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STATED PREFERENCE ANALYSIS OF BUS SERVICE ATTRIBUTES IN PHNOM PENH

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A Thesis Submitted in Partial Fulfillment of the Requirements

for the Degree of Master of Engineering Program in Civil Engineering

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ระบบการขนส่งในกรุงพนมเปญยังขาดการขนส่งสาธารณะที่เหมาะสมในปัจจุบัน ปริมาณรถจักรยานยนต์ที่ค่อนข้างสูงก่อให้เกิดปัญหาการจราจรติดขัดในเขตเมือง โดยที่ยังไม่มีรูปแบบการขนส่งสาธารณะด้วยรถประจำทางภายในเขตเมือง แม้ว่ารูปแบบดังกล่าวจะจัดเป็นแนวทางที่ยั่งยืนและสามารถช่วยลดปัญหาการจราจรได้ อนึ่งในการให้บริการรถโดยสารประจำทาง จำเป็นอย่างยิ่งที่จะต้องคำนึงถึงทัศนคติของผู้โดยสารต่อคุณลักษณะต่างๆของการให้บริการรถโดยสารสาธารณะ ในงานวิจัยนี้ ผู้วิจัยได้เสนอแนวทางในการสำรวจทัศนคติของผู้เดินทางต่อคุณลักษณะต่างๆของการให้บริการรถโดยสารสาธารณะในพนมเปญ โดยอาศัยการวิเคราะห์แบบ Stated Preference ผู้วิจัยได้สำรวจข้อมูลการเดินทางในปัจจุบันและการตัดสินใจเลือกใช้รถโดยสารสาธารณะของกลุ่มตัวอย่างโดยพิจารณาจากคุณลักษณะต่างๆ ได้แก่ อัตราค่าโดยสาร ความถี่ของรถโดยสาร ระยะเวลาในการเดินมายังป้ายรถโดยสาร และความสบายภายในรถโดยสาร จากข้อมูลดังกล่าวผู้วิจัยได้พัฒนาแบบจำลองอรรถประโยชน์ด้วยวิธี Conditional logistic regression และพิจารณาถึง trade-off ของคุณลักษณะต่างๆที่ทำการศึกษา จากแบบจำลองพบว่าคุณลักษณะด้านความสบายภายในรถโดยสารและอัตราค่าโดยสารมีนัยสำคัญค่อนข้างสูงสำหรับผู้เดินทางในพนมเปญ ผลที่ได้รับจากงานวิจัยคาดว่าสามารถช่วยให้เกิดความเข้าใจเกี่ยวกับทัศนคติของผู้เดินทางในประเด็นของรถโดยสารสาธารณะมากยิ่งขึ้น และสามารถนำไปใช้เป็นพื้นฐานของการวางแผนการให้บริการรถโดยสารสาธารณะในพนมเปญต่อไปได้

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Current transportation system in Phnom Penh indicates a lack of proper public transportation. With high number of motorcycles, traffic congestion within the city is getting worse. In addition, a formal public transport such as a bus service is not yet available in the city, although it can be considered a sustainable transportation mode and could potentially reduce the traffic congestion in the city. In order to introduce an efficient bus service, passengers' attitude towards bus service attributes is one of the main issues. In this study, a methodology was developed to elucidate the commuters' attitude towards the bus service in Phnom Penh via stated preference analysis. A survey was conducted to collect current travel information and decision behaviors of respondents regarding bus patronage considering several bus service attributes, namely bus fare, bus headway, walking time and bus comfort. A utility model was developed using conditional logistic regression and the passengers' trade-offs between each attribute were analyzed. As a result, it was found that two attributes, i.e. bus comfort and fare were among the most significant attributes for commuters in Phnom Penh. The findings of this research are expected to further the understanding of passengers' viewpoint on basic attributes of the bus service and the results can be used as a fundament in a strategic planning for establishing the bus service in the city of Phnom Penh.

Department: Civil Engineering	Student's Signature ....
Field of Study: Civil Engineering	Advisor's Signature ....
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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER I

INTRODUCTION

1.1 Introduction

The fast growing population and urban development of Phnom Penh has recently caused several traffic problems. First, the number of vehicles circulating through the city and daily trips has been increasing due to an increase in urban population. Secondly, the capacity of road network in both urban and suburban areas, including national roads, cannot support the growing traffic demand, and the pavement status is generally in poor conditions. In addition, many motorists do not respect traffic rules; some even do not understand the traffic signs. To exacerbate the problem, there is a lack of traffic signals at some locations. Currently, there is no proper public transportation in the city. Only motorcycle-taxis (motodups) and tricycles (cyclos) are available. Motodups are used by non-commuters for temporary or urgent use only, while cyclos are typically used to transport goods for a short distance. Bus service is only available for inter-city travel.

One of the reasons for the increase in traffic congestion is that there is no proper public transportation mode. A lack of proper public transportation can potentially cut down the number of trips, resulting in a negative impact to the economics and society development. In such a situation, it is hoped that the introduction of intra-city bus service will be beneficial and help improve the current traffic and transportation system in Phnom Penh. Therefore, there is a need to conduct a transportation planning research study in order to elucidate the passengers' behavior towards the system.

1.2 Problem Statement

Inadequate transport facilities and management system best describe the current situation of transportation system in Phnom Penh. Traffic signals, signs and pavement marking are not sufficient, and the pavement conditions of most road network are poor. Currently, most of urban public transport relies on the motodup, which is the only public transport mode available. However, the motodup is considered unsafe, uncomfortable, inefficient, and is probably a major cause of traffic congestion.

According to a previous study conducted by JICA in 2001, the intra-city bus service was recommended, and traffic demand for the bus service was found to be sufficient for providing the service (JICA, 2001). Based on the study, the public transport system has been proposed based on the future urban size (population and area), income level, and public transport demand in Phnom Penh. It is expected that the intra-city bus system will be one of the most appropriate public transport systems for the Phnom Penh Metropolitan Area in the future.

