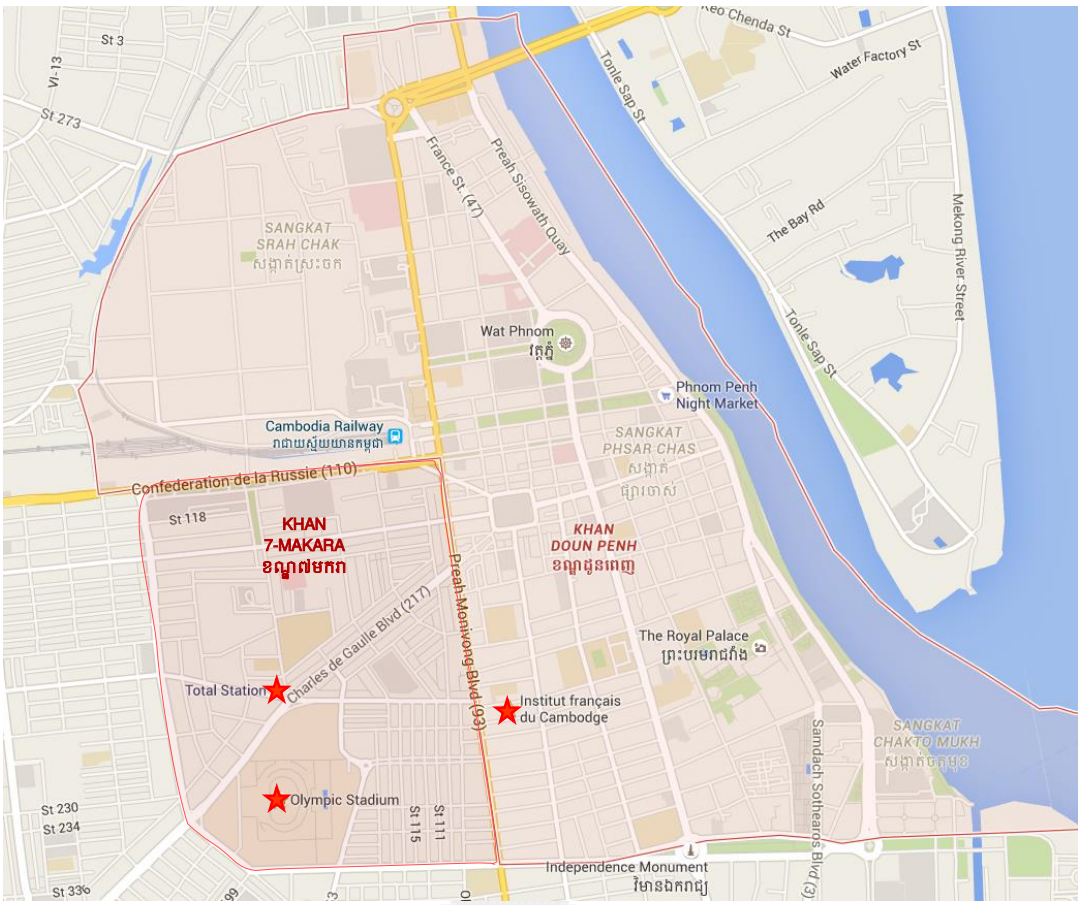


Figure 3-3 Survey locations in CBD area

3.2.2. Educational Area

In this zone, there is one public high school and several higher educational institutions, one of which is the largest and the oldest public university in Cambodia known as Royal University of Phnom Penh. Those educational institutions together form an enormous number of students – no less than 20,000. It is likely that student respondents and public-sector staff can be found within this zone. Compared to CBD, the operation of paratransit here is less due to the fact that most students and staff own their personal vehicle. Nonetheless, paratransit still exists for students whose parents are not able to accompany them to/from school, particularly the high school ones, and for those who need paratransit service occasionally. Russian Federation Boulevard, which lies across this zone, is the route of public bus line 03(C). The availability of public bus provides another travel option for those who live along the boulevard.

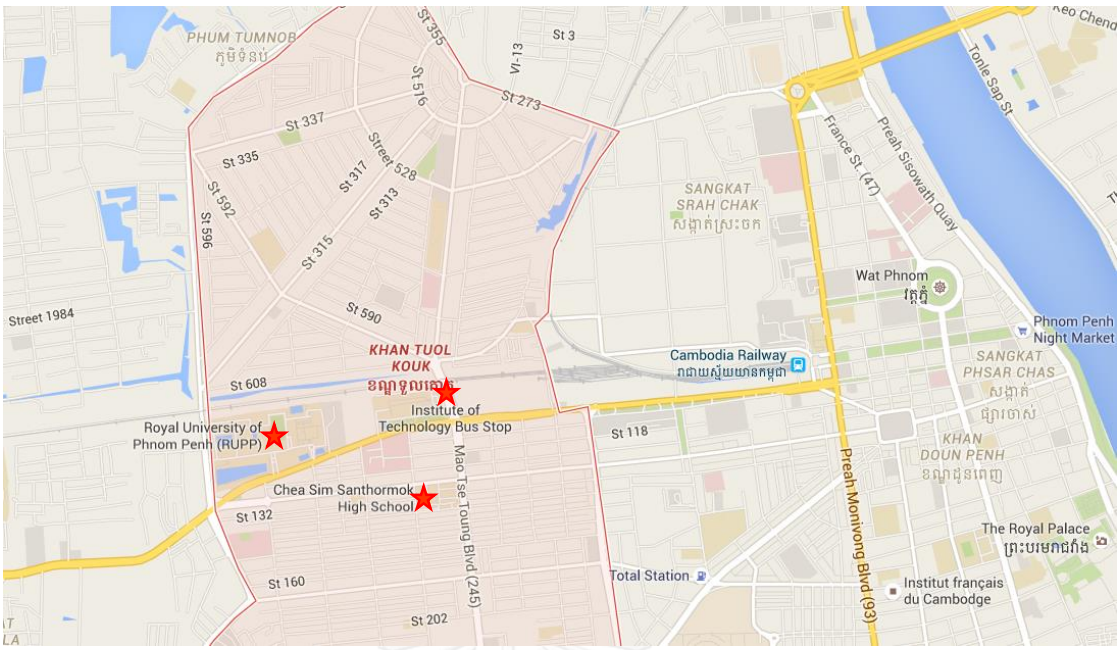


Figure 3-4 Survey locations in educational area

3.2.3. Residential area

Residential area for this study is located on the North side of Phnom Penh. This area is composed of many houses, especially housing in the form of flat. Those houses gather together as a big residential zone, and there are few zones there. Each zone belongs to different real estate companies that construct the houses for sale. Within the area, there are also local markets where paratransit can be found.

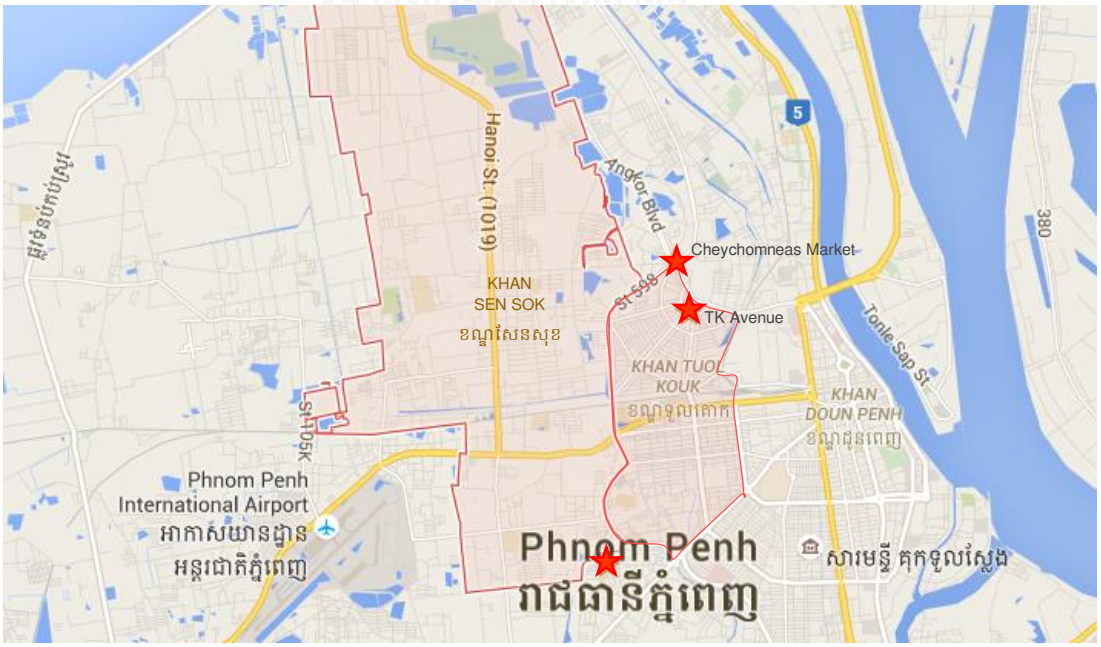


Figure 3-5 Survey locations in residential area

3.2.4. Suburb Area

West side of Phnom Penh is selected as a suburb area for data collection. It is where the national road number 3 and 4 meet each other and connect with Russian Federation Boulevard, which is a main road to downtown. This condition makes the traffic situation in this area busy. Paratransit operation can be seen obviously because local market, both public and private primary schools, textile industries are available. Also, it is where the last station for bus line 03(C) is set up.

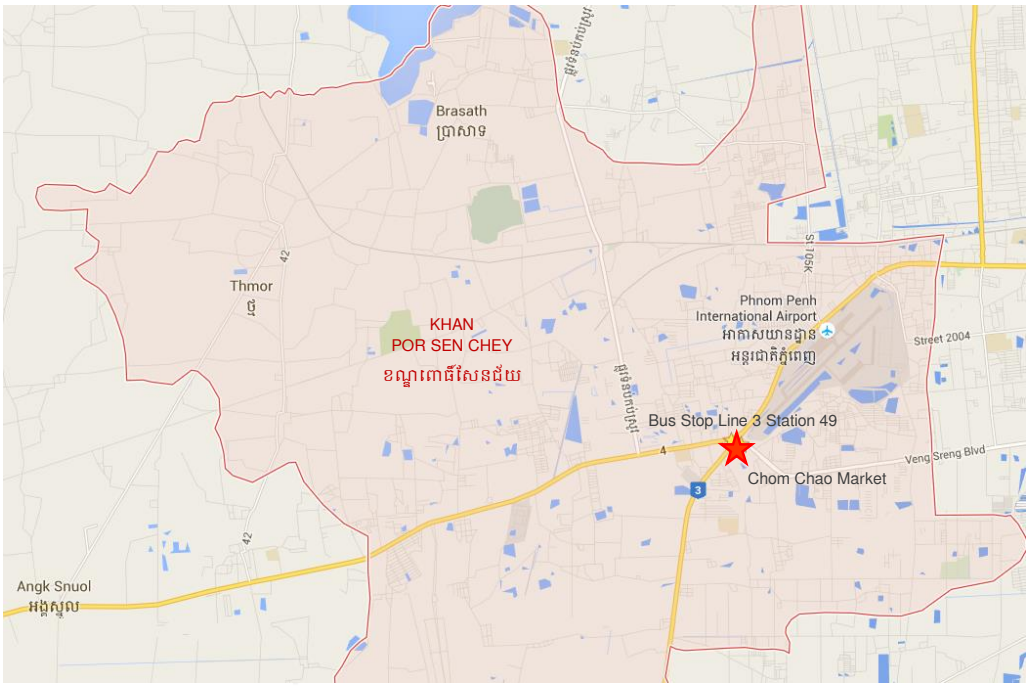


Figure 3-6 Survey locations in suburb area

3.3. Questionnaire Design

Questionnaire was first written in English and translated into Khmer language. Doubled translation technique was applied in order to keep the consistency between these two languages. Survey questionnaire is classified into 3 main parts.

- Part 1 aims to seek for passengers' trip characteristics. In this part, questionnaire is separated by mode choices, including Motodup, Remork and public bus. Trip frequency, trip purpose and other information related to passengers' trip with these three modes are included.

- Part 2 provides respondents with a list of attitudinal statements so that they can rate those statements by using 5-point Likert scale (1: Strongly disagree, 2: Disagree,

3: Neutral, 4: Agree, 5: Strongly agree). This part would like to investigate passengers' perception toward operational characteristics of Motodup, Remork and public bus. Also, some statements are purposefully included to scrutinize passengers' intention when some possible conditions arise to the operation of the three studied modes.

- Part 3 asks respondents about their socioeconomics information. This includes their personal and household information that would affect the usage of public transportation.

3.4. Sample Size

Sample size can be calculated through varieties of methods. It is possible to determine the sample size from sample mean, from sample proportion or based on Yamane (1967). Several official survey-websites such as Survey Monkey, Survey System, Roasoft, and National Statistical Service (NSS) provide online tool to compute the sample size as a function of three main parameters, which are population size, confidential level and confidential interval or margin of error.

With 95% of confidential level, 50% of response rate, 4% of marginal error allowed (4% or 5% is commonly used and is recommended by some survey websites) and the population size of 2 million, 600 sample size is suggested. The computation of this sample size is based on normal distribution (50%) so that the optimum result can be reached.

3.5. Randomness of Data Collection

The goal of this survey is to get the respondents randomly, and thus different day and different part of daytime will influence the randomness of respondents. Data collection is planned to conduct on both weekday and weekend. The reason is that trip purpose of going to school or workplace may catch up only on weekday, while social trip would arise virtually on weekend. Moreover, the respondents whose occupation is student or employee tend to be found in the early morning or in the evening when they leave school or workplace.

3.6. Data Collection

Data collection was conducted in Phnom Penh from December 7, 2015 to December 10, 2015 with the aid of 6 survey assistants. All of them were trained in advance to make sure that they understood each individual question well, and they could deal with respondents who did not understand the questions. Plus, some survey techniques were informed so that they could work in the survey field effectively. Survey forms were distributed equally to four survey areas – 150 samples for each area. As the plan, 150 samples were expected to complete in one day, but it was found that data was difficult to collect in residential area that it took two days to complete. To get thing done according to the plan, we divided our team members to survey in different places within the area. Table 3-1 provides the detail of process of data collection.

Table 3-1 Summary of data collection process

Date	Survey locations		Start	End	Sample
Dec. 07, 2015	Educational area	Santhormok High School	8:30	12:00	150
		Institute of Technology of Cambodia (ITC)			
		Royal University of Phnom Penh (RUPP)	14:00	17:30	
Dec. 08, 2015	Residential area	Cheychomneas Market	13:30	17:30	80
		TK Avenue			
Dec. 09, 2015	Residential area	Solar Market	8:00	12:00	70
Dec. 10, 2015 (Public Holiday)	Suburb area	Bus stop line 3 (chom chao roundabout)	7:30	12:00	150
		Chom Chao Market			
		Tela gas station			
	CBD area	Olympic stadium	13:30	18:30	150
		Nearby French Institute			
		Nearby Neang Konghing roundabout			
			Total		600

Figure 3-7 Face-to-face survey

3.7. Data Analysis

The procedure of data analysis is initiated after data has been already input and cleaned. The analysis is done with the aid of statistical software SPSS and STATA. At the early stage, descriptive statistics is performed. This is to observe the behavior and characteristics of passengers who use Motodup/Remork/public bus. Also, descriptive results reflect the potential variables that would be used in the modeling.