One of the major issues in bus service planning is to investigate passengers' demand. For example, a reasonable fare should be introduced to suit the passengers' low standard of living. Contrarily, if people do not mind a long elapse time of waiting for a bus, the bus headway can be adjusted. In this sense, it is necessary to understand passengers' trade-offs on bus service attributes such as bus fare, bus headway, walking distance from home to a bus stop/bus stop to a destination and bus comfort.

1.3 Research Objectives

The study has been designed to investigate the attitudes of commuters in Phnom Penh as a source of information for decision makers and transportation planners to decide the feasibility of starting a bus service in the city. Four main objectives are set for the present study:

1. To review current traffic and transportation situations in Phnom Penh
2. To examine passengers' likelihood of using bus service system in Phnom Penh city if introduced in the future
3. To analyze users' tradeoff between each of the bus service attributes, namely, bus fare, bus headway, walking time, and bus comfort.

1.4 Scope of the Research

The scope of the study will be limited to potential passengers in Phnom Penh, the capital city of Cambodia. A stated preference survey will be employed. A set of bus service scenario generated from orthogonal design will be presented during the survey. Target subjects will be car users, motodup users, motorcyclists, bicyclists and pedestrians, who are traveling or stopping by in the survey areas. The survey interview will take place in several business areas in Phnom Penh.

1.5 Expected Benefits

Upon the completion of the study, the following benefits are expected:

1. Passengers' behaviors will be revealed in such trade-off between all attributes by a utility function
2. Research results will shed some light on intra-city bus service planning in terms of its service, demand and fare
3. The analysis results can be additionally used for future research and study on transportation planning in order to establish an appropriate service of an intra-city bus system in Phnom Penh.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

Phnom Penh, the capital city of Cambodia, stands right at the intersection of the four rivers, namely, upstream Mekong, Tonle Sab, Tonle Bassac, and downstream Mekong. With this favorable location, Phnom Penh is the center of tourism, commerce, industry and communication of the country. The four rivers provide potential freshwater and river ecosystem as important resources for sustainable environment condition, beauty of nature and prosperous culture for people of Phnom Penh from the past to the present time (MPP, 2004). Furthermore, waterway is also available, especially during raining season from June to November every year. Tonle Sab can be used efficiently in raining season as a waterway between Phnom Penh and Siem Reap, where Angkor Wat is located.

The capital city and its suburb cover 375 square kilometers, consisting of 11,401 hectares of rice-field, and 26,106 hectares of roads, wetland, resettlement and lakes (MPP, 2004). The agriculture land of about 34.685 square kilometers is located in three suburban areas, namely, Dangkoar, Mean Chey and Reussey Keo communes.

The total population of Cambodia amounts to 14 million in 2007 with a growth rate of 1.78%. With its land area of 181,035 square kilometers, the density of 77 persons per square kilometer is quite low (126 persons per square kilometer for Thailand). The population in the city of Phnom Penh amounts to 2 million, which is 14.3% of the total population.

2.1.1 Road Network

Road network can be considered a basic infrastructure supporting a transport system. The road network in Phnom Penh is generally divided into two categories, the urban and suburban road networks.

1. Urban Road Network

Phnom Penh has a well-planned urban road network; however, pavement conditions of most urban roads are very poor, particularly for collectors and local streets. As a result, vehicles tend to detour to arterial streets, usually causing traffic congestion. Some sections of the collectors and local streets are sometimes flooded and cannot be used during rainy season.

2. Suburban Road Network

The majority of municipal roads are in very poor conditions with insufficient width and unpaved rough surface. Some bridges on these roads are severely deteriorated and are not convenient for passenger cars and small trucks. There are also some missing links on the arterial road network such as the outer ring roads. Due to such problems, the suburban road network is not functioning properly, causing traffic congestion and a lack of proper transport services to many remote villages.

Consequently, both urban and suburban road networks are not only imposing inconveniences to the citizens in their daily activities but also expected to be unable to support the growing traffic in the metropolitan area of Phnom Penh. It is expected that there will be severe traffic congestion mainly on urban streets and some sections of national roads immediately outside of the urbanized area in the target year of 2015, if no measures are to be taken (MPWT, 2005).

2.1.2 Characteristics of Public Transport

There are mainly eight modes of public transportation currently operating in Phnom Penh, as shown in Table 2.1. Interestingly, taxi and bus service, which are common public transport modes in urban areas, are not available in the city except airport taxis painted yellow and white serving only passengers at the airport. In terms of inter-city transportation, buses and taxi-buses (van, pick-up and sedan) typically provide inter-city service. Buses are more convenient because they are operated throughout the time schedule with fixed departure times, while taxi-buses will depart only when passengers are fully loaded and most often are over loaded.

Table 2.1 Public Transport Modes in Phnom Penh (JICA, 2001)

No.	Mode	Operation	Responsible Agency	Type of Service	No. of Terminals	No. of Fleet
1	Air transport	N/A	State Secretariat of Civil Aviation	International/ Inter-city	Phnom Penh International Airport	N/A
2	Railway transport	Royal Railways of Cambodia	Royal Railways of Cambodia	Inter-city	3 stations in Phnom Penh	29 locomotives 239 wagons
3	River transport	Private Sector	Department of Inland Waterway Transport/ Department of Water Transport	Inter-city/ Intra-city	6 jetties for 7 ferry routes (3 for intra-city and 4 for inter-city)	7 boats
4	Bus	Private Sector	Ministry of Public Works and Transport/ Department of Public Works and Transport	Inter-city	5 terminals	50
	Taxi-bus				6 terminals	2,660
5	Taxi	Private Sector		Intra-city	No Terminal	82
6	Motodup					6098
7	Cyclo					1203
8	Motorumok/ Cyclerumok					227

Motodups, motorumoks and cyclos, which are common public transport modes in the city, are only para-transit. Because of its high level of service in terms of frequency and door-to-door service, motodups are probably regarded as the most popular public mode of transport in Phnom Penh. The motorumok, a motorcycle attached with a cart, are usually used in suburban areas, mainly by factory workers to commute to/from work and by farmers to transport their agricultural goods to the city. The cyclos, which are traditional 3-wheel bicycles, are especially used by people leaving from the market with heavy stuffs. Due to their low speed and labor-based, cyclos are not popular nowadays. The number of cyclos has decreased from 10,000 in 1980's to just 1,200 in recent years (JICA, 2001).