Statistical modeling is conducted according to the studied modes by following the procedure of ordered probit model. Potential variables are tested in the models whether or not they are significant. Some statistical methods such as correlation, generation of dummy variables and interactive terms are included in order to profoundly investigate the relationship of independent variables. Modeling will seek for the best models that best describe the factors influencing passengers' frequency in using paratransit and public bus.

Chapter 4

DESCRIPTIVE RESULTS

4.1. General

This chapter presents the descriptive statistics of the data set obtained from data collection, which was conducted in December 2015 in Phnom Penh. A total of 600 survey form was distributed, among which 483 could be used for analysis. 108 respondents reported that they have never used public transport, while other 9 provided insufficient information. Some challenges were confronted. Some respondents found it difficult to understand the questions, whereas some misunderstood them. We also met respondents who were not able to read, and all the above problems were copped under the assistance of survey team. The descriptive results cover the main aspects of passengers' characteristics, including their experiences in using public transportation, their socioeconomics, trip characteristics and their perception toward operation of paratransit and public bus.

4.2. Passengers' mode share

Passengers have different experiences toward the usage of Motodup, Remork and public bus. Not everyone has experienced using all of these three modes, and that is why the percentage varies across the modes. The overlap of the usage of Motodup, Remork and public bus is shown in Figure 4-1. It can be seen that the percentage of passengers who have ever used Motodup is up to 80.1%, which is a big proportion compared to other two modes. It could be true for the reason that Motodup is a very conventional public mode available and popular after civil war ended in 1979. In other words, it appears before the existence of Remork and public bus, and remains attractive up to the present day. From the diagram, 58.1% and 49.6% of all valid data are the percentage of passengers who have experienced using Remork and public bus respectively, while about one forth (27.2%) of respondents have ever used all of these three modes.

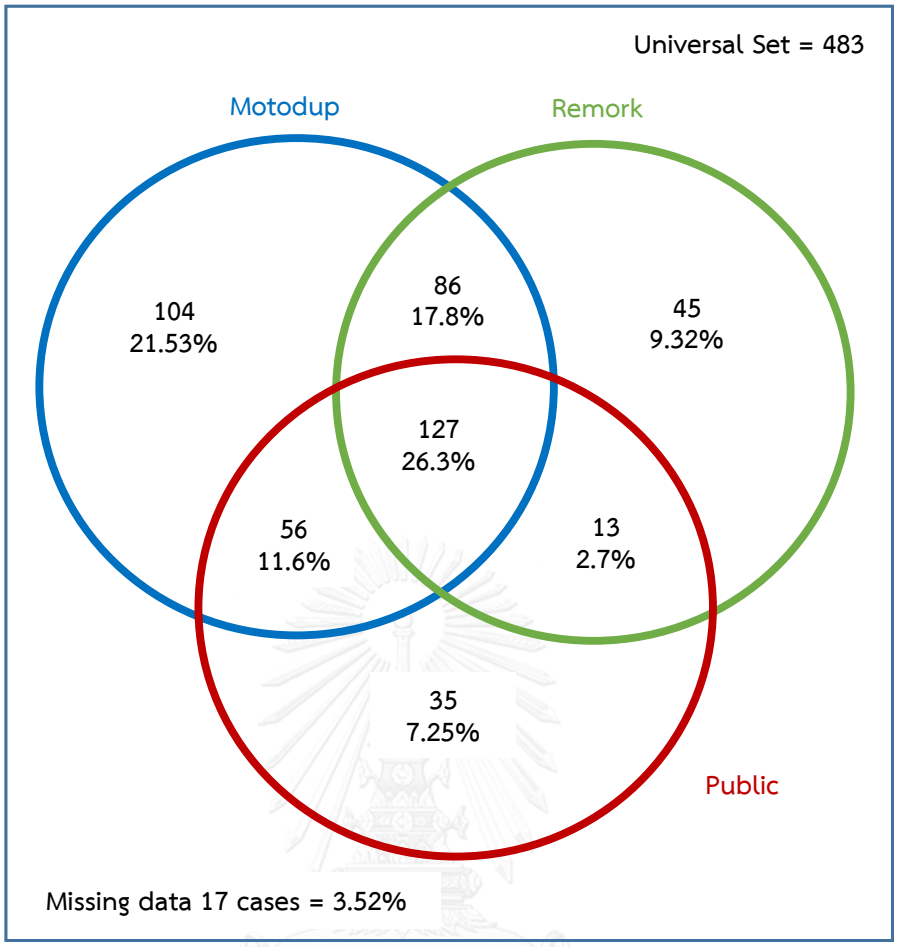


Figure 4-1 Venn Diagram of Passengers Usage of Paratransit and Public bus

4.3. Socioeconomic Characteristics

The share of gender among four survey areas does not have a great difference. As an entire data set, male accounts for 49.4%, while female does 50.6%. The majority of respondents are young adult who ages between 19 and 25 years old (61.8%). From Table 4-1, respondents are mainly students, corresponding with 62% of total sample. Students and age group of respondent strongly associate with each other. This results also show the consistency with population pyramid published by CIA (2015) (see Figure 4-2). 80% of respondents fall in low income group, which earns less than 200 USD per month per person. In terms of educational level, bachelor degree share the biggest proportion for the whole data set, but this attribute varies across survey areas. The detail of respondents' socioeconomics is summarized in Table 4-1.

Table 4-1 Descriptive summary of respondents' socioeconomics

Attributes	Level	Survey locations				Total
		CBD	educational	residential	suburb	
Gender	Male	45.5	59.1	44.4	47.0	49.4
	Female	54.5	40.9	55.6	53.0	50.6
Age Group	≤ 18 years old	10.7	12.8	17.4	14.7	13.8
	19 – 25 years old	76.3	81.9	43.5	32.7	61.8
	26 – 35 years old	11.5	5.3	20.0	27.3	14.4
	36 – 50 years old	1.5	0.0	14.8	13.7	6.6
	≥ 51 years old	0.0	0.0	4.3	11.6	3.4
Occupation	Student	74.0	92.1	47.6	26.0	62.0
	Employee	19.9	5.6	29.0	33.0	21.2
	Employer	1.5	0.8	2.4	2.0	1.7
	Vendor	3.8	0.8	7.3	19.0	7.1
	Others	0.8	0.8	13.7	20.0	8.0
Monthly Income (USD)	Low	82.7	94.8	68.2	73.0	80.0
	Medium	11.0	3.5	21.2	24.0	14.4
	High	6.3	1.7	10.6	3.1	5.6
Education	Primary	0.8	0.0	7.4	16.1	5.2
	Secondary	2.3	10.2	8.2	14.9	8.4
	High school	8.6	29.1	20.5	39.1	23.1
	Assoc. bachelor	3.9	1.6	4.1	1.1	2.8
	Bachelor	82.0	58.3	54.1	21.8	56.9
	Graduate school	2.3	0.8	5.7	6.9	3.7

Note: levels of income per month per person are classified: low ≤ 200 USD, Medium 201-500 USD, High ≥ 501 USD

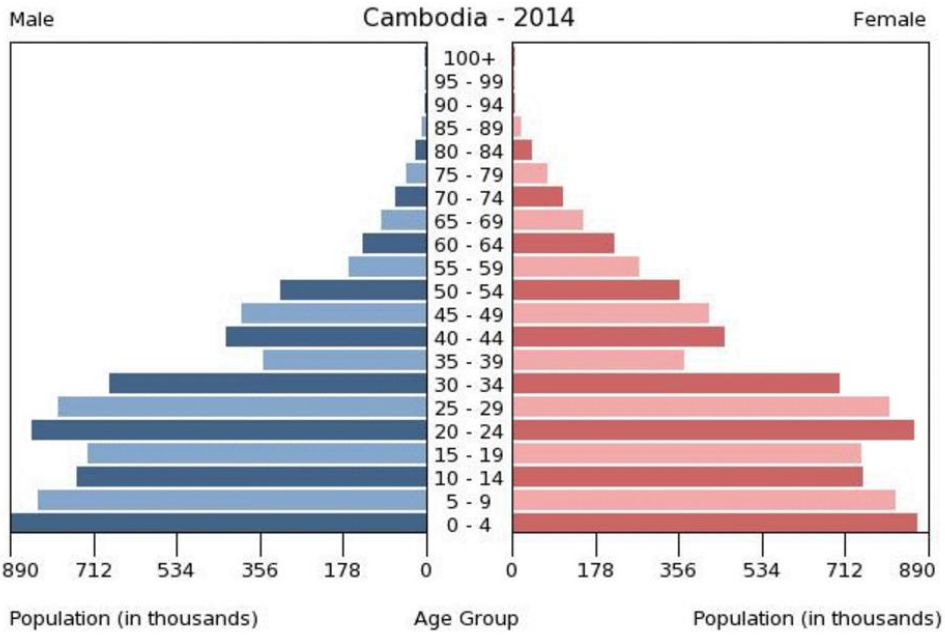
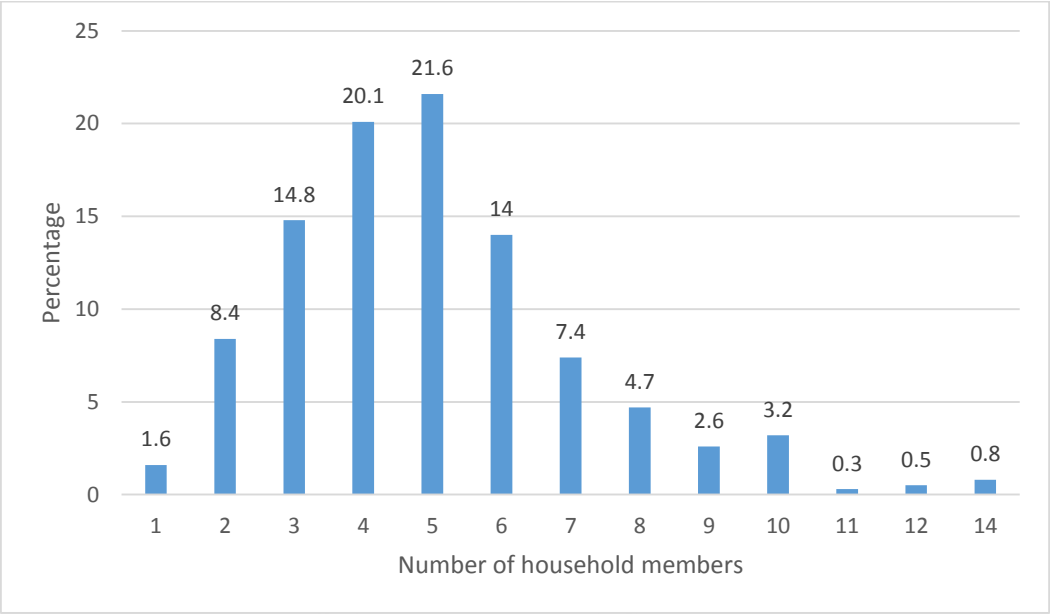


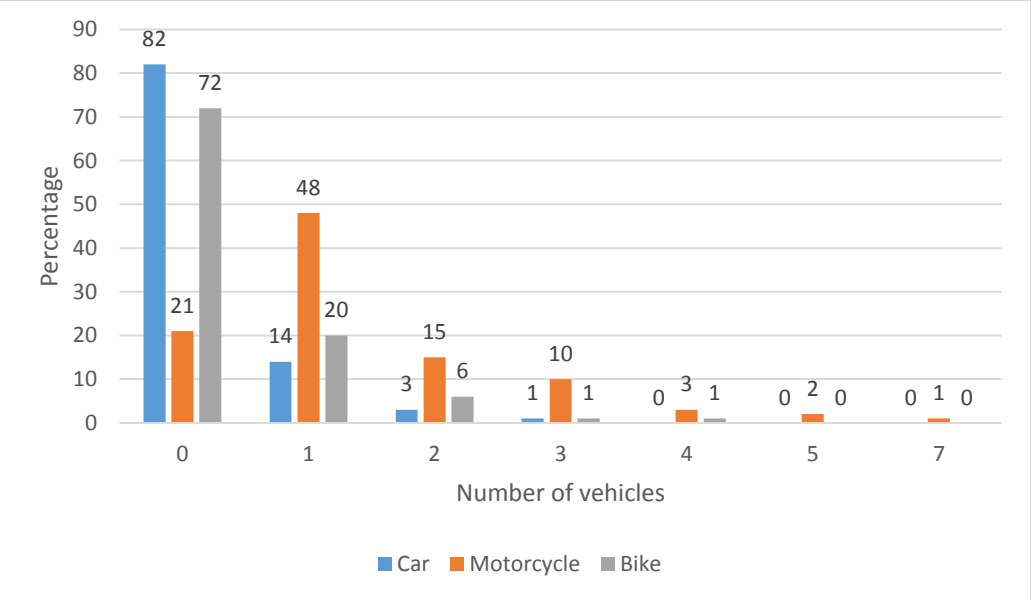
Figure 4-2 Cambodian population pyramid (CIA, 2015)

Figure 4-3 shows the household information of respondents. It can be seen from Figure 4-3 (a) that the highest percentage of household size is 21.6%, corresponding with 5

members per household. In terms of vehicle ownership, the results show that up to 82% of households do not own any car, while 14% own one. On the other hand, 48%, 15% and 10% of household own one, two and three motorcycles respectively. Majority of household (72%) reported that they do not have bicycle. However, 20% of them said they have one. The distribution of vehicle ownership is presented in Figure 4-3 (b).



(a) Distribution of household members



(b) Distribution of vehicle ownership per household

Figure 4-3 Respondents' household information

4.4. Passengers' Trip Characteristic

4.4.1. Trip Frequency

The distribution of passengers' trip frequency in using Motodup, Remork and public bus is summarized in Table 4-2. It can be seen that majority of passengers use Motodup, Remork and public bus occasionally. Since public bus is the most recent mode compared to Motodup and Remork, up to 50% of respondents reported that they have never used it. According to the descriptive statistics of trip frequency, it can be implied that public transportation, either the paratransit or public bus is not used for daily trip. The reason is that price charge of using paratransit is not low enough that commuters can afford in their daily basis. On the other hand, although public bus's fare is affordable, the operation is only available on the major roads, and travel time (waiting time and in-vehicle time) is unreliable that most commuters tend to consider private vehicle instead.

Table 4-2 Passengers' Trip Frequency (in percent)

Mode	Level	Survey locations				Total
		CBD	educational	residential	suburb	
Motodup	Daily	1.5	3.1	3.3	9.0	3.73
	4-5 days/week	1.5	3.9	8.9	6.0	2.28
	2-3 days/week	1.5	0.8	3.3	4.0	4.97
	Occasionally	86.4	78.7	54.5	54.0	69.57
	Never	9.1	13.4	30.1	27.0	19.46
Remork	Daily	0.8	0.8	1.6	3.0	1.47
	4-5 days/week	0.8	0.0	4.1	4.0	0.63
	2-3 days/week	0.8	2.4	0.8	1.0	2.53
	Occasionally	62.2	69.4	48.0	28.0	54.11
	Never	35.4	27.4	45.5	64.0	41.26
Public bus	Daily	0.8	4.2	1.6	12.0	4.45
	4-5 days/week	0.8	5.8	0.0	2.0	1.06
	2-3 days/week	0.8	1.7	1.6	2.0	2.75
	Occasionally	54.7	58.3	20.3	29.0	41.74
	Never	43.0	30.0	76.4	55.0	50.00

4.4.2. Trip Purpose

Table 4-3 presents the summary of Motodup, Remork and public bus passengers' trip purpose. Studying and shopping are the most noticeable trip purpose for Motodup, while passengers tend to use Remork for shopping and social trip. Social trip here encounters all activities that involve with people or social act as a relaxation or

entertainment. This includes hanging out, visiting relatives, traveling as a group to nearby resorts and so forth. For public bus, the distribution of trip purpose seems to spread across variety of purposes, except for business purpose where the percentage is only 1.73%.

Table 4-3 Passengers' Trip Purpose (in percent)

Mode	Level	Survey locations				Total
		CBD	educational	residential	suburb	
Motodup	Study	19.0	26.4	16.3	13.9	20.31
	Work	7.8	9.1	14.0	20.8	11.72
	Business	2.6	0.9	3.5	5.6	3.39
	Shopping	30.2	22.7	29.1	29.2	27.08
	Social	1.7	4.5	7.0	15.3	7.12
	Other	38.7	36.4	30.1	15.2	30.38
Remork	Study	6.3	10.2	13.4	2.9	8.79
	Work	8.9	8.0	7.5	11.4	8.42
	Business	1.3	3.4	7.5	14.3	5.13
	Shopping	46.8	38.6	29.9	21.4	38.46
	Social	10.1	11.4	14.9	22.9	14.82
	Other	26.6	28.4	26.8	17.1	24.38
Public bus	Study	29.6	35.4	31.0	31.8	32.47
	Work	16.9	9.8	0.0	15.9	12.12
	Business	2.8	1.2	3.5	2.3	1.73
	Shopping	8.5	9.8	20.7	11.4	10.82
	Social	18.3	9.8	20.7	11.4	15.05
	Other	23.9	34.0	24.1	27.2	27.81

4.4.3. Trip Expenses

Charging criteria of paratransit is completely negotiable, or in other word there is no baseline for fare setting at all. According to passengers' experience, the mean price of using Motodup per trip is 5800 KHR (1.42 USD) with standard deviation 3400 KHR (0.83 USD). Since Remork can accommodate more capacity, the price per trip is higher than Motodup, which is 10700 KHR (2.61 USD) with standard deviation 5400 KHR (1.32 USD). However, public bus is operated with fixed price (1500 KHR or roughly 0.37 USD) for all destinations, but some groups of passengers (e.g. students) are free of charge for the service.

From Table 4-4, it can be seen that the mean distances of using Motodup, Remork and public bus per trip are very close to each other, which is approximately 5 kilometers for one trip. In terms of travel time per trip, Motodup seems to be the mode that has

lowest travel time compared to Remork and public bus. This is because Motodup has a small vehicle size that it can access more flexibly in narrow road or in congestion. In contrary, the average travel time of public bus is reported to be 44.31 minutes, which seems to be high compared to its average distance (6.38 km). Public bus can operate with average speed of only 10km/h (Phun et al., 2015a) in the mixed traffic situation where all kinds of modes come together without following the specific lanes. This makes public bus disadvantageous in moving, especially during peak hour.

Table 4-4 Summary statistics of passengers' trip characteristics

Variables	Modes	N	Mean	S.D.	Min	Max
Cost (KHR)	Motodup	363	5800	3400	1500	20000
	Remork	249	10700	5400	3000	30000
	Public bus	157	1100	600	0	1500
Distance (km)	Motodup	296	4.74	3.68	1	25
	Remork	193	5.82	4.64	1	20
	Public bus	109	6.38	3.89	0.2	15
Time (min)	Motodup	356	19.08	11.25	3	70
	Remork	242	24.54	13.52	5	80
	Public bus	138	44.31	37.44	5	150

Note: 1USD = 4100 KHR (as of June 13, 2016)

4.5. Passengers' Perception toward Operational Characteristics

Ten statements associated with operational characteristics of Motodup/Remork/public bus were provided for respondents to rate based on five-point Likert scale. For every mode, the statements cover seven important aspects as shown in Table 4-8. For the first five statements, which are related to travel time, availability and waiting time, Motodup passengers seems to have a positive perception; however, it is not the case for public bus. On the other hand, public bus passengers perceive a good perception for the last five statements, which are associated with comfort, vehicle condition, safety and fare while Motodup passengers seems to be neutral with these statements. For Remork, passengers have neutral idea whether operational characteristic is either good or bad since the mean of all statements for this mode is somehow very close to 3. The distribution and summary statistics of passengers' perception toward operational characteristics of Motodup, Remork and public bus is shown from Figure 4-4 to Figure 4-6 and from Table 4-5 to Table 4-7.

Table 4-5 Summary statistics of passengers' perception toward Motodup operation

items	Strongly disagree → Strongly agree					Mean	S.D.
	1	2	3	4	5		
M_Q1	8.2	8.9	24.5	21.3	37.1	3.70	1.28
M_Q2	7.4	7.1	16.2	20.7	48.7	3.99	1.25
M_Q3	6.1	4.2	13.2	23.0	53.4	4.14	1.18
M_Q4	4.5	4.5	16.1	18.8	56.1	4.19	1.12
M_Q5	7.8	7.2	17.1	21.7	46.3	3.92	1.27
M_Q6	21.6	23.2	31.6	14.3	9.2	2.63	1.21
M_Q7	14.0	26.4	38.3	9.4	11.9	2.74	1.15
M_Q8	12.2	27.6	38.6	12.9	8.6	2.76	1.10
M_Q9	20.3	30.1	24.0	14.7	10.9	2.65	1.27
M_10	16.7	22.6	27.7	19.3	13.7	2.89	1.29

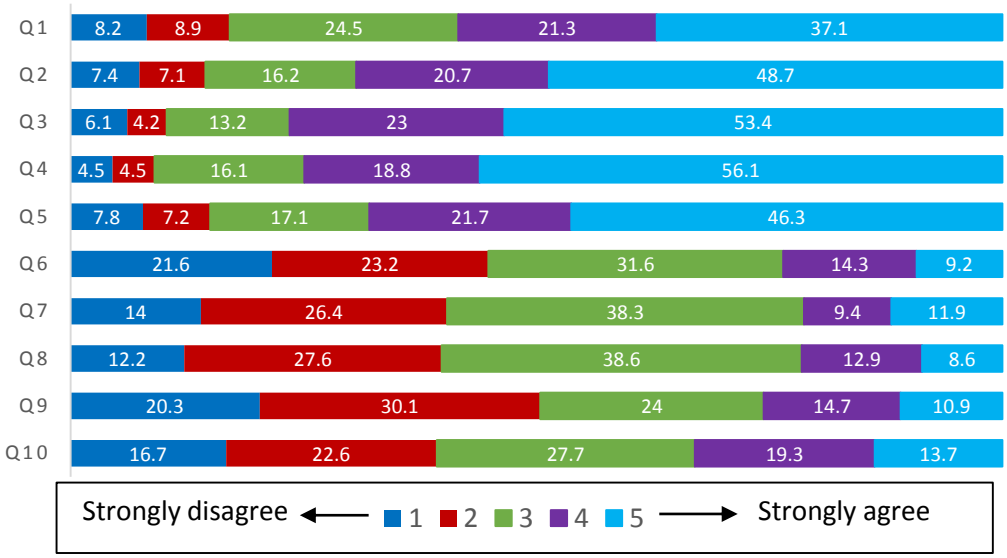


Figure 4-4 Distribution of passengers' perception toward Motodup operation

Table 4-6 Summary statistics of passengers' perception toward Remork operation

items	Strongly disagree → Strongly agree					Mean	S.D.
	1	2	3	4	5		
R_Q1	8.7	16.7	39.4	24.6	10.6	3.09	1.09
R_Q2	5.3	14.0	28.4	25.0	27.3	3.56	1.18
R_Q3	3.8	12.3	29.1	25.3	29.5	3.64	1.14
R_Q4	5.3	11.0	29.2	24.2	30.3	3.63	1.18
R_Q5	5.7	10.6	27.0	28.1	28.5	3.62	1.17
R_Q6	8.0	16.0	34.7	24.0	17.2	3.26	1.15
R_Q7	6.5	16.8	40.8	22.9	13.0	3.20	1.07
R_Q8	6.5	22.8	36.5	24.3	9.9	3.08	1.06
R_Q9	7.2	17.4	35.2	26.1	14.0	3.21	1.11
R_10	17.7	26.3	33.1	15.0	7.9	2.71	1.16

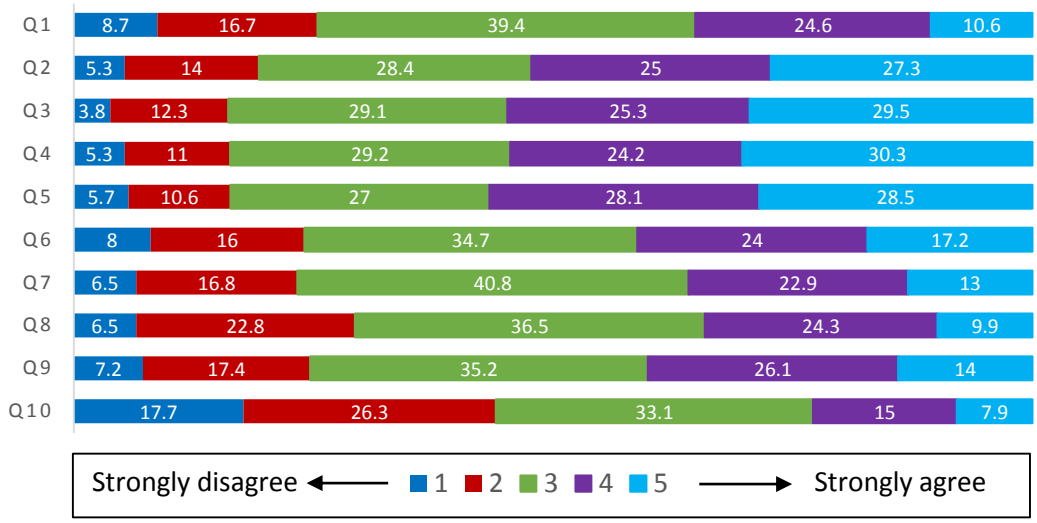


Figure 4-5 Distribution of passengers' perception toward Remork operation

Table 4-7 Summary statistics of passengers' perception toward public bus operation

items	Strongly disagree → Strongly agree					Mean	S.D.
	1	2	3	4	5		
B Q1	28.4	23.6	23.1	13.8	11.1	2.58	1.34
B Q2	22.9	25.6	23.8	12.6	15.2	2.73	1.36
B Q3	28.2	19.1	22.7	13.2	16.8	2.70	1.44
B Q4	31.1	22.1	24.3	9.0	13.5	2.51	1.37
B Q5	27.7	25.9	15.2	14.7	16.5	2.65	1.44
B Q6	5.7	10.1	12.3	28.1	43.9	3.93	1.24
B Q7	4.4	7.9	21.1	30.4	36.1	3.85	1.14
B Q8	3.5	7.1	30.5	30.5	28.3	3.74	1.05
B Q9	6.6	11.0	11.5	22.5	48.5	3.94	1.28
B 10	11.1	6.2	15.0	15.0	52.7	3.93	1.38

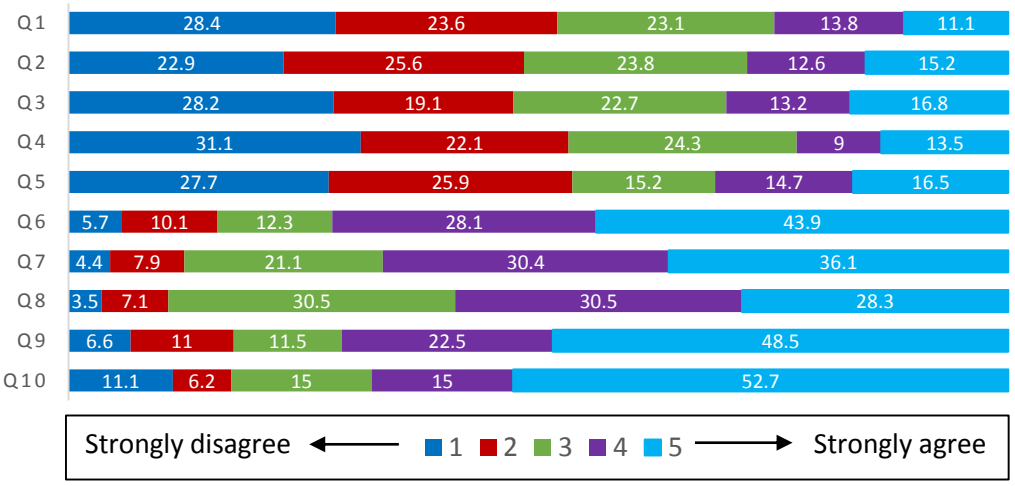


Figure 4-6 Distribution of passengers' perception toward public bus operation

Each attitudinal statement is asked for three different modes. In this case, Chi-square test is used observe the homogeneity of each mode's distribution. The hypothesis can be stated as:

H_0: With the same attitudinal statement, the distribution of each mode is the same

H_1: At least one mode has different distribution from others

The Chi-square value of all statements is quite high compared to the critical value of $\chi 2$ distribution. Within this case, it is very likely to reject the null hypothesis, and we can conclude that at 95% of confidential level there is sufficient evidence to prove that the distribution of Motodup/Remork/public bus is not the same for at least one mode in every statement. The summary of statistical testing result is shown in Table 4-8.

Table 4-8 Attitudinal statement associated with operational characteristics

Constructs	Items	Statements	χ^2	p-value
Travel time	Q1	Can move fast	149.49	.000
Availability	Q2	Operation is available across the city	144.82	.000
	Q3	Can be found any time you need	191.09	.000
	Q4	Can be found nearby	229.27	.000
Waiting time	Q5	Short waiting time	163.20	.000
Comfort	Q6	Seat is comfortable	174.12	.000
Vehicle condition	Q7	Vehicle is clean	151.74	.000
	Q8	Interior material is well maintained	114.14	.000
Safety	Q9	High overall safety from road accident	200.18	.000
Fare	Q10	Low fare	184.38	.000

Chapter 5

MODELING RESULTS

5.1. General

In order to observe the factors influencing the frequency of using public transportation, modeling analysis is needed. By developing the models, we can identify the potential variables which have an impact on frequency of using paratransit and public bus. Models are performed independently in respect to the modes considered in the study. The modeling of each mode takes into account four sets of independents, including socioeconomics, trip characteristics, attitudinal statement and criteria of choosing public transportation.