In terms of rail transportation, the Royal Railways of Cambodia operates a 650-kilometers railway network comprising two lines from Phnom Penh towards the sea port and another commercial area in the western province. For water transportation, the River transport operates over a total length of about 1,400 kilometers in rainy season and less than 650 kilometers in summer. As for air transportation, the air transport network comprises 9 international routes and 7 domestic routes, centered at Phnom Penh International Airport which is served by 19 airlines. The total annual number of air passengers was approximately 1,300,000 in 2006 (Airport of Phnom Penh, 2006).

Table 2.2 Operational Characteristics of Para-transit in Phnom Penh (JICA, 2000)

Motodup		Cyclo	Motorumok
Average Working Hours per Day (hour)	9	9.2	8.3
Average No. of Trips per Day (trip)	9.5	8.7	5.2
Average No. of Pax per Trip (person)	1.4	1.6	7
Average Fare per Pax per Trip (Riel)	808	755	945
Average Trip Length (kilometers)	4.1	1.8	20.1

Table 2.2 presents the operational average trip length of 4.1 kilometers for motodup, 1.8 kilometers for cyclo and 20.1 kilometers for motorumok. The average number of daily trips is 9.5 for motodup, 8.7 for cyclo and 5.2 for motorumok. Besides, the average fare per passenger per trip is around 800 and 900 Riel for these modes.

Table 2.3 Vehicle Statistics in Phnom Penh (CIPS, 2004)

Vehicles/Year	1998	2000	2002	2004
Cars, minibuses and pickups	144,830	151,090	162,997	185,420
Bus	2,387	2,483	2,736	3,045
Trucks	18,781	25,876	27,830	30,448
Other vehicles	317	371	421	440
Motorcycles	361,441	426,571	487,217	537,772
Total vehicles	527,756	606,391	681,201	757,125
% increase per year	-	7.45%	6.17%	5.57%

Table 2.3 shows vehicle statistics in Phnom Penh. It can be observed that the number of vehicles has been increasing from year to year. The majority of vehicles in the city are motorcycles, which is amounted to 537,772 in the year 2004. According to a previous survey (CIPS, 2004), not all of the vehicles were registered. In fact, it was found that nearly half of the motorized vehicles were not registered. From Tables 2.3 and 2.4, the number of total registered vehicles throughout the country does not even amount to the total vehicles in Phnom Penh alone. Due to the government's strict regulation, many vehicles are now registered so that in case of loss, there might be more possibility to find and retrieve them back.

Table 2.4 Vehicle Registration Statistics of Cambodia (ADB, 2002)

Registered Motorcycles	336,502
Registered Cars	64,805
Registered Buses	1,331
Registered Light Commercial Vehicles	28,746
Registered Trucks	15,321
Registered Other Vehicles	723
Total Registered Vehicles	447,428

Figure 2.1 shows a variety of public transportation in Phnom Penh. Three-wheel rumok in figure (a) is recently seen operating in the city and is popular for tourists since no taxi service is available. The cyclo in figure (b) is tricycle, which is mostly used by passengers with belongings. The motorumok in figure (c) usually operates in suburban area and is popular for factory workers for its fair price. The pick-up in figure (d) transports passengers from city to other provinces similarly to the taxi-bus in figure (f) but with lower price. In 2001, both inter-city buses in figure (e) and taxi-buses were prohibited from entering the city; however, recently they can enter the downtown area. The motodup in figure (g) is the most popular public transport mode in Phnom Penh because taxi in figure (h) is available only from the airport to downtown.

(a) Three-wheel rumok

(b) Cyclo

(c) Motorumok

(d) Pick-up

(e) Inter-city bus

(f) Van (inter-city taxi bus)

(g) Motorcycle-taxi (motodup)

(h) Taxi

Figure 2.1 Varieties of Public Transport Modes in Phnom Penh

2.1.3 Level of Services

Table 2.5 shows the average travel speed over the entire sections of the major roads in Phnom Penh. The average travel speeds of the major arterial roads are clearly within the lowest acceptable range (LOS D). However, the Highway Capacity Manual defines "LOS D" as the situation where "small increase in flow may cause a substantial increase in delay and hence decrease in speed". Therefore, even a small increase in traffic volume on these roads will lead to severe traffic congestion. In addition, travel speeds of those sections with LOS C are close to that of LOS D. Based on these facts, the traffic condition on the urban arterial roads is approaching an unacceptable level.

Table 2.5 Travel Speed and Level of Service on Arterial Streets (JICA, 2001)

Street Name		Direction	AM peak		Noon		PM peak		Average	
			Km/h	LOS	Km/h	LOS	Km/h	LOS	Km/h	LOS
Radial roads	France/ Norodom	N-bound	21.3	C	28.2	C	24.8	C	26.3	C
		S-bound	22.3	C	29.0	C	20.7	D	25.4	C
	Monivong	N-bound	19.9	D	26.2	C	20.6	D	23.3	C
		S-bound	22.4	C	26.3	C	20.7	D	23.8	C
	Charles de Gaulle/ Monireth	NE-bound	14.1	D	20.4	C	16.4	D	17.4	D
		SW-bound	18.9	D	17.5	D	17.2	D	18.0	D
	Confederation de la Russie	E-bound	27.6	B	39.1	B	26.7	C	31.9	B
		W-bound	27.8	B	37.2	B	25.8	C	32.0	B
Ring roads	Inner ring road	S/E-bound	18.7	C	21.9	C	20.4	D	20.5	C
		W/N-bound	18.7	C	21.1	C	19.4	D	20.1	C
	Kim Il Sung /Mao Tse Tung/ Sisowath	S/E/N-bound	20.6	C	29.8	C	21.9	C	24.9	C
		S/W/N-bound	21.5	C	27.4	C	20.0	D	24.3	C
	Jawaharlal Nehru/ Sihanouk	S/E-bound	14.6	C	24.2	C	18.3	D	21.0	C
		W/N-bound	18.5	C	24.0	C	16.6	D	20.6	C

In conclusion, transportation system in Phnom Penh indicates poor management and lack of facilities. With levels of service of D and E in general, most vehicles can go at relatively low speed. The main reason is that the pavement of most roads is in poor condition. In addition, a variety of vehicles circulating on the road and a large number of motorcycles make the traffic congestion worse.