5.2. Application of Ordered Probit Model in the Study

The frequency of using Motodup, Remork and public bus (as dependent variable) is provided based on passengers' experiences. It is obvious to spot dependent variable in this study as ordinal categories where 1: occasionally, 2: two-three days/week, 3: four-five days/week and 4: everyday. For this reason, ordered probit model is the most appropriate method for in-depth analysis. It has been known that multinomial logit failed to put the ordering of dependent variables into account, while regression model treats the difference between categories the same (Abdel-Aty, 2001). This would not be the case for dependent variable that has ordering outcomes, and that these two modeling methods are seen to be less appropriate for this study than ordered probit model. Since there are three modes considered in this study – Motodup, Remork and public bus, modeling of each mode is done independently.

Dependent variable of each mode provides four values of outcomes, and thus the expression can be written as:

$$y_i = \begin{cases} 1 \text{ if } & -\infty < y_i^* \le \mu_1 & \text{(Use a mode occasionally)} \\ 2 \text{ if } & \mu_1 < y_i^* \le \mu_2 & \text{(Use a mode 2 - 3 days / week)} \\ 3 \text{ if } & \mu_2 < y_i^* \le \mu_3 & \text{(Use a mode 4 - 5 days / week)} \\ 4 \text{ if } & \mu_3 < y_i^* < +\infty & \text{(Use a mode everyday)} \end{cases} \qquad \text{Eq. 9}$$

Where,

- $y_i^* = \beta x_i + \varepsilon_i$: the frequency of using a mode by an individual *i,* coded as 1, 2, 3, 4
- μ_1, μ_2, μ_3 : cut-points or threshold parameters

The probabilities translated from the change of explanatory variables can be computed by standard normal cumulative function. Considering each ordinal outcome, the probabilities can be written as:

$$
\begin{aligned}
P[y_i = 1] &= P[-\infty < y_i^* \le \mu_1] \\
&= P[y_i^* \le \mu_1] \qquad \text{but } y_i^* = \beta x_i + \varepsilon_i \\
&= P[\beta x_i + \varepsilon_i \le \mu_1] \\
&= P[\varepsilon_i \le \mu_1 - \beta x_i] \\
&= F(\mu_1 - \beta x_i)
\end{aligned}
$$

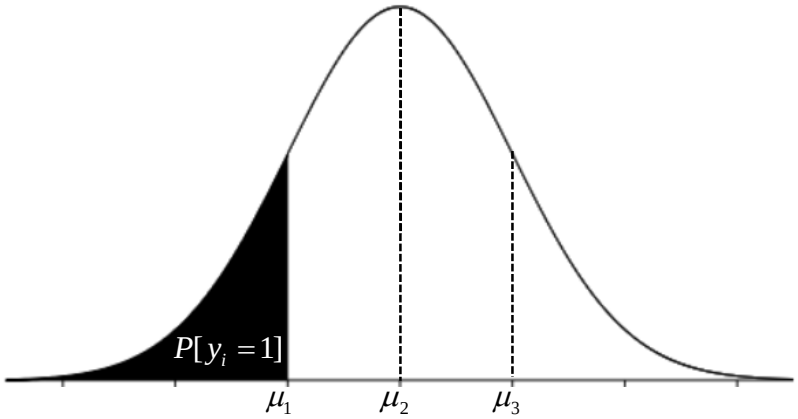


Figure 5-1 Probability of ordinal outcome 1

$$
\begin{aligned}
P[y_i = 2] &= P[\mu_1 < y_i^* \le \mu_2] \\
&= P[\mu_1 < \beta x_i + \varepsilon_i \le \mu_2] \\
&= P[\mu_1 - \beta x_i < \varepsilon_i \le \mu_2 - \beta x_i] \\
&= F(\mu_2 - \beta x_i) - F(\mu_1 - \beta x_i)
\end{aligned}
$$

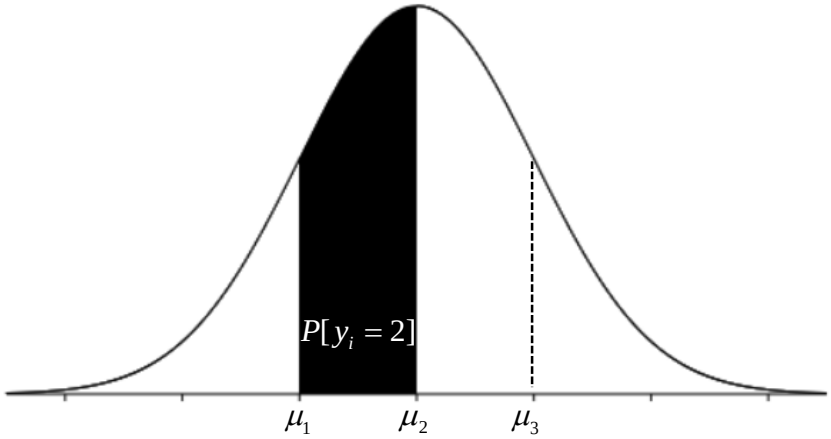


Figure 5-2 Probability of ordinal outcome 2

It is straightforward for ordinal outcome 3 and 4 that

$$P[y_i = 3] = F(\mu_3 - \beta x_i) - F(\mu_2 - \beta x_i)$$

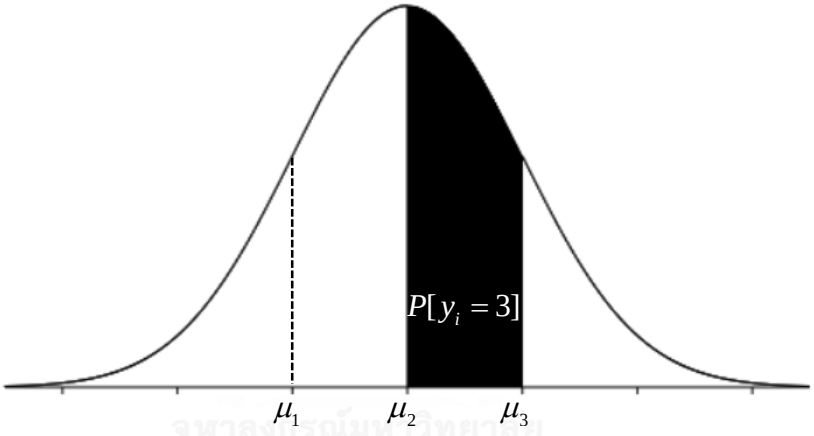


Figure 5-3 Probability of ordinal outcome 3

$$P[y_i = 4] = F(\mu_4 - \beta x_i) - F(\mu_3 - \beta x_i) = 1 - F(\mu_3 - \beta x_i)$$

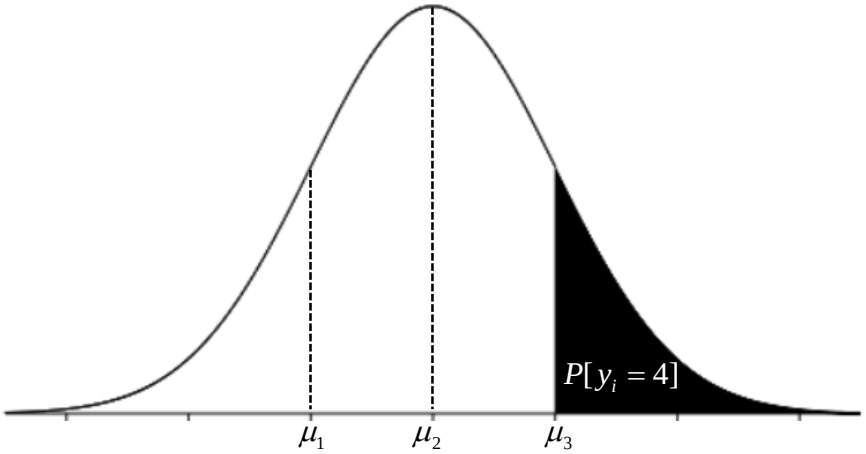


Figure 5-4 Probability of ordinal outcome 4

5.3. Descriptive of Independent Variables

Model is performed under the effect of four set of explanatory variables, including passengers' socioeconomics, passengers' trip characteristics, passengers' perception toward operational characteristics and passengers' criterion when choosing public transportation. Dummy variables are generated for categorical variable scale which order cannot be told. This is to indicate the absence or presence of a quality or an attribute such as gender, occupations, interval of income, trip purpose and so on. This kind of variable is coded as 1 if it is true for the quality/attribute, and zero if it is not. Interactive terms among dummy variables and other explanatory variables are added up into modeling process and are also checked for their significance. Table 5-1 to Table 5-4 summarized four sets of explanatory variables possibly have an impact on the model.

Table 5-1 Summary of socioeconomics variables

Variables	Description
Age	Passengers' age
Household	Number of household
Car	Number of car per household
Motorcycle	Number of motorcycle per household
Bicycle	Number of bicycle per household
Female	1: if passenger is female, 0: otherwise
Student	1: if passenger is student, 0: otherwise
Employee	1: if passenger is employee, 0: otherwise
Vendor	1: if passenger is vendor, 0: otherwise
High school	1: if passenger is in high school, 0: otherwise
Pre-university	1: if educational level is before university, 0: otherwise
Undergraduate	1: if educational level is at undergraduate, 0: otherwise
Graduate	1: if educational level is at graduate, 0: otherwise
Low income	1: if low income, 0: otherwise
Medium income	1: if medium income, 0: otherwise
High income	1: if high income, 0: otherwise
Business area	1: if live in business area, 0: otherwise
Educational area	1: if live in educational area, 0: otherwise
Residential area	1: if live in residential area, 0: otherwise
Suburb area	1: if live in suburb area, 0: otherwise
Interactive terms	
stu_female	1: if female student, 0: otherwise
stu_linc	1: if low income student, 0: otherwise
stu_edu	1: if student and live in educational area, 0: otherwise

Table 5-2 Summary of trip characteristics variables

Variables	Description
Weekday	1: if use public mode on weekday, 0: otherwise
Weekend	1: if use public mode on weekend, 0: otherwise
Morning	1: if use public mode in the morning, 0: otherwise
Afternoon	1: if use public mode in the afternoon, 0: otherwise
Evening	1: if use public mode in the evening, 0: otherwise
For study	1: if use public mode to study, 0: otherwise
For work	1: if use public mode to work, 0: otherwise
For business	1: if use public mode to do business, 0: otherwise
For shopping	1: if use public mode to shopping, 0: otherwise
Cost	Average travel cost per trip (KHR)
Distance	Average travel distance per trip (Km)
Time	Average travel time per trip (min)
Interactive terms	
Stu_study	1: if student use public mode to study, 0: otherwise
Stu_wday	1: if student use public mode in weekday, 0: otherwise

Table 5-3 Summary of passengers' perception toward operational characteristics

Items	Statements	Rating Scales
Q1	Can move fast	1: strongly disagree 2: disagree 3: neutral 4: agree 5: strongly agree
Q2	Operation is available across the city	
Q3	Can be found any time you need	
Q4	Can be found nearby	
Q5	Short waiting time	
Q6	Seat is comfortable	
Q7	Vehicle is clean	
Q8	Interior material is well maintained	
Q9	High overall safety from road accident	
Q10	Low fare	

Table 5-4 Summary of passengers' criteria when choosing public transportation

Factors	Rating Scales
Convenience	1: Thirdly important 2: Secondary important 3: The most important
Travel time	
Safety	
Comfort	
Fare	
Availability	

5.4. Modeling Results for Motodup

Dependent variable of the model is frequency of using Motodup. Modeling takes into consideration only respondents who have experienced using this mode. The frequency of Motodup is categorized into four groups – occasionally, 2-3 days/week, 4-5 days/week and everyday. The distribution of dependent variable is shown in Table 5-5.

Table 5-5 Frequency distribution of using Motodup

Frequency level	Code for alternatives	Frequency	Percentage	Cumulative percentage
Occasionally	1	336	86.38	86.38
2-3 days/week	2	24	6.17	92.54
4-5 days/week	3	11	2.83	95.37
Everyday	4	18	4.63	100.00

Model of frequency using Motodup is developed under four phases. At the initial phase, model M1 considers only passengers' socioeconomics, then passengers' trip characteristics are added in the model M2. In phase 3, model M3 is improved with addition of attitudinal statement associated with passengers' perception on Motodup's operational characteristics. Lastly, we extend model M3 by adding passengers' criteria in choosing public transportation. Models development and their summary statistics are presented in Table 5-6.

It can be seen from Table 5-6 that in model M1 variable of medium income is significant 0.1 level. However, the addition of trip characteristics makes this variable significant at 0.05 level. Although travel cost helps to improve the level of significance of dummy variable medium income, it is not significant for itself. Nonetheless, the addition of another variable set (attitudinal statements) in model M3 turns travel cost to be significant at 0.1 level. From the first until the last phase of model, it can be noticed that there is an increase in Pseudo R^2. This simply means that final model can explain more about the effects on frequency of using Motodup compared to the initial model.

The final model for Motodup is obtained with Pseudo R^2 = 0.11, which represents the goodness-of-fit. The likelihood ratio Chi-square with degree of freedom 7 is reported to be 34.22. With this value, the overall model is significant at 95% confidential level, and null hypothesis is very likely to be rejected. This means the coefficients of all variables are not the same.

Student and employee as explanatory dummy variables are statistically significant at 95% confidential level. The coefficients of these variables carry the negative sign, which can be implied that student and employee are not the group of passengers who use Motodup frequent. However, the result shows that medium income earners have positive impact on the model. This simply means that if it is true that passengers are the earners in this category, they will use Motodup more frequent.

In terms of passengers' trip characteristic, travel cost is seen to be the factor that decrease the frequency of using Motodup. On the other hand, rated statement "Q6: seat is comfortable" is found significant in the main model. It can be said that the more passengers agree with this statement, the more frequent they would use Motodup.

The last set of independent variables indicates the important attributes that passengers consider when choosing public transportation. The model shows the two significant variables, which are convenience and comfort. Both variables carry positive coefficient and are statistically significant at 90% confidential level. It can be implied from their coefficient that the more passengers consider these two attributes important, the more they frequent they use Motodup. In other word, if passengers value convenience and comfort, Motodup would be their choice. The detail of modeling result is shown in Table 5-6.