Currently, most of the public transportations rely on motodups which are the only public transportation mode in the city. Providing door to door service, motodups are very popular; however, they are considered unsafe. In this sense, a mass public transportation is needed. Therefore, it is hoped that an intra-city bus system will be the most appropriate mode of public transportation to help facilitate the traffic flow in the city and provide a safe and comfortable mode of public transport.

2.2 Previous Studies on Bus Service in Phnom Penh

In cooperation with the municipality of Phnom Penh, JICA implemented a one-month period of intra-city bus service in 2001 as an experiment. The purposes of the experiment were to identify potential and effects of bus services in Phnom Penh, to collect data for estimating the demand for bus services, to find out the problems to be solved for smooth operation of bus services in the city, and to help the citizens of Phnom Penh understand the merits of the bus system (JICA, 2001).

The accumulative total number of bus passengers reached 103,239 during the experimental period. The operation consisted of two bus lines, a straight line running through the city downtown areas from north to south, and a circle line crossing several business areas (see Figure 2.2). A 23-bus fleet was operated employing 88 staffs. According to the experiment, the average daily trip length per bus was approximately 95 kilometers and the average fuel consumption per bus was 4.5 kilometers/liter. The actual average travel speed was higher than the estimated figure, as shown in Table 2.6. The outline of the JICA's experiment of city bus operation is presented in Table 2.7.

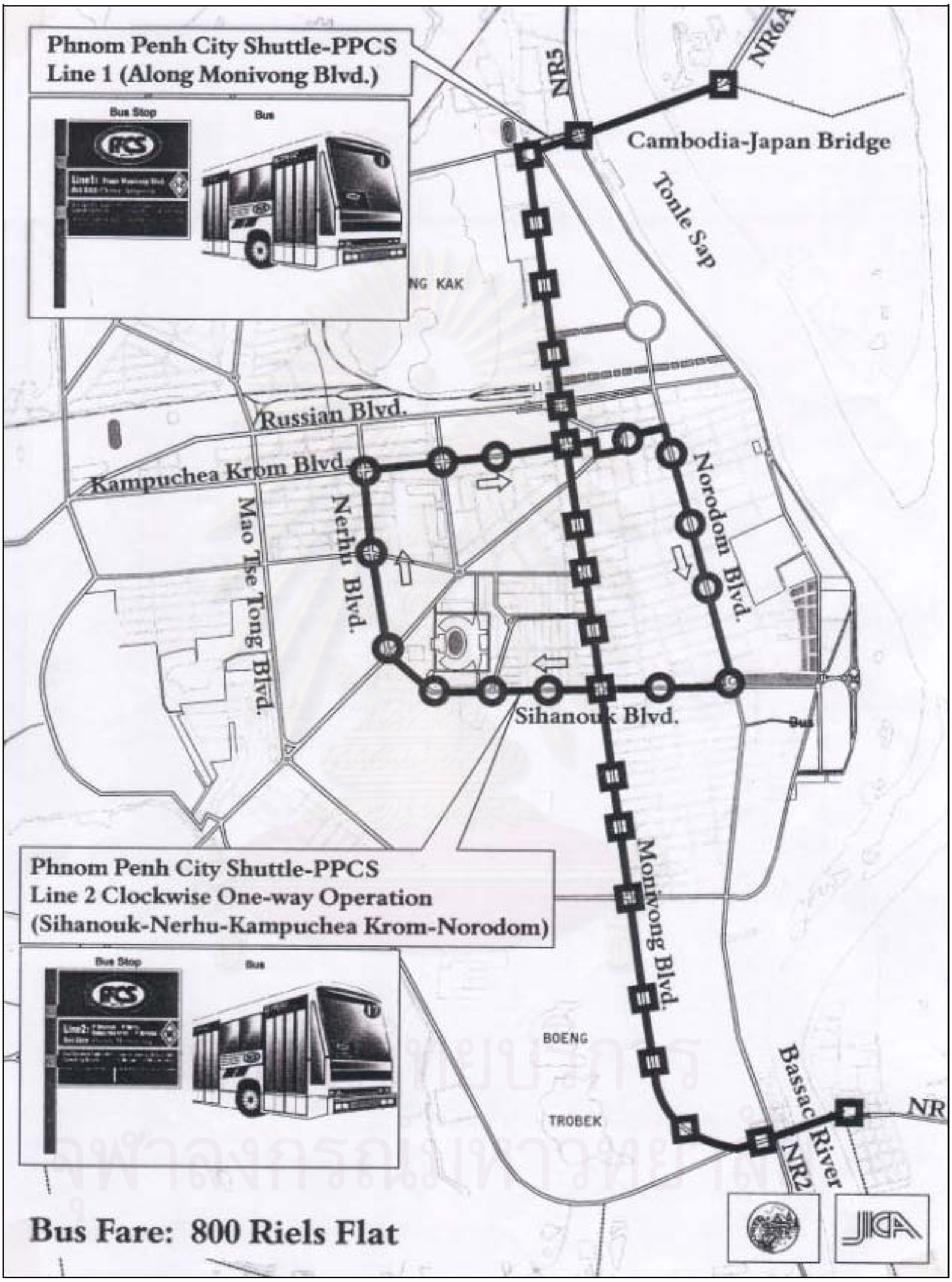


Figure 2.2 Bus Route for JICA’s Experiment (JICA, 2001)