Table 5-6 Modeling result for Motodup

Variables	Model				Model's statistics		
	Coef.	Std. Err.	t-stat.	p-value			
Model M1: Socioeconomics							
student	-0.9077**	0.2003	-4.53	0.000	N	=	389
employee	-0.7586**	0.2396	-3.17	0.002	LR χ^2 (3)	=	28.76
Medium income	0.4105*	0.2296	1.79	0.074	p > χ^2	=	0.000
-Cut 1	0.4911**	0.1705	2.88		Pseudo R^2	=	0.0683
-Cut 2	0.8688**	0.1755	4.95		Log Likelihood	=	-196.22
-Cut 3	1.1281**	0.1828	6.17				
Model M2: Socioeconomics + Trip Characteristics							
student	-0.8458**	0.2141	-3.95	0.000	N	=	363
employee	-0.7078**	0.2544	-2.78	0.005	LR χ^2 (4)	=	25.90
Medium income	0.5631**	0.2446	2.30	0.021	p > χ^2	=	0.000
Cost (x100 KHR)	-0.0027	0.0025	-1.06	0.289	Pseudo R^2	=	0.0683
-Cut 1	0.4255*	0.2434	1.74		Log Likelihood	=	-176.57
-Cut 2	0.8127**	0.2479	3.27				
-Cut 3	1.1200**	0.2547	4.39				
Model M3: Socioeconomics + Trip Characteristics + Attitudinal Statements							
student	-0.8410**	0.2452	-3.43	0.001	N	=	291
employee	-0.7490**	0.2968	-2.52	0.012	LR χ^2 (5)	=	27.59
Medium income	0.6131**	0.2784	2.20	0.028	p > χ^2	=	0.000
Cost (x100 KHR)	-0.0049*	0.0029	-1.68	0.093	Pseudo R^2	=	0.0913
Q6	0.1614**	0.0794	2.03	0.042	Log Likelihood	=	-137.34
-Cut 1	0.7573**	0.3435	2.20				
-Cut 2	1.0376**	0.3473	2.98				
-Cut 3	1.3462**	0.3538	3.80				
Model M4: Socioeconomics + Trip Characteristics + Attitudinal Statements + Criteria of choosing Public transportation							
student	-1.0582**	0.2630	-4.02	0.000	N	=	274
employee	-0.7402**	0.3070	-2.41	0.016	LR χ^2 (7)	=	34.22
Medium income	0.4672	0.2871	1.63	0.104	p > χ^2	=	0.000
Cost (x100 KHR)	-0.0055*	0.0030	-1.79	0.074	Pseudo R^2	=	0.1150
Q6	0.1556*	0.0828	1.88	0.060	Log Likelihood	=	-131.63
Pt_convenience	0.1994*	0.0751	2.01	0.045			
Pt_comfort	0.1537*	0.0993	1.71	0.087			
-Cut 1	0.9164**	0.3883	2.36				
-Cut 2	1.2114**	0.3922	3.08				
-Cut 3	1.5365**	0.3992	3.84				

Note: **p < 0.1, **p < 0.05*

During the modeling process, many variables were applied and tested, however, only seven of explanatory variables are statistically significant. These variables are extracted from four set of variables whose statistical summary are presented in Table 5-7.

Table 5-7 Summary statistics of variables for Motodup

Variables	Description	N	Mean	S.D.	Min	Max
Dependent variable						
Frequency[(1)]	Frequency of using Motodup	389	1.25	0.72	1	4
Socioeconomics						
student	1: if passenger is student, 0: otherwise	389	0.64	0.47	0	1
employee	1: if passenger is employee, 0: otherwise	389	0.20	0.40	0	1
Medium income	1: if medium income, 0: otherwise	389	0.12	0.32	0	1
Trip Characteristics						
Cost	Average travel cost by Motodup per trip per person (KHR)	363	5800	3400	1500	20000
Passengers' perception toward Motodup operational characteristics						
Q6[(2)]	Five-rated-scale statement for "seat is comfortable"	312	2.63	1.21	1	5
Passengers' criterial when choosing public transportation						
Pt_Convenience[(3)]	If consider convenience important when choosing public transport	364	1.36	1.23	0	3
Pt_Comfort	If consider comfort important when choosing public transport	364	0.67	1.05	0	3

Note: [(1)] Frequency level: (1) occasionally, (2) 2-3 days/week, (3) 4-5 days/week, (4) everyday
[(2)] Five-rated-scale statement: (1) strongly disagree, (2) disagree, (3) neutral, (4) agree, (5) strongly agree
[(3)] Criterial of choosing public transportation: (0) not important, (1) thirdly important, (2) secondary important, (3) the most important

5.4.1. Marginal Effects for Motodup

Marginal effects of each frequency category can be computed as partial derivation between probability of each category in respect to each individual explanatory variable. For instance,

Marginal effect of dummy variable "*student*" in category $1 = \frac{\partial \Pr(y=1)}{\partial(student)} = F(\beta x)\beta_{student}$

Where,

- $\Pr[y=1] = F(\mu_1 - \beta x)$: Probability that passengers use Motodup occasionally
- *student:* Dummy explanatory variable (i.e. 1: if passenger is student, 0: otherwise)

- $F(\beta x) = \frac{1}{\sqrt{2\pi}} e^{\frac{-(\beta x)^2}{2}}$
- $\beta_{student}$: coefficient of dummy explanatory variable "*student*"

Marginal effects reflects the probabilities that passengers are more or less likely to use Motodup in each frequency categories. For example, the fact that passengers are students associate with 24.3% more likely to use Motodup occasionally, while 6.7%, 6.3% and 11.2% less likely to use Motodup 2-3 days/week, 4-5 days/week and everyday respectively. The sum of marginal effects of each category must be equal to zero (e.g. Student: 0.2433 – 0.0672 – 0.0636 – 0.1125 = 0). The summary of marginal effects related with the frequency of using Motodup is presented in Table 5-8.

Absolute values of all variables decrease from the least frequent category to the most frequent category, meaning that frequency of using Motodup appears to be in the "occasionally" category. This could be the case since most travelers have already owned their personal vehicle (mainly motorcycle). More importantly, travel cost by using Motodup is somehow expensive compared to private vehicle that is why it is not a choice for daily trip.

Table 5-8 Marginal effects on frequency of using Motodup

Variables	Frequency of using Motodup			
	Occasionally	2-3 days/week	4-5 days/week	Everyday
student	0.2433**	-0.0672**	-0.0636**	-0.1125**
employee	0.0988**	-0.0367**	-0.0283**	-0.0338**
Medium income	-0.1043	0.0312	0.0283	0.0448
Cost (x100 KHR)	0.00099*	-0.00033	-0.00028	-0.00038*
Q6	-0.0281*	0.0095*	0.0079*	0.0107*
Pt_convenience	-0.0361**	0.0122*	0.0102*	0.0137*
Pt_comfort	-0.0278*	0.0094	0.0078	0.0106

Note: **p < 0.1, **p < 0.05*

5.4.2. Predicted Probabilities for Motodup

Table 5-9 shows the comparison of between predicted probabilities and actual distribution of frequency of using Motodup. From the result table, it can be seen that the difference between the two distributions in respect to the frequency categories

are quite small. This reflects the good performance of the model in predicting the frequency of using Motodup based on passengers' experiences.

Table 5-9 Comparison of predicted probabilities and actual data for Motodup

Frequency of using Motodup	Mean of predicted probabilities	Actual distribution from data set
Occasionally	86.57	86.38
2-3 days/week	4.68	6.17
4-5 days/week	3.58	2.83
Everyday	5.15	4.63

5.5. Estimated Results for Remork

Dependent variable of modeling is frequency of using Remork. Modeling seeks for factors influencing the frequency of using Remork, and it considers only passengers who have experienced using this mode. Frequency of using Remork is classified into four categories coded from 1 to 4 regarding to the least frequent to the most frequent. The distribution of passengers' frequency in using Remork is summarized in Table 5-10.

Table 5-10 Frequency distribution of using Remork

Frequency level	Code for alternatives	Frequency	Percentage	Cumulative percentage
Occasionally	1	257	92.11	92.11
2-3 days/week	2	12	4.30	96.42
4-5 days/week	3	3	1.08	97.49
Everyday	4	7	2.51	100.00

Model of frequency using Remork is initially run with only the effects of passengers' socioeconomics. In the following phases, trip characteristics, attitudinal statements and criterial in choosing public transportation are added up subsequently. In model R1, female and student as dummy variables are not significant. However, these two variables appear to be significant at 0.1 level after a set of trip characteristics' variables is added. It is the same case for attitudinal variable Q2, which is significant at 0.1 level in model R4, while in model R3 it is not. By checking Pseudo R^2, it can be seen that models improve under the four-phase development (R^2 = 0.0911 in model R1 and R^2 = 0.4224 in model R4).

All of socioeconomics variables are statistically significant at 95% confidential level. Student as dummy variables has a positive effect in the final model, while female and educational level carry negative ones. The sign of coefficient can be interpreted that the fact passengers are student will increase the likelihood of using Remork frequently.

Table 5-11 Modeling result for Remork

Variables	Model				Model's statistics		
	Coef.	Std. Err.	t-stat.	p-value			
Model R1: Socioeconomics							
Female	-0.3668	0.2496	-1.47	0.142	N	=	267
Student	0.5502	0.3399	1.62	0.106	LR χ^2 (3)	=	16.50
Edu. level	-0.2844**	0.0871	-3.26	0.001	p > χ^2	=	0.000
-Cut 1	0.6519	0.4328	1.50		Pseudo R^2	=	0.0911
-Cut 2	1.0836**	0.4410	2.45		Log Likelihood	=	-82.30
-Cut 3	1.2771**	0.4481	2.85				
Model R2: Socioeconomics + Trip Characteristics							
Female	-0.5251*	0.2855	-1.84	0.066	N	=	267
Student	0.8431**	0.4283	1.97	0.049	LR χ^2 (7)	=	50.54
Edu. level	-0.2846**	0.1001	-2.84	0.004	p > χ^2	=	0.000
Weekday	0.7823**	0.2872	2.72	0.006	Pseudo R^2	=	0.2791
Morning	0.9393**	0.3237	2.90	0.004	Log Likelihood	=	-65.28
Evening	0.6083*	0.3130	1.94	0.052			
For business	1.1143**	0.4330	2.57	0.010			
-Cut 1	1.9525**	0.5930	3.29				
-Cut 2	2.5493**	0.6180	4.12				
-Cut 3	2.8459**	0.6383	4.45				
Model R3: Socioeconomics + Trip Characteristics + Attitudinal Statements							
Female	-0.6587*	0.3448	-1.91	0.056	N	=	245
Student	1.2197**	0.5437	2.24	0.025	LR χ^2 (9)	=	61.47
Edu. level	-0.2540**	0.1113	-2.28	0.023	p > χ^2	=	0.000
Weekday	1.1024**	0.3523	3.13	0.002	Pseudo R^2	=	0.3786
Morning	0.9365**	0.3723	2.51	0.012	Log Likelihood	=	-50.44
Evening	0.8365**	0.3674	2.28	0.023			
For business	1.5939**	0.5216	3.06	0.002			
Q2	0.2175	0.1502	1.45	0.148			
Q3	0.4130**	0.2026	2.04	0.042			
-Cut 1	5.2306**	1.3645	3.83				
-Cut 2	5.9379**	1.3903	4.27				
-Cut 3	6.1645**	1.3965	4.41				

Model R4: Socioeconomics + Trip Characteristics + Attitudinal Statements + Criteria of choosing Public transportation							
Female	-1.0555**	0.4099	-2.57	0.010	N	=	232
Student	1.2773**	0.5815	2.20	0.028	LR χ^2 (11)	=	67.72
Edu. level	-0.2942**	0.1252	-2.35	0.019	p > χ^2	=	0.000
Weekday	1.3043**	0.3978	3.28	0.001	Pseudo R^2	=	0.4224
Morning	1.0766**	0.4018	2.68	0.007	Log Likelihood	=	-46.30
Evening	0.9632**	0.3945	2.44	0.015			
For business	2.0633**	0.6184	3.34	0.001			
Q2	0.2678*	0.1608	1.67	0.096			
Q3	0.5711**	0.2300	2.48	0.013			
Pt_comfort	0.2400	0.1634	1.47	0.142			
Pt_availability	0.2923*	0.1585	1.84	0.065			
-Cut 1	6.7377**	1.7116	3.93				
-Cut 2	7.5121**	1.7436	4.30				
-Cut 3	7.7661**	1.7517	4.43				

Note: **p < 0.1, **p < 0.05*

However, if passengers are female, they tend to use it less frequent. Interestingly, educational level is seen to be the factor that decrease the frequency of using Remork. The higher the education, the less frequent the usage. This could be true for the fact that educational level seems to associate with income and vehicle ownership. Basically, travelers with high education tend to own private vehicle, and they tend to depend less on Remork service. Results also indicate that time of using Remork including Weekday, Morning and Evening and the use of Remork in business purpose are statistically significant in the model. These variables have positive coefficients, which signify that if they are true for passengers, Remork will be used more often.

Two attitudinal statements - Q2 and Q3 are significant at 90% and 95% of confidential level respectively. The positive coefficients of them can be interpreted that passengers will use Remork more if they agree that Remork is available across the city and can be found anytime.

Remarkably, comfort as a factor to be considered when choosing public transportation is not significant in the final model. However, it is kept for reasons. If we check the p-value of this variables, it is close enough to 90% of significant level. Moreover, the

removal of this variable will make attitudinal statement Q2 insignificant. Using likelihood ratio test to scrutinize the goodness-of-fit before and after removing both variable (comfort and Q2), the result shows that the non-restrictive model with more variables fit the data significantly better than the restrictive one (see the detail of this hypothesis testing in Table 5-12).

Table 5-12 Likelihood ratio test of Remork's models

Main Model				Model with removal of insignificant variables			
Variable	**Coef.**	**t-stat.**	**p-value**	**Variable**	**Coef.**	**t-stat.**	**p-value**
Female	-1.0555**	-2.57	0.010	Female	-0.7631**	-2.29	0.022
Student	1.2773**	2.20	0.028	Student	0.9288*	1.87	0.061
Edu. level	-0.2942**	-2.35	0.019	Edu. level	-0.2335**	-2.12	0.034
Weekday	1.3043**	3.28	0.001	Weekday	0.8687**	2.69	0.007
Morning	1.0766**	2.68	0.007	Morning	0.9982**	2.82	0.005
Evening	0.9632**	2.44	0.015	Evening	0.7111**	2.08	0.038
For business	2.0633**	3.34	0.001	For business	1.5979**	3.17	0.002
Q2	0.2678*	1.67	0.096	Q3	0.4566**	2.59	0.010
Q3	0.5711**	2.48	0.013	Pt_availability	0.2349*	1.77	0.077
Pt_comfort	0.2400	1.47	0.142	-Cut 1	4.4280**	3.72	
Pt_availability	0.2923*	1.84	0.065	-Cut 2	5.0371**	4.17	
-Cut 1	6.7377**	3.93		-Cut 3	5.3543**	4.40	
-Cut 2	7.5121**	4.30					
-Cut 3	7.7661**	4.43					
Model statistics							
N	=	232		N	=	237	
LR χ^2 (11)	=	67.72		LR χ^2 (9)	=	58.37	
p > χ^2	=	0.000		p > χ^2	=	0.000	
Pseudo R^2	=	0.4224		Pseudo R^2	=	0.3432	
Log Likelihood	=	-46.3021		Log Likelihood	=	-55.8515	

Likelihood Ratio Test

$H_0: \quad \beta_{Q2} = \beta_{Pt\_comfort} = 0$

$H_1: \quad \beta_{Q2}; \beta_{Pt\_comfort} \neq 0$

$\chi^2_{statistic} = -2\left[\log L(\beta_{initial}) - \log L(\beta_{convergence})\right] = -2\left[-55.8515 - (-46.3021)\right] = 19.0988$

$\chi^2_{critical}(2) = 5.9910 \quad \rightarrow$ reject null hypothesis

Conclusion: Non-restrictive model fit the data significantly better than the restrictive one.

Note: **p < 0.1, **p < 0.05*

A total of 11 explanatory variables determines the frequency of using Remork, among which 3 are socioeconomics variables, 4 are trip characteristics variables, 2 are extracted from attitudinal statements and 2 are the factors passengers consider when choosing public transportation. The statistical summary of each variable is illustrated in Table 5-13.