Table 2.6 Bus Travel Speed (in kilometer per hour) (JICA, 2001)

Lines	Peak/Off-peak	Estimated (Before experiment)	Actual (During experiment)	Difference
Line 1	Peak	10.3	13.4	3.1
	Off-peak	11.8	14.4	2.6
Line 2	Peak	10.8	11.7	0.9
	Off-peak	12.5	14.5	2.0

Note: Bus travel speed at peak period is the average speed between 6:30-8:30 and 16:30-18:30

Bus travel speed at off-peak period is the average speed from 8:30-16:30

Table 2.7 Outline of Bus Operation Experiment (JICA, 2001)

a. Bus route	Radial route and ring route
b. Bus fleet	23 air-conditioned minibus (29 seats) with logo sticker, front board and designated number
c. Fare system	800 Riel flat fare
d. Operation hours and frequency	5:30-19:30 (14 hours) every 6-10 minutes
e. Bus stop and bus shelter	Installation of 56 bus stops and renovation of 8 shelters, a bus stop was provided every 300-500m
f. Improvement of the circumstances	Prohibition of motorcycles along bus route (along Monivong between Sihanouk and Charles de Gaulle), installation of bus stop marking, prohibition of parking in front of bus stop
g. Advertisement and others	Traffic campaign, public information by TV, radio, banner and newspaper, distribution of posters and pamphlets
h. Bus passenger demand forecast	500 Riel flat fare: 12,900 passengers/day 800 Riel flat fare: 4,900 passengers/day
i. Measures to help smooth operation	Prohibition of 2-wheeled vehicles on a section of Monivong Blvd. between Sihanouk Blvd. and Charles de Gaulle Blvd., also pavement of St. 63 and St. 105 was improved to provide detour routes

The experiment received widespread acceptance from passengers in Phnom Penh, and the degree of satisfaction was also high according to the interview survey. However, the most serious problem of the bus system was pointed out to be the waiting time of passengers at bus stops. Therefore, it is necessary to minimize passenger inconvenience at the bus stops by giving enough information of bus operation and setting up bus shelters at transfer points and bus stops located near traffic generation facilities such as markets and schools.

The experiment encountered some problems such as conflict between owners of shops in front of bus turning point, slight traffic accident, rumor of a motodup drivers' strike against the bus experiment, and illegal parking in the bus stop zone. Major achievements of the JICA's experiment were:

1. Potential of bus services in Phnom Penh was proved by smooth operation and large number of passengers.
2. Sufficient data were collected to estimate passenger demand.
3. Several problems on operation were identified and solved.
4. Bus services were well known and supported by the citizens.

The average daily passengers of the experiment were 3,441, with 4,687 passengers for the flat fare of 500 Riel and 2,738 passengers when the flat fare was set at 800 Riel. It was forecasted that in the year 2005, the bus passenger demand would be increased to 17,714 (five times the number of passengers of the experiment) for the operation of four bus lines with the same operating conditions as in the experiment. In addition, if the fare was reduced by 10% (by issuing coupon ticket and decreasing access time) the daily passenger demand would be up to 23,534. The forecast was based on the forecasted origin/destination of 2005.

2.3 Other Studies on Bus Services

2.3.1 Quality of Bus Service

Several aspects of bus service planning, namely, the bus quality of service and user's perceptions have been studied in literature. For instance, Samir (2001) looked into the level of service quality in bus service operation in Dhaka, Bangladesh. The objective of the study was to define the measure of effectiveness index over several performance measures, namely, travel time, waiting time, load factor, regularity of service, and comfort. The measure of effectiveness index consisted of six service levels from A through F, and was developed using analytic hierarchy process (AHP). Result found that the measure of effectiveness index of travel time was LOS D or LOS E comparing with the defined service categories due to the fact that no special priority on the road provided to the bus service, i.e. they had to run in the mixed mode situation, no special lanes for them. However, the measure of effectiveness index of waiting time, load factor and comfort were found to be LOS A, while regularity of service was found to be LOS C.

In Bangkok, Choocharukul (2004) investigated the quality bus service from passengers' viewpoint. The objective of the study was to develop a quality of service measure for passengers in Bangkok and to compare the obtained LOS thresholds with those outlined in the Highway Capacity Manual (HCM) and the Transit Capacity and Quality of Service Manual (TCQSM). In the study, 195 passengers were surveyed onboard from regular and air-conditioned buses. Several ordered probability models were developed and it was found that the LOS concept outlined in TCQSM did not fit well for commuters in Bangkok specifically the perceived load factor ranges were found higher than the TCQSM standard.

In Hanoi, Trinh (2005) investigated the existing bus system in order to examine bus service characteristics, user characteristics, and to analyze the deficiencies of bus service. Using GIS application, the research employed a survey of 1,000 bus users and people traveling or living along the 41 bus routes. Several performance indicators such as resource, service efficiency, and social effectiveness were analyzed. Results showed that the main reason why people did not use bus was the long walking distance from the bus stop to the destination and vice versa. According to the performance indicators, most bus companies operated the service ineffectively and inefficiently.

In another study, Guarino (2001) recently looked into the viability of consolidating bus companies operating in Metro Manila. It was recorded that, in 1996 there were 437 active bus companies, 19 of which provided more than 100 units of buses, and 263 bus companies had less than 10 units. These companies did not warrant market differentiation in terms of passengers' choice behavior because with too many bus companies, it would cause stiff competition for more profit among them and result in bus service in efficiency. It was found that passengers had no preference for bus companies that offered the service; they usually caught any bus that came on their way first as long as it took them to their destinations. Furthermore, the situation then did not warrant the promotion of new transport policies, such as intelligent fare collection and fare deregulation.

2.3.2 Passengers' Attitudes and Perceptions

From literature review, there are several past studies on the aspect of passengers' attitudes. For instance Phanikumar and Maitra (2006) conducted a study of bus transportation systems in Kolkata, India. The objective was to search for solutions to improve bus patronage that would help minimizing the usage of private vehicles, decreasing road congestion, and economically safeguarding the environment. The willingness-to-pay (WTP) values were estimated for various qualitative and quantitative attributes of bus service system in Kolkata. Based on trip purposes and socio-economic characteristics of users such as age, gender, income, household size, and car ownership, several statistical models, including multinomial logit (MNL) and random parameter logit (RPL), were employed. The WTP was estimated separately for commuting and non-commuting trips. From modeling estimates, it was found that travel time was valued higher than waiting time, which was not common in developed countries. Moreover, the WTP value for non-commuting users was higher than that of commuting users for qualitative attributes; and this was also true for the effect of socio-economic attributes especially for the high-income group.

Noticeably, the perception of passengers on the waiting time at bus stops is an important issue regarding bus service planning and operation. Commonly, passengers perceive the waiting time to be greater than the actual amount of waiting time. In addition, people are more willing to wait if they know the exact amount of time that they will have to spend waiting for a bus. To confirm this belief, a study conducted by Mishalani et al. (2006) aimed to quantify the relationship between perceived and actual waiting times, and the value of providing real time information to passengers at a bus stop in Columbus. The value of the eliminated additional time was also assessed in the form of reduce vehicle hours per day resulting from a longer headway. Results confirmed that the perceived waiting time was greater than the actual value when the waiting time fell in the range between 3 and 15 minutes. Moreover, there was a possibility that the difference between perceived and actual wait time increased under longer waiting time.

In another study, Sivakumar (2006) investigated users' attitudes towards bus rapid transit (BRT) in Sri Lanka by means of stated preference survey. The objectives of the study were to identify the effects of questionnaire design (media: images and text), literacy of users, the trade-off between important variables such as comfort and fare, and to compare preference of existing bus and bus rapid transit. Results found that questionnaire design in terms of image presentation was more efficient. Income level was not a good predictor but car ownership was and had a correlation with literacy. BRT was preferred comparing with the existing bus, especially car users who are generally viewed as high income class.

2.4 Stated Preference Analysis

Stated preference (SP) technique is recognized as a potential tool in consumers' behavior research. Under this technique, a survey is designed using experimental design to construct a series of hypothetical situations or scenarios. These scenarios are developed from the combinations of different levels of factors (attributes) that affect the decision of the respondents and are under the control of the analyst. Responses to different situations can be achieved by asking respondents to either select the most desirable alternative or rank/rate each scenario. Based on this analysis technique, a wide range of trade-offs can be investigated in order to study the influence of factors on respondents' preferences.

Ranking, rating, and choice are among the common techniques used in the SP scenarios. A recent research study comparing the appropriateness of the above techniques showed that each method has its own advantage depending on the circumstance of the survey. The length and degree of difficulty of the interview, data analysis and modeling tasks are the factors needed to be considered in using each method (Ortuzar et al., 1994).

The SP method was first used in 1963 to value hunting in Maine (Steven, 2005). Since then, SP valuation has become very popular. A recent review of the literature indicates that over 2,000 SP studies have been conducted (Carson, 2000). This method has been applied to a wide range of real world problems such as water quality, wilderness and wildlife preservation, air quality, health care, food safety, and especially transportation research. As noted by Carson (2000), most modern SP studies are undertaken for the purpose of policy evaluation. Many state agencies, governments, and international organizations like the World Bank are now using SP technique.

The SP technique has been widely applied throughout many areas of transportation. For instance, Copley (1991) used SP to study the demand for a proposed light rail system in Manchester. The objective of the study was to investigate the trade-off between a range of level of service attributes, namely, journey time, fares, frequency access, and egress time. A utility function was derived and provided as the basis for the calibration of a choice model between bus and rail.

Another example of application of SP is the study for Trainload Freight, a part of the ex-British railways in 1992 (Terzis, 1992). Its objective was to identify potential customers and to understand how those people decided to choose one among all alternative transport modes. The Train load Freight was a commercial enterprise responsible for the movement of coal, metals, aggregates, building materials, domestic waste and petroleum products. It was the only rail-based freight business in Western Europe that has operated profitably in such a trading environment. In the study, freight executives were invited to compare four alternative shipments described in terms of cost, reliability and responsiveness, and rate them in relative terms.

Application of SP in freight mode choice has been widely conducted in Europe because of the difficulties embodied in the revealed preference approach. Another SP application was conducted to measure the effects of parking on traffic congestion by Mede and Visser (1988). In the Netherlands, traffic congestion during peak hour occurred not only in the downtown area but also in the suburban area due to the increasing number of car ownership. It was believed that if people had to pay for parking at their workplace they would tend to change their travel modes. Thus, the SP was used in the form of ranking towards eight alternatives within one set. Several attributes were analyzed, including parking fee, searching time for parking space, walking time from parking space to work, and access time. Results revealed that parking fee had more effects in reducing car use than walking and searching time did.

In short, SP techniques are widely used throughout the field of transportation. Many studies have employed SP in the design of hypothetical scenarios. The SP method has been used with different techniques such as ranking, rating, and choices. In addition, SP is commonly employed together with orthogonal design, which is a method for the design of the experiments. Orthogonal design or fractional factorial design is necessarily used when the full factorial design of experiments cannot be conducted.

2.5 Theory of the Models

2.5.1 Theory of Binary Choice

From utility theory, an individual is assumed to choose the alternative for which the expected value of the utility is maximal. If such an assumption is accepted, the utility theory can be used to predict or prescribe the choice that the decision maker will make, or should make, among the available alternatives. The utility of any alternative is known as a random variable, in which its probability can be written as follows (Ben-Akiva and Lerman, 1985):

$$P(i \mid C_n) = \Pr(U_{in} \geq U_{jn}, \forall j \in C_n) \tag{5.1}$$

From Eq. (5.1), $P(i \mid C_n)$ is the probability of any alternative i being selected by individual n from the choice set C_n.