Table 5-13 Summary statistics of variables for Remork

Variables	Description	N	Mean	S.D.	Min	Max
Dependent variable						
Frequency[(4)]	Frequency of using Remork	279	1.13	0.54	1	4
Independent socioeconomic variables						
Female	1: if passenger is female, 0: otherwise	389	0.49	0.50	0	1
Student	1: if passenger is student, 0: otherwise	389	0.64	0.47	0	1
Educational level[(5)]	The latest education respondents achieved	274	4.17	1.25	1	6
Trip Characteristics						
Weekday	1: if passengers use Remork on weekday, 0: otherwise	287	0.19	0.39	0	1
Morning	1: if passengers use Remork in the morning, 0: otherwise	287	0.43	0.49	0	1
Evening	1: if passengers use Remork in the evening, 0: otherwise	287	0.31	0.46	0	1
Business purpose	1: if use Remork for business purpose, 0: otherwise	389	0.06	0.24	0	1
Passengers' perception toward Motodup operational characteristics						
Q2[(6)]	Five-rated-scale statement for "operation is available across the city"	269	3.56	1.18	1	5
Q3	Five-rated-scale statement for "can be found anytime"	266	3.64	1.14	1	5
Passengers' criterial when choosing public transportation						
Pt_Comfort[(7)]	If consider comfort important when choosing public transport	451	0.74	1.12	0	3
Pt_availability	If consider availability important when choosing public transport	451	1.03	1.13	0	3

Note: [(4)] Frequency level: (1) occasionally, (2) 2-3 days/week, (3) 4-5 days/week, (4) everyday

[(5)] Educational level: (1) primary school, (2) secondary school, (3) high school, (4) associate bachelor, (5) bachelor, (6) graduate school

[(6)] Five-rated-scale statement: (1) strongly disagree, (2) disagree, (3) neutral, (4) agree, (5) strongly agree

[(7)] Criterial of choosing public transportation: (0) not important, (1) thirdly important, (2) secondary important, (3) the most important

5.5.1. Marginal Effects for Remork

Marginal effects express the change in frequency of using Remork when explanatory variables change. In ordered probit modeling, this change is measured as probabilities that passengers more or less likely to use Remork in particular frequency levels. For instance, the fact that passengers are female associates with 1.2% more likely to use Remork occasionally, 1.1% less likely to use two-three days/week, 0.07% less likely to use four-five days/week and 0.05% less likely to use everyday. The sum of marginal effects for each variable need to be equal to zero (i.e., Female: 0.0121 – 0.0109 – 0.0007 – 0.0005 = 0). The results of marginal effects on frequency of using Remork is presented in Table 5-14.

Table 5-14 Marginal effects on frequency of using Remork

Variables	Frequency of using Remork			
	Occasionally	2-3 days/week	4-5 days/week	Everyday
Female	0.0121	-0.0109	-0.0007	-0.0005
Student	-0.0075	0.0069	0.0004	0.0002
Educational level	0.0027	-0.0025	-0.0001	-0.0001
Weekday	-0.0432	0.0367	0.0034	0.0031
Morning	-0.0160	0.0143	0.0010	0.0007
Evening	-0.0167	0.0148	0.0011	0.0008
Business purpose	-0.2207	0.1587	0.0254	0.0366
Q2	-0.0025	0.0023	0.0001	0.0001
Q3	-0.0054	0.0050	0.0002	0.0002
Pt_comfort	-0.0023	0.0021	0.0001	0.0001
Pt_availability	-0.0027	0.0025	0.0001	0.0001

5.5.2. Predicted Probabilities for Remork

The predicted probabilities for frequency of using Remork are 92.37%, 4.22%, 0.81% and 2.58% corresponding with frequency levels Occasionally, 2-3 days/week, 4-5 days/week and Everyday respectively (see detail in Table 5-15). It can be seen that the predicted probabilities are very close to the actual distribution of frequency level. This could be implied that model performs well enough in predicting the frequency of using Remork.

Table 5-15 Comparison of predicted probabilities and actual data for Remork

Frequency of using Remork	Mean of predicted probabilities	Actual distribution from data set
Occasionally	92.37	92.11
2-3 days/week	4.22	4.30
4-5 days/week	0.81	1.08
Everyday	2.58	2.51

5.6. Estimated Results for Public Bus

Among the three modes considered in this study, public bus is the most recent mode. For this reason, it is expected that respondents who have experienced using public bus is less than Motodup and Remork. Table 5-16 presents the frequency distribution of passengers who have ever used public bus.

Table 5-16 Frequency distribution of using public bus

Frequency of using Remork	Code for alternatives	Frequency	Percentage	Cumulative percentage
Occasionally	1	197	83.47	83.47
2-3 days/week	2	13	5.51	88.98
4-5 days/week	3	5	2.12	91.10
Everyday	4	21	8.90	100.00

Model development of frequency of using public bus is done under three phases, while attitudinal statements related to public bus operation do not have an influence on passengers' frequency of using public bus. The results from Table 5-17 indicate that high school as dummy variable is not significant in model B1, but it appears to be significant at 0.1 level in model B3 after trip characteristics and factors determining the selection of public transport are added. It should be aware that the addition of other new variables does not always improve the existing variables in the model. The case of educational level indicates that it is significant in model B1, but it is not in model B2 when trip characteristics are considered. Nonetheless, in model B3 it happens to approach significant level at 90% of confidential level. Regarding to the development of models, there is a big difference of Pseudo R^2 in model B1 (R^2 = 0.0543) and B3 (R^2 = 0.4016). This indicates that model could explain more about the effects of independent variables on model of frequency using public bus.

Educational level in the final model signifies the negative impact on frequency of using public bus. It simply means that the higher the education, the less frequent passengers use public bus. Focusing on only high school level, it can be seen that this dummy variable has positive coefficient and is significant at 0.1 level. For the fact that passengers is in high school, public bus is used more frequent.

Table 5-17 Modeling results for public bus

Variables	Model				Model's statistics		
	Coef.	Std. Err.	t-stat.	p-value			
Model B1: Socioeconomics							
High school	0.3744	.0.2518	1.49	0.137	N	=	234
Edu. level	-0.2088**	0.0950	-2.20	0.028	LR χ^2 (2)	=	15.10
-Cut 1	0.2373	0.4406	0.53		p > χ^2	=	0.000
-Cut 2	0.5189	0.4417	1.17		Pseudo R^2	=	0.0543
-Cut 3	0.6290	0.4426	1.42		Log Likelihood	=	-131.65
Model B2: Socioeconomics + Trip Characteristics							
High school	0.6152	0.3932	1.56	0.118	N	=	102
Edu. level	-0.1663	0.1616	-1.03	0.304	LR χ^2 (5)	=	48.69
Weekday	2.0050**	0.5464	3.67	0.000	p > χ^2	=	0.000
Cost (x100 KHR)	-0.0752**	0.0229	-3.28	0.001	Pseudo R^2	=	0.3119
Distance	0.0711*	0.0410	1.73	0.083	Log Likelihood	=	-53.71
-Cut 1	1.5473*	0.9256	1.67				
-Cut 2	1.9556**	0.9304	2.01				
-Cut 3	2.1799**	0.9350	2.33				
Model B3: Socioeconomics + Trip Characteristics + Criteria of choosing public transportation							
High school	0.8881*	0.4584	1.94	0.053	N	=	95
Edu. level	-0.4058	0.2473	-1.64	0.101	LR χ^2 (7)	=	54.88
Weekday	2.8346**	0.7498	3.78	0.000	p > χ^2	=	0.000
Cost (x100 KHR)	-0.1218**	0.0320	-3.80	0.000	Pseudo R^2	=	0.4016
Distance	0.1116**	0.0546	2.04	0.041	Log Likelihood	=	-40.88
Pt_comfort	0.6185**	0.2625	2.36	0.018			
Pt_availability	0.4620**	0.2099	2.20	0.028			
-Cut 1	2.3312**	1.0771	2.16				
-Cut 2	2.6275**	1.0838	2.42				
-Cut 3	2.9153**	1.0961	2.65				

Note: **p < 0.1, **p < 0.05*

In terms of trip characteristics, using public bus on weekday is significant in the main model. On the other hand, travel cost is seen to be a factor reducing likelihood of using public bus, while travel distance has an opposite influence. This could be the

case because the public bus provides passengers with a low fare for all stations in the city. Therefore, passengers can save more if their trip is a long-distance one. Comfort and availability as the important factors for passengers when choosing public transportation are found significant at 0.05 level. These two explanatory variables have the positively coefficient, which could be interpreted that passengers will use public bus more often if they consider comfort and availability importantly. The goodness-of-fit of overall model is acceptable, demonstrated by Pseudo R^2 = 0.40. Moreover, the model is statically significant at 95% of confidential level, while likelihood ratio Chi-square with degree of freedom 7 is equal to 54.88. Detail of modeling result is shown in Table 5-17.

There are seven explanatory variables affected the frequency of using public bus. It can be seen that these explanatory variables are extracted from three set of variables, while passengers' perception toward public bus operational characteristics does not play any role in the model. Statistical summary of independent variables is presented in Table 5-18.

Table 5-18 Summary statistics of variables for public bus

Variables	Description	N	Mean	S.D.	Min	Max
Dependent variable						
Frequency[8]	Frequency of using bus	236	1.36	0.90	1	4
Independent socioeconomic variables						
Educational level[9]	The latest education respondents achieved	244	4.24	1.18	1	6
High school	1: if passenger achieves high school, 0: otherwise	484	0.11	0.32	0	1
Trip Characteristics						
Weekday	1: if passengers use Remork on weekday, 0: otherwise	247	0.36	0.48	0	1
Cost	Travel cost by bus per trip per person (KHR)	157	1100	600	0	1500
Distance	Average travel distance by bus per trip (Km)	109	6.38	3.89	0.2	15
Passengers' criterial when choosing public transportation						
Pt_Comfort[10]	If consider comfort important when choosing public transport	451	0.74	1.12	0	3
Pt_availability	If consider availability important when choosing public transport	452	1.03	1.13	0	3

Note: [8] Frequency level: (1) occasionally, (2) 2-3 days/week, (3) 4-5 days/week, (4) everyday

[9] Educational level: (1) primary school, (2) secondary school, (3) high school, (4) associate bachelor, (5) bachelor, (6) graduate school

[10] Criterial of choosing public transportation: (0) not important, (1) thirdly important, (2) secondary important, (3) the most important

5.6.1. Marginal Effects for Public Bus

Unlike linear regression where marginal effects can be interpreted directly from coefficient of regressors as a change in Y when there is a change in X, it is not the case for ordered probit modeling. In this study, marginal effects are measured as a probabilities associated with likelihood of using public bus in each frequency category. Since there are four frequency categories, four marginal effects are observed as well. The sum of all marginal effects for each explanatory variable must be equal to zero (e.g. Educational Level: 0.0302 – 0.0134 – 0.0081 – 0.0087 = 0). The interpretation of marginal effects for public bus can be made such that, for instance, the increase in education by one level associates with 3% more likely to use public bus occasionally, 1% less likely to use public bus 2-3 days/week, roughly 1% less likely to use public bus 4-5 days/week and about 1% less likely to use public bus everyday.

Table 5-19 Marginal effects on frequency of using public bus

Variables	Frequency of using Public bus			
	Occasionally	2-3 days/week	4-5 days/week	Everyday
Educational level	0.0302	-0.0134	-0.0081	-0.0087
High school	-0.0905	0.0362	0.0237	0.0306
weekday	-0.3123**	0.0960**	0.0745*	0.1418**
Cost	0.00008	-0.00004	-0.00002	-0.00002
Distance	-0.0082	0.0036	0.0022	0.0024
Pt_comfort	-0.0461	0.0205	0.0123	0.0133
Pt_availability	-0.0344	0.0153	0.0092	0.0099

Note: *$p < 0.1$, **$p < 0.05$

5.6.2. Predicted Probabilities for Public Bus

The predicted probabilities of outcomes for each frequency category are made. The mean of these predicted probabilities are compared with percentage distribution of frequency of using public bus obtaining from the actual data set. The statistic of this comparison is summarized in Table 5-20.

Table 5-20 Comparison of predicted probabilities and actual data for public bus

Frequency of using Public bus	Mean of predicted probabilities	Actual distribution from data set
Occasionally	76.94	83.47
2-3 days/week	4.10	5.51
4-5 days/week	3.56	2.12
Everyday	15.38	8.90

5.7. Summary

The frequency of using Motodup and Remork is influenced by socioeconomics, trip characteristics, attitudinal statements and criteria of choosing public transport. However, attitudinal statements does not take any role in public bus's model. The absolute values of marginal effects of all the modes decline gradually from "occasionally" category to "everyday" category. This simply indicates that either paratransit or public bus is only used occasionally. It could be true because all the household own their private vehicle(s) that make them less dependent on public transportation. Travelers prefers their own vehicle due to the convenience and cost saving, while paratransit may not be available near their resident and it is expensive for daily trip. Public bus's fare is cheap compared to paratransit, but the operated speed is quite slow resulting in long waiting time.

Chapter 6
Summary and Conclusion

6.1. Summary

This study addresses analysis of trip frequency of paratransit and public bus passengers under the effects of socioeconomics, trip characteristics and operational characteristics and passengers' criteria when choosing public transportation. As a major public transportation, which exist for decades in the city, paratransit roles importantly although public bus was put into full operation in 2014. Motodup and Remork as a paratransit are operated with non-fixed price and route. Mostly, drivers own the vehicle and also the right to set the price independently. Basically, Motodup is supposed to be cheaper than Remork since it can accommodate less capacity. The operation of these two modes can be seen extensively across the city, and in some cases, they are even used to reach the provinces nearby Phnom Penh. Public bus, on the other hand, has been operated by municipality of Phnom Penh. Price was fixed to be 1500 KHR (roughly 0.37 USD) for all stations, but there are also some group of passengers such as students, senior citizens, disable people and monks can use public bus for free. Currently, there are 3 bus routes operated for public from 5:00 to 20:30 with operative distance 19km, 19km and 13.5km for line 1, line 2 and line 3 respectively. Although public bus has been seen to be one of the sustainable solutions for transportation in the city, it still leave behind the narrowly local roads remain unserved, and that paratransit has to take the role. Within this case, the combination of paratransit and public bus is quite important for urban transportation, while congestion is one of major concerns Phnom Penh is facing today.

6.2. Conclusion

Descriptive statistics obtaining from the survey of 483 passengers in Phnom Penh describe the behavior of paratransit and public bus passengers. Among the three modes considered in the study, passengers experience using Motodup more than other

two modes. Plus, the survey reported that 27.2% of respondents have ever used all of these three modes. Female shares somewhat bigger proportion than male. Majority of respondents are students with bachelor degree. Many of them fall in low income category, which earn less than 200 USD per month per person. From the survey, respondents are principally young adult whose mean age of 24.6 years old with standard deviation of 8.94. In average, the household size is 5 people, and standard deviation is 2.21. In terms of vehicle in household, motorcycle is the mode that is available in all household, while car and bicycle are not the case.

Among all of using frequency levels starting from the most frequent to the least frequent, majority of respondents provide the answer that they use Motodup/Remork public bus occasionally. Passengers use Motodup for studying and shopping, while Remork is used for shopping and social trip. Public bus, on the other hand, is used for variety of purposes, but not mainly for business purpose. From the descriptive statistics result, the mean of travel cost is different across the modes – 5800 KHR for Motodup and 10700 KHR for Remork. Public bus, however, has a fixed fare, which is 1500 KHR, but some groups of passengers (e.g. students) are free of charge for the service. These travel costs correspond with travel distance 4.74km, 5.82km, and 6.38km of Motodup, Remork and public bus respectively. Survey of passengers' average travel time reported the mean value of 19.8 minutes for Motodup and 24.54 minutes for Remork. However, public bus has a long travel time (44.31 minutes) compared to Motodup and Remork. This could be the case since public bus is operated in the mixed traffic where all type of vehicles come together without following a specific lane. Within this case, public bus seems to be disadvantageous to move, especially during peak hour.

The survey on passengers' perception toward operational characteristics covers seven main aspects including travel time, availability, waiting time, comfort, vehicle condition, safety and fare. These aspects distribute into ten statements, and are rated by 5-likert scale. Evidence from the survey indicates that Motodup passengers seems to have a positive perception for travel time, availability and waiting time; however, it is not the case for public bus. Nonetheless, public bus passengers perceive a good perception

for comfort, vehicle condition, safety and fare while Motodup passengers seems to be neutral with these attributes. For Remork, passengers seem to have neutral perception toward all aspects related to its operational characteristics.

The study applies the concept of ordered probit model to determine the factors influencing passengers' trip frequency in using Motodup, Remork and public bus. The models were run under the effects of four sets of explanatory variables including socioeconomics, trip characteristics, passengers' perception toward operational characteristics and passengers' criteria in choosing public transportations. Since there are three modes to be considered, models were performed in three different cases.

For Motodup, students employee, and travel cost are seen to be the factors decreasing the likelihood of using Motodup. However, medium income earners tend to be the ones who use Motodup more often. The results from modeling indicate that passengers, who consider comfort and convenience importantly, potentially regard Motodup to be the choice.

Female passengers and educational level have the negative impacts on frequency of using Remork, meaning that these two variables reduce the likelihood of using this mode. Interestingly, students are seen to be passengers who use Remork more frequent, but they do not prefer Motodup. In addition to this, results indicate that Remork is used for business purpose. It could be true because beside being a mean of transport for passengers, Remork is also used to transport the goods, especially the goods from the market to mini-truck's terminal, and subsequently distribute to the provinces. Passengers perceive comfort and availability of Remork importantly. The more they value these attributes, the more frequent they use Remork.

The frequency of using public bus is influenced by passengers' socioeconomics, trip characteristics and criteria of choosing public transportation. Modeling result shows that educational level and travel cost give a negative impact to the model, meaning that the increase in these two variables will result in decreasing likelihood of using public bus. Furthermore, public bus is found significant for weekday use. It is possibly

true since passengers in high school, which is also significant in the model, would use it for to get to school.

However, the other variables including dummy variable of high school and weekday, travel distance, and the level of importance of comfort and availability affect the model in positive way. Public bus is a newly introduced public transportation in urban area of Phnom Penh, and it is also a highly promoted mode. It is expected that Public bus will contribute immensely in reducing congestion level in the city as well as provide passengers with safety and comfort. However, the performance of current Public bus needs to be improved in order to attract more passengers (PHUN et al., 2015b). By considering the factors influencing the frequency of using Public bus, some appropriate transportation policies can be implemented. Authority who is in charge of Public bus operation should consider comfort and availability as the prioritized service attributes for the reason that these two aspects are significant in increasing the likelihood of using Public bus more. Moreover, dummy variable for high school suggests that this group of passengers seems to be the ones who use Public bus more. Within this case the operation should inspect high school students to be the target passengers. Because students are free of charge for using Public bus, having them as passengers surely does not provide any financial profits, but we can take marketing benefits instead. At this early stage, the subsidy is absolutely essential until the operation becomes stable. It is true that Phnom Penh inhabitants have not been quite familiar with Public bus yet that the advertisements and promotions play such an important role. In this case, passengers who have experienced using Public bus would be the best advertisers we could find.

Overall, good collaboration between paratransit and public bus reflects a good sign of better urban transportation. They are not only provide passengers with more choices of travel modes, but also connect the transportation system together. The improvement of urban transportation system would lead a city to take economic benefit as well as to reach transportation sustainability.

6.3. Policy Implementation and Future Work

The results of this study could lead to some transportation policy recommendations. It has been known that although Motodup and Remork have a role in urban transportation, their operation is also problematic. Number of Motodup in the city cannot be identified since everyone can be a driver by just having a motorcycle. Remork, on the other hand, is observed to increase lately, and this mode is blamed to be partly a cause of congestion. The operation of Motodup and Remork provides a difficulty to manage. Therefore, we want them to exist in the level that they can be controlled and serve as a feeder to mass transit system in the future.

Public bus is a highly promoted mode. From the results of this study, some possible transportation policies could be implemented to increase the usage of this mode. Policy makers should enrich the quality of comfort and availability since these two attributes have positive impact on frequency of using public bus. In addition to this, the length of operational routes should be extended given that fare remain the same. The reason is that public bus provides a public transportation service with low fare, safety and comfort, so passengers could travel in a long trip with better quality of transportation service. Last but not least, the results from the study suggest that public bus is not the preference of highly educated people. In this case, the operation should for focus young travelers as target passengers, especially high school students. If new public bus route was designed, the operation should get across high school area so that public bus could attract more passengers. Because public bus is offered for free for some group of passengers, the operation does not earn much profit. At this early stage, the subsidy from the government is absolutely essential until the operation could earn sufficiently financial profit for its sustainability.

Overall, good collaboration between paratransit and public bus reflects a good sign of better urban transportation. They are not only provide passengers with more choices of travel modes, but also connect the transportation system together. The improvement of urban transportation system would lead a city to take economic benefit as well as to reach transportation sustainability.

The scope of this study is limited when urban transportation in Phnom Penh as a whole is considered. This work could be improved if more set of variables are included such as passengers' experiences in using paratransit and public bus, the accessibility to nearest public modes' station/parking. The future study may evaluate how travelers depend on public transportation, and what are factors influencing their usage.

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APPENDIX

Survey questionnaire of travel behavior of paratransit users in Phnom Penh

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PART I: Trip Characteristics

Section (A): About Motodup

A-1. How often do you use Motodup?

☐ Everyday ☐ 4-5 days/week ☐ 2-3 days/week ☐ Occasionally ☐ Never

If you never use Motodup, please skip this section and continue to Section (B)

A-2. What day of the week do you mostly use Motodup?
(answer can be MORE THAN ONE)

☐ Monday ☐ Tuesday ☐ Wednesday ☐ Thursday
☐ Friday ☐ Saturday ☐ Sunday

A-3. During what time period do you mostly use Motodup?
(answer can be MORE THAN ONE)

☐ 6am – 9am ☐ 9am – 12pm ☐ 12pm – 3pm
☐ 3pm – 6pm ☐ 6pm – 9pm ☐ 9pm – 6am

A-4. What is your main purpose of using Motodup?
(Please choose ONLY ONE answer)

☐ Education ☐ Work ☐ Business
☐ Shopping ☐ Other ……..……

A-5. On average, for a trip using Motodup you spend:
Travel Cost ……**Riel,** Distance..……**Km,** Travel time……..…**Minutes**

Section (B): About Remork

B-1. How often do you use Remork?

☐ Everyday ☐ 4-5 days/week ☐ 2-3 days/week ☐ Occasionally ☐ Never

If you never use Remork, please skip this section and continue to Section (C)

B-2. What day of the week do you mostly use Remork?
(answer can be MORE THAN ONE)

☐ Monday ☐ Tuesday ☐ Wednesday ☐ Thursday
☐ Friday ☐ Saturday ☐ Sunday

B-3. During what time period do you mostly use Remork?
(answer can be MORE THAN ONE)

☐ 6am – 9am ☐ 9am – 12pm ☐ 12pm – 3pm
☐ 3pm – 6pm ☐ 6pm – 9pm ☐ 9pm – 6am

B-4. What is your main purpose of using Remork?
(Please choose ONLY ONE answer)

☐ Education ☐ Work ☐ Business
☐ Shopping ☐ Other ……..……

B-5. On average, for a trip using Remork you spend:
Travel Cost ……**Riel,** Distance…..……**Km,** Travel time…..……**Minutes**

Section (C): About Public bus

C-1. How often do you use public bus?

☐ Everyday ☐ 4-5 days/week ☐ 2-3 days/week ☐ Occasionally ☐ Never

If you never use Public bus, please skip this section and continue to Part II.

C-2. What day of the week do you mostly use public bus?
(answer can be MORE THAN ONE)
☐ Monday ☐ Tuesday ☐ Wednesday ☐ Thursday
☐ Friday ☐ Saturday ☐ Sunday

C-3. During what time period do you mostly use public bus?
(answer can be MORE THAN ONE)
☐ 6am – 9am ☐ 9am – 12pm ☐ 12pm – 3pm
☐ 3pm – 6pm ☐ 6pm – 9pm ☐ 9pm – 6am

C-4. What is your main purpose of using public bus?
(Please choose ONLY ONE answer)
☐ Education ☐ Work ☐ Business
☐ Shopping ☐ Other ……..……

C-5. On average, for a trip using public bus you spend:
Travel Cost ……**Riel,** Distance…..…**Km,** Travel time…..……**Minutes**

Part II: User perceptions

1. Which important factors do you think of when you choose public transportation in Phnom Penh? Please choose only 3 most important factors (Put 1 for the most important, and put 2 for secondary importance, and 3 for the third importance)

…….. Convenience …….. Travel time …….. Safety …….. Comfort
…….. Fare …….. Availability …….. Other (Please specify)……..…

2. Considering each travel mode, how do you agree with these statements? Please tick (✓) over the number from 1 (Strongly disagree) to 5 (Strongly agree)

N⁰	Statements	Motodop	Remork	Public bus
		1 strongly disagree ➡ strongly agree 5		
2.1	Can move fast	①②③④⑤	①②③④⑤	①②③④⑤
2.2	Operation is available across the city	①②③④⑤	①②③④⑤	①②③④⑤
2.3	Can be found any time you need	①②③④⑤	①②③④⑤	①②③④⑤
2.4	Can be found nearby	①②③④⑤	①②③④⑤	①②③④⑤
2.5	Short waiting time	①②③④⑤	①②③④⑤	①②③④⑤
2.6	Seat is comfortable	①②③④⑤	①②③④⑤	①②③④⑤
2.7	Vehicle is clean	①②③④⑤	①②③④⑤	①②③④⑤
2.8	Interior material is well maintained	①②③④⑤	①②③④⑤	①②③④⑤
2.9	Overall safety from road accident is high	①②③④⑤	①②③④⑤	①②③④⑤
2.10	Low fare	①②③④⑤	①②③④⑤	①②③④⑤
2.11	I prefer this transportation service	①②③④⑤	①②③④⑤	
2.12	This transportation service is very convenience	①②③④⑤	①②③④⑤	
2.13	The presence of this transportation service is essential	①②③④⑤	①②③④⑤	

2.14	I feel safe in terms of road accident when using this transportation service	①②③④⑤	①②③④⑤
2.15	Driver's driving behavior is good	①②③④⑤	①②③④⑤
2.16	Driver's attitude is good	①②③④⑤	①②③④⑤
2.17	I feel secured in terms of crime when using this transportation service	①②③④⑤	①②③④⑤
2.18	Driver charges customer reasonably	①②③④⑤	①②③④⑤
2.19	This transportation service contribute in pollution less than others	①②③④⑤	①②③④⑤
2.20	Overall, I am satisfied with this transportation service	①②③④⑤	①②③④⑤
2.21	I still want to see the presence of this transport service though other public transportations are available.	①②③④⑤	①②③④⑤
2.22	I still want to see this transport co-exists with other public transportation modes	①②③④⑤	①②③④⑤
2.23	I will still use this transport service though my income increases.	①②③④⑤	①②③④⑤
2.24	I will still use this transport service though operation is restricted to some specific areas.	①②③④⑤	①②③④⑤
2.25	I don't want number of this transport service to be cut down.	①②③④⑤	①②③④⑤

PART IV: About Yourself

1. Gender: ☐ Male ☐ Female Age……..……..
2. Occupation:
   ☐ Student ☐ Public-sector staff ☐ Private-sector staff ☐ Vendor
   ☐ Employer ☐ Unemployed ☐ Other……..……
3. Education:
   ☐ Primary School ☐ Secondary School ☐ High School
   ☐ Associate bachelor ☐ Bachelor ☐ Graduate school
4. Monthly income/allowance (in USD):
   ☐ None ☐ ≤ $100 ☐ $101 - $200 ☐ $201 - $300
   ☐ $301 – $400 ☐ $401 – $500 ☐ $501 – $1,000 ☐ ≥ $1,001
5. Which district do you live in?
   ☐ 7 Makara ☐ Chamkarmon ☐ Chbar Ampov ☐ Chroy Changva
   ☐ Dangkor ☐ Doun Penh ☐ Mean Chey ☐ Por Sen Chey
   ☐ Prek Pnov ☐ Russei Keo ☐ Sen Sok ☐ Tuol Kork
6. How many people in your house? (Including yourself) ……
7. How many vehicles in your house? (Please specify the number)
   ☐ Car (Amount ……) ☐ Motorcycle (Amount ……)
   ☐ Bicycle (Amount ……) ☐ Do not have any

Thanks for your participation!

ការស្វង់មតិពីឥរិយាបថធ្វើដំណើររបស់អ្នកប្រើប្រាស់សេវារត់ឌុប
ក្នុងទីក្រុងភ្នំពេញ
មហាវិទ្យាល័យវិស្វកម្ម, សាកលវិទ្យាល័យដូឡាឡុងកន

ផ្នែកទី I: លក្ខណៈនៃការធ្វើដំណើរ

ផ្នែក (A): អំពី ម៉ូតូឌុប

A-1. តើអ្នកប្រើប្រាស់ម៉ូតូឌុបញឹកញាប់ប៉ុណ្ណា?