For binary choices, the choice set C_n has only two alternatives, which can be denoted as $\{i, j\}$. Therefore, the probability of individual n choosing alternative i and j are

$$\begin{aligned} P_n(i) &= \Pr(U_{in} \geq U_{jn}) \\ P_n(j) &= 1 - P_n(i) \end{aligned} \tag{5.2}$$

As random variable, the utility can be separated into two components as follows:

$$\begin{aligned} U_{in} &= V_{in} + \varepsilon_{in} \\ U_{jn} &= V_{jn} + \varepsilon_{jn} \end{aligned} \tag{5.3}$$

From Eq. (5.3), V_{in} and V_{jn} are called the systematic components of the utility i and j; ε_{in} and ε_{jn} are the random parts or disturbances. Manski (1973) identified the sources of randomness as unobserved attributes, unobserved taste variations, measurement errors and imperfect information, and instrumental (or proxy) variables.

The systematic components, V_{in} and V_{jn}, which are functions and assumed to be deterministic (nonrandom), can be perceived as the means of U_{in} and U_{jn}, respectively. Another way to explain the relative nature of the utilities is to rewrite the probability as:

$$\begin{aligned} P_n(i) &= \Pr(U_{in} \geq U_{jn}) \\ &= \Pr(V_{in} + \varepsilon_{in} \geq V_{jn} + \varepsilon_{jn}) \\ &= \Pr(\varepsilon_{jn} - \varepsilon_{in} \leq V_{in} - V_{jn}) \end{aligned} \quad (5.4)$$

From Eq. (5.4), all that matters is whether the difference in the V's is less than the difference in the ε's. The systematic component of the utility V_{in} and V_{jn} can be expressed as:

$$\begin{aligned} V_{in} &= V(x_{in}), \quad x_{in} = h(Z_{in}, S_n) \\ V_{jn} &= V(x_{jn}), \quad x_{jn} = h(Z_{jn}, S_n) \end{aligned} \quad 5.5)$$

Z_{in} – vector of trip attributes (such as fare, walking time, comfort, etc.)

S_n – vector of socio-economic attributes (such as age, gender, income, etc.)

Therefore, the systematic components of the utility can be written as:

$$\begin{aligned} V_{in} &= \beta_1 x_{in1} + \beta_2 x_{in2} + \beta_3 x_{in3} + \ldots + \beta_K x_{inK}, \\ V_{jn} &= \beta_1 x_{jn1} + \beta_2 x_{jn2} + \beta_3 x_{jn3} + \ldots + \beta_K x_{jnK} \end{aligned} \quad (5.6)$$

2.5.2 Binary Logistic Regression

Binary (or binomial) logistic regression is a form of regression that is used when the dependent variable is a dichotomy and the independent variables are of any type. Logistic regression can be used to predict a dependent variable on the basis of continuous or categorical independent variables. Generally, logistic regression results can be used to determine the percent of variance in the dependent variable explained by the independent variables with the value of a pseudo R^2, to rank the relative importance of independent variables by looking at their t-statistics, and to assess potential interaction effects. In logistic regression, the dependent variable is transformed into a logit variable (log of the odds), which estimates the probability of a certain event occurring, i.e. the changes in the log of the odds of the dependent, not changes in the dependent itself.

Logistic regression and OLS (Ordinary Least Square) regression have many properties in common. For example, logit coefficients correspond to beta coefficients in the logistic regression equation, and the standardized logit coefficients correspond to beta weights. However, logistic regression does not make restrictive assumptions like OLS regression. For example, linear relationship between the dependents and the independents is not required; normal distribution is not necessary but at least the distribution must be poisson, binomial, gamma, etc.; homoscedasticity is not necessary; and normal distribution of error terms is not required.

The binary logit model arises from the assumption that $\varepsilon_n = \varepsilon_{jn} - \varepsilon_{in}$ is logistically distributed, namely,

$$\begin{aligned} F(\varepsilon_n) &= \frac{1}{1+e^{-\mu\varepsilon_n}}, \quad \mu > 0, \quad -\infty < \varepsilon_n < \infty \\ f(\varepsilon_n) &= \frac{\mu \times e^{-\mu\varepsilon_n}}{(1+e^{-\mu\varepsilon_n})^2} \end{aligned} \tag{5.7}$$

From Eq. (5.7), μ is a positive scale parameter. Under the assumption that ε_n is logistically distributed, the choice probability for alternative *i* is given by

$$\begin{aligned} P_n(i) &= \Pr(U_{in} \geq U_{jn}) \\ &= \frac{e^{\mu V_{in}}}{e^{\mu V_{in}} + e^{\mu V_{jn}}} \\ &= \frac{1}{1+e^{-\mu(V_{in}-V_{jn})}} \end{aligned} \tag{5.8}$$

2.5.3 Theory of Multinomial Choice

In a more general case, rather than having two alternatives, the choice set, C_n, may consist of many alternatives. The number of alternatives within a choice set may vary across individuals since for certain circumstances, a particular alternative may not be feasible for a group of individual. In such instances, analysis of multinomial choice becomes more complex than binary choice analysis; particularly, assumption on univariate distribution of the differences in disturbances, $\varepsilon_{jn} - \varepsilon_{in}$, is not sufficient. Instead, the complete joint distribution of all the disturbances needs to be characterized.