☐ រាល់ថ្ងៃ ☐ 4-5 ថ្ងៃ/សប្តាហ៍ ☐ 2-3 ថ្ងៃ/សប្តាហ៍ ☐ យូរៗម្តង ☐ មិនដែល

ប្រសិនបើអ្នកមិនដែលប្រើប្រាស់ម៉ូតូឌុប សូមរំលងផ្នែកនេះហើយបន្តទៅផ្នែក (B)

A-2. តើភាគច្រើនអ្នកប្រើប្រាស់ម៉ូតូឌុបនៅថ្ងៃណានៃសប្តាហ៍? (ចម្លើយអាចលើសពីមួយ)

☐ ថ្ងៃច័ន្ទ ☐ ថ្ងៃអង្គារ ☐ ថ្ងៃពុធ ☐ ថ្ងៃព្រហស្បតិ៍
☐ ថ្ងៃសុក្រ ☐ ថ្ងៃសៅរ៍ ☐ ថ្ងៃអាទិត្យ

A-3. តើភាគច្រើនអ្នកប្រើប្រាស់ម៉ូតូឌុបនៅចន្លោះពេលណា? (ចម្លើយអាចលើសពីមួយ)

☐ 6 ព្រឹក – 9 ព្រឹក ☐ 9 ព្រឹក – 12 ថ្ងៃត្រង់ ☐ 12 ថ្ងៃត្រង់ – 3 រសៀល
☐ 3 រសៀល – 6 ល្ងាច ☐ 6 ល្ងាច – 9 យប់ ☐ 9 យប់ – 6 ព្រឹក

A-4. តើអ្វីជាគោលបំណងចំបងដែលអ្នកប្រើប្រាស់ម៉ូតូឌុប? (សូមជ្រើសរើសចម្លើយតែមួយគត់)

☐ សិក្សា ☐ ការងារ ☐ មុខជំនួញ
☐ ទិញឥវ៉ាន់ ☐ ផ្សេងៗ .....

A-5. ជាមធ្យម សម្រាប់ការធ្វើដំណើរតាម ម៉ូតូឌុប អ្នកចំណាយ:

ថ្លៃធ្វើដំណើរ.....**រៀល**, ចម្ងាយ.....**គ.ម**, រយៈពេលធ្វើ ដំណើរ.....**នាទី**

ផ្នែក (B): អំពី រ៉ឺម៉ក

B-1. តើអ្នកប្រើប្រាស់រ៉ឺម៉កញឹកញាប់ប៉ុណ្ណា?

☐ រាល់ថ្ងៃ ☐ 4-5 ថ្ងៃ/សប្តាហ៍ ☐ 2-3 ថ្ងៃ/សប្តាហ៍ ☐ យូរៗម្តង ☐ មិនដែល

ប្រសិនបើអ្នកមិនដែលប្រើប្រាស់ម៉ូតូឌុប សូមរំលងផ្នែកនេះហើយបន្តទៅផ្នែក (C)

B-2. តើភាគច្រើនអ្នកប្រើប្រាស់រ៉ឺម៉កនៅថ្ងៃណានៃសប្តាហ៍? (ចម្លើយអាចលើសពីមួយ)

☐ ថ្ងៃច័ន្ទ ☐ ថ្ងៃអង្គារ ☐ ថ្ងៃពុធ ☐ ថ្ងៃព្រហស្បតិ៍
☐ ថ្ងៃសុក្រ ☐ ថ្ងៃសៅរ៍ ☐ ថ្ងៃអាទិត្យ

B -3. តើភាគច្រើនអ្នកប្រើប្រាស់រ៉ឺម៉កនៅចន្លោះពេលណា? (ចម្លើយអាចលើសពីមួយ)

☐ 6 ព្រឹក – 9 ព្រឹក ☐ 9 ព្រឹក – 12 ថ្ងៃត្រង់ ☐ 12 ថ្ងៃត្រង់ – 3 រសៀល
☐ 3 រសៀល – 6 ល្ងាច ☐ 6 ល្ងាច – 9 យប់ ☐ 9 យប់ – 6 ព្រឹក

B-4. តើអ្វីជាគោលបំណងចំបងដែលអ្នកប្រើប្រាស់រ៉ឺម៉ក? (សូមជ្រើសរើសចម្លើយតែមួយគត់)

☐ សិក្សា ☐ ការងារ ☐ មុខជំនួញ
☐ ទិញឥវ៉ាន់ ☐ ផ្សេងៗ .....

B-5. ជាមធ្យម សម្រាប់ការធ្វើដំណើរតាម រ៉ឺម៉ក អ្នកចំណាយ:

ថ្លៃធ្វើដំណើរ.....**រៀល**, ចម្ងាយ.....**គ.ម**, រយៈពេលធ្វើដំណើរ.....**នាទី**

ផ្នែក (C): អំពី ឡានក្រុង

C-1. តើអ្នកប្រើប្រាស់ឡានក្រុងញឹកញាប់ប៉ុណ្ណា?

☐ រាល់ថ្ងៃ ☐ 4-5 ថ្ងៃ/សប្តាហ៍ ☐ 2-3 ថ្ងៃ/សប្តាហ៍ ☐ យូរៗម្តង ☐ មិនដែល

ប្រសិនបើអ្នកមិនដែលប្រើប្រាស់ម៉ូតូឌុប សូមរំលងផ្នែកនេះហើយបន្តទៅផ្នែក (II)

C -2. តើភាគច្រើនអ្នកប្រើប្រាស់ឡានក្រុងនៅថ្ងៃណានៃសប្តាហ៍? (ចម្លើយអាចលើសពីមួយ)

☐ ថ្ងៃច័ន្ទ ☐ ថ្ងៃអង្គារ ☐ ថ្ងៃពុធ ☐ ថ្ងៃព្រហស្បតិ៍

☐ ថ្ងៃសុក្រ ☐ ថ្ងៃសៅរ៍ ☐ ថ្ងៃអាទិត្យ

C -3. តើភាគច្រើនអ្នកប្រើប្រាស់ឡានក្រុងនៅចន្លោះពេលណា? (ចម្លើយអាចលើសពីមួយ)

☐ 6 ព្រឹក – 9 ព្រឹក ☐ 9 ព្រឹក – 12 ថ្ងៃត្រង់ ☐ 12 ថ្ងៃត្រង់ – 3 រសៀល

☐ 3 រសៀល – 6 ល្ងាច ☐ 6 ល្ងាច – 9 យប់ ☐ 9 យប់ – 6 ព្រឹក

C-4. តើអ្វីជាគោលបំណងចំបងដែលអ្នកប្រើប្រាស់ឡានក្រុង? (សូមជ្រើសរើសចម្លើយតែមួយគត់)

☐ សិក្សា ☐ ការងារ ☐ មុខជំនួញ

☐ ទិញឥវ៉ាន់ ☐ ផ្សេងៗ .....

C-5. ជាមធ្យម សម្រាប់ការធ្វើដំណើរតាម ឡានក្រុង អ្នកចំណាយ:

ថ្លៃធ្វើដំណើរ.....**រៀល**, ចម្ងាយ.....**គ.ម**, រយៈពេលធ្វើដំណើរ.....**នាទី**

ផ្នែកទី II: ការយល់ឃើញរបស់អ្នកប្រើប្រាស់

1. តើអ្នកគិតដល់កត្តាសំខាន់អ្វីខ្លះ នៅពេលដែលអ្នកជ្រើសរើស មធ្យោបាយធ្វើដំណើរសាធារណៈនៅភ្នំពេញ? សូមជ្រើសរើសកត្តាសំខាន់ៗត្រឹមតែ 3 ប៉ុននោះ (ដាក់លេខ 1 សម្រាប់កត្តាសំខាន់ជាងគេ, លេខ 2 សម្រាប់កត្តាសំខាន់ទីពីរ និង លេខ 3 សម្រាប់កត្តាសំខាន់ទីបី)

..... ភាពងាយស្រួល ..... រយៈពេលធ្វើដំណើរ ..... សុវត្ថិភាព ..... ផាសុខភាព

..... ថ្លៃធ្វើដំណើរ .....ភាពងាយរក ..... ផ្សេងៗ (សូមបញ្ជាក់).....

2. ដោយគិតទៅលើមធ្យោបាយធ្វើដំណើរនីមួយៗ តើអ្នកយល់យ៉ាងដូចម្តេចនឹងការលើកឡើងទាំងនេះ? *សូម ✓ លើលេខខាងក្រោមពី 1 (មិនយល់ស្របខ្លាំង) ដល់ លេខ 5 (យល់ស្របខ្លាំង)*

	ការលើកឡើង	ម៉ូតូឌុប	រ៉ឺម៉ក	ឡានក្រុង
		1 មិនយល់ស្របខ្លាំង ⟹ យល់ស្របខ្លាំង 5		
2.1	អាចធ្វើដំណើរបានលឿន	①②③④⑤	①②③④⑤	①②③④⑤
2.2	ប្រតិបត្តិការមានពេញទីក្រុង	①②③④⑤	①②③④⑤	①②③④⑤
2.3	អាចរកបានរៀងរាល់ពេលអ្នកត្រូវការ	①②③④⑤	①②③④⑤	①②③④⑤
2.4	អាចរកបាននៅជិតៗ	①②③④⑤	①②③④⑤	①②③④⑤
2.5	រយៈពេលរង់ចាំ ខ្លី	①②③④⑤	①②③④⑤	①②③④⑤
2.6	កន្លែងអង្គុយមានផាសុខភាព	①②③④⑤	①②③④⑤	①②③④⑤
2.7	យានដំនិះ ស្អាត	①②③④⑤	①②③④⑤	①②③④⑤
2.8	បរិក្ខារក្នុងយានមានការថែទាំបានល្អ	①②③④⑤	①②③④⑤	①②③④⑤
2.9	សុវត្ថិភាពជារួមពីគ្រោះថ្នាក់ចរាចរណ៍ ខ្ពស់	①②③④⑤	①②③④⑤	①②③④⑤
2.10	តម្លៃធ្វើដំណើរ ថោក	①②③④⑤	①②③④⑤	①②③④⑤
2.11	ខ្ញុំចូលចិត្តប្រើប្រាស់សេវាធ្វើដំណើរនេះ	①②③④⑤	①②③④⑤	
2.12	សេវាធ្វើដំណើរនេះពិតជាមានភាពងាយស្រួល	①②③④⑤	①②③④⑤	
2.13	វត្តមានរបស់សេវាធ្វើដំណើរនេះ ពិតជាសំខាន់	①②③④⑤	①②③④⑤	
2.14	ខ្ញុំមានអារម្មណ៍ថាមានសុវត្ថិភាពពីគ្រោះថ្នាក់ចរាចរណ៍ ពេលប្រើប្រាស់សេវាធ្វើដំណើរនេះ	①②③④⑤	①②③④⑤	
2.15	ឥរិយាបថបើកបររបស់តៃកុង ល្អ	①②③④⑤	①②③④⑤	

2.16	អត្តចរិតរបស់តៃកុង ល្អ	①②③④⑤	①②③④⑤
2.17	ខ្ញុំមានអារម្មណ៍ថាមានសុវត្ថិភាពពីឧក្រិដ្ឋកម្ម ពេលប្រើប្រាស់សេវាធ្វើដំណើរនេះ	①②③④⑤	①②③④⑤
2.18	តៃកុងយកថ្លៃធ្វើដំណើរពីភ្ញៀវសមរម្យ	①②③④⑤	①②③④⑤
2.19	សេវាកម្មធ្វើដំណើរនេះរួមចំណែកក្នុងការបំពុលតិចជាងមធ្យោបាយធ្វើដំណើរផ្សេង	①②③④⑤	①②③④⑤
2.20	ជារួមមកខ្ញុំពេញចិត្តនឹងសេវាកម្មធ្វើដំណើរនេះ	①②③④⑤	①②③④⑤
2.21	ខ្ញុំនៅតែចង់ឃើញវត្តមានសេវាធ្វើដំណើរនេះទោះបីមានសេវាធ្វើដំណើរនេះផ្សេងទៀតក៏ដោយ	①②③④⑤	①②③④⑤
2.22	ខ្ញុំនៅតែចង់ឃើញសេវាធ្វើដំណើរនេះចូលរួមចំណែកជាមួយសេវាធ្វើដំណើរផ្សេងទៀត	①②③④⑤	①②③④⑤
2.23	ខ្ញុំនឹងនៅតែប្រើប្រាស់សេវាធ្វើដំណើរនេះទោះបីចំណូលខ្ញុំកើនឡើងក៏ដោយ	①②③④⑤	①②③④⑤
2.24	ខ្ញុំនឹងនៅតែប្រើប្រាស់សេវាធ្វើដំណើរនេះទោះបី ការរត់ឧបត្រូវបានកំណត់ឲ្យមានតែនៅតំបន់មួយចំនួនក៏ដោយ	①②③④⑤	①②③④⑤
2.25	ខ្ញុំមិនចង់ឲ្យចំនួនសេវាធ្វើដំណើរនេះត្រូវបានកាត់បន្ថយទេ	①②③④⑤	①②③④⑤

ផ្នែកទី III: អំពីខ្លួនអ្នក

1. ភេទ: ☐ ប្រុស ☐ ស្រី អាយុ: ……

2. មុខរបរ: ☐ សិស្ស ☐ បុគ្គលិករដ្ឋ ☐ បុគ្គលិកឯកជន ☐ អាជីវករ
☐ ពាណិជ្ជករ ☐ មិនទាន់មានការងារ ☐ ផ្សេងៗ……

3. កម្រិតវប្បធម៌: ☐ បឋមសិក្សា ☐ អនុវិទ្យាល័យ ☐ វិទ្យាល័យ
☐ បរិញ្ញាបត្ររង ☐ បរិញ្ញាបត្រ ☐ ថ្នាក់ក្រោយឧត្តមសិក្សា

4. ចំណូល/ប្រាក់ឧបត្ថម្ភ ប្រចាំខែ (គិតជាដុល្លារអាមេរិច):
☐ មិនមាន ☐ ≤ 100$ ☐ 101$ - 200$ ☐ 201$ - 300$
☐ 301$ – 400$ ☐ 401$ – 500$ ☐ 501$ – 1,000$ ☐ ≥ 1,001$

5. តើអ្នករស់នៅក្នុងខណ្ឌណា?
☐ 7 មករា ☐ ចំការមន ☐ ច្បារអំពៅ ☐ ជ្រោយចង្វា ☐ ដង្កោ ☐ ដូនពេញ
☐ មានជ័យ ☐ ពោធិ៍សែនជ័យ ☐ ព្រែកព្នៅ ☐ ឬស្សីកែវ ☐ សែនសុខ ☐ ទួលគោក

6. តើអ្នកមានសមាជិកប៉ុន្មាននៅក្នុងផ្ទះ?(រាប់ទាំងខ្លួនអ្នក) ……

7. តើអ្នកមានយានដំនិះប៉ុន្មាននៅក្នុងផ្ទះ? (សូមបញ្ជាក់ចំនួន)
☐ ឡាន (ចំនួន……) ☐ ម៉ូតូ (ចំនួន……)
☐ កង់ (ចំនួន……) ☐ មិនមានទេ

អរគុណសម្រាប់ការចូលរួម!

VITA

Nguonsong Eung is transportation engineer who graduated from Chulalongkorn University, Thailand. He was born in 1990 in Siem Reap Province, Cambodia. Nguonsong earned his high school diploma in 2009 from SOS Hermann Gmeiner Angkor Siem Reap School, which is located in his hometown. In the same year, he moved to Phnom Penh for his bachelor degree in engineering at Institute of Technology of Cambodia. In 2011 while he was in his third year, Nguonsong chose to specialize in Architectural Engineering, and graduated in July 2014. He was quite interested in urban studies, and fortunately he was awarded AUN/SEED-Net Scholarship supported by Japanese government to pursue his master's degree in Thailand specializing in transportation engineering. His research mainly focused on urban transportation planning and travel behavior. Nguonsong planned to get into professional work for several years first before extending his research in another degree, and then returning back to his home country for a public-sector work.