Given the number of feasible choices for each individual, $J_n \le J$, the probability that any alternatives *i* within choice set, C_n, is chosen by decision maker *n* is given by (Ben-Akiva and Lerman, 1985)

$$\begin{aligned} P_n(i) &= \Pr(U_{in} \ge U_{jn}, \forall j \in C_n) \\ &= \Pr(V_{in} + \varepsilon_{in} \ge V_{jn} + \varepsilon_{jn}, \forall j \in C_n) \\ &= \Pr(\varepsilon_{jn} \le V_{in} - V_{jn} + \varepsilon_{in}, \forall j \in C_n) \end{aligned} \quad (5.9)$$

Eq. (5.9) can be used to derive particular multinomial choice models given specific assumptions on the joint distribution of the disturbances. If $f\left(\varepsilon_{1n}, \varepsilon_{2n}, ..., \varepsilon_{J_n n}\right)$ denotes the joint density function of the disturbance terms, without loss of generality consider alternative *i* to be the first alternative in C_n,, then

$$P_n(1) = \int_{\varepsilon_{1n}=-\infty}^{\infty} \int_{\varepsilon_{2n}=-\infty}^{V_{1n}-V_{2n}+\varepsilon_{1n}} ... \int_{\varepsilon_{J_n n}=-\infty}^{V_{1n}-V_{J_n n}+\varepsilon_{1n}} f\left(\varepsilon_{1n}, \varepsilon_{2n}, ..., \varepsilon_{J_n n}\right) d\varepsilon_{J_n n} d\varepsilon_{J_n -1,n} ... d\varepsilon_{1n} \quad (5.10)$$

From Eq. (5.10), it is not easy to calculate $P_n(i)$; thus, a convenient way is to express $P_n(i)$ with the cumulative distribution function of the disturbances $F_i\left(\varepsilon_{1n}, \varepsilon_{2n}, ..., \varepsilon_{J_n n}\right)$. Then

$$P_n(1) = \int_{\varepsilon_{1n}=-\infty}^{\infty} F_1\left(\varepsilon_{1n}, V_{1n} - V_{2n} + \varepsilon_{1n}, V_{1n} - V_{3n} + \varepsilon_{1n}, ..., V_{1n} - V_{J_n n} + \varepsilon_{1n}\right) d\varepsilon_{1n} \quad (5.11)$$

Another way to express $P_n(i)$ is to reduce the multinomial choice to a binary one. In this case, we note that the condition $U_{in} \ge U_{jn}, \forall j \in C_n, j \ne i$, is equivalent to $U_{in} \ge \max_{\substack{j \in C_n \\ j \ne i}} U_{jn}$. Then

$$P_n(i) = \Pr\left[V_{in} + \varepsilon_{in} \geq \max_{\substack{j \in C_n \\ j \neq i}} \left(V_{jn} + \varepsilon_{jn} \right) \right] \tag{5.12}$$

Since U_{jn} is a random variable, $\max_{\substack{j \in C_n \\ j \neq i}} U_{jn}$ will also be random; and we need to derive the distribution of the utility of this composite alternative from the underlying distribution of the disturbances, F. This task is not an easy one; however, it is feasible in the multinomial logit case.

The multinomial logit model can be expressed as

$$P_n(i) = \frac{e^{V_{in}}}{\sum_{j \in C_n} e^{V_{jn}}} \tag{5.13}$$

If we assume that $U_{in} = V_{in} + \varepsilon_{in}$, for all $i \in C_n$, and that all the disturbances ε_i are independent and identically distributed, and also Gumbel-distributed with a location parameter η, and a scale parameter $\mu > 0$, then

$$P_n(i) = \frac{e^{\mu V_{in}}}{\sum_{j \in C_n} e^{\mu V_{jn}}} \tag{5.14}$$

From the basic properties of Gumbel distribution, multinomial logit model can be derived by assuming that $\eta = 0$ for all the disturbances, and that $i = 1$, then

$$P_n(1) = \Pr\left[V_{1n} + \varepsilon_{1n} \geq \max_{j=2,\ldots,J_n} \left(V_{jn} + \varepsilon_{jn} \right) \right] \tag{5.15}$$

Define $U_n^* = \max_{j=2,\ldots,J_n} (V_{jn} + \varepsilon_{jn})$, where U_n^* is Gumbel distributed with parameters $\left(\frac{1}{\mu} \ln \sum_{j=2}^{J_n} e^{\mu V_{jn}}, \mu \right)$. We can write $U_n^* = V_n^* + \varepsilon_n^*$, where $V_n^* = \frac{1}{\mu} \ln \sum_{j=2}^{J_n} e^{\mu V_{jn}}$, and ε_n^* is Gumbel distributed with parameters (0, μ).

Since:

$$
\begin{aligned}
P_n(1) &= \Pr\left[V_{1n} + \varepsilon_{1n} \geq V_n^* + \varepsilon_n^*\right] \\
&= \Pr\left[(V_n^* + \varepsilon_n^*) - \left(V_{1n} + \varepsilon_{1n}\right) \leq 0\right]
\end{aligned}
\tag{5.16}
$$

Then:

$$
P_n(1) = \frac{1}{1 + e^{\mu(V_n^* - V_{1n})}} = \frac{e^{\mu V_{1n}}}{e^{\mu V_{1n}} + e^{\mu V_n^*}} = \frac{e^{\mu V_{1n}}}{e^{\mu V_{1n}} + \exp\left(\ln \sum_{j=2}^{J_n} e^{\mu V_{jn}}\right)} = \frac{e^{\mu V_{1n}}}{\sum_{j=1}^{J_n} e^{\mu V_{jn}}} \tag{5.17}
$$

There are two limiting cases of the multinomial logit model that result from extreme values of μ (Ben-Akiva and Lerman, 1985):

1. As $\mu \to 0$, the variance of the disturbances approaches infinity. The choice model then provides no information, so the alternatives are equally likely.

$$
\lim_{\mu \to 0} P_n(i) = \frac{1}{J_n}, \forall i \in C_n \tag{5.18}
$$

2. As $\mu \to \infty$, the variance of the utility disturbances approaches zero and a deterministic choice model is obtained because all the information about individual preferences is included in the systematic utilities.

$$
\begin{aligned}
\lim_{\mu \to \infty} P_n(i) &= \lim_{\mu \to \infty} \frac{1}{1 + \sum_{\substack{j \in C_n \\ j \neq i}} e^{\mu\left(V_{jn} - V_{in}\right)}} \\
&= \begin{cases} 1 & \text{if } V_{in} > \max\limits_{\substack{j \in C_n \\ j \neq i}} V_{jn} \\ 0 & \text{if } V_{in} < \max\limits_{\substack{j \in C_n \\ j \neq i}} V_{jn} \end{cases}
\end{aligned}
\tag{5.19}
$$

In the event of a tie among the utilities for some of the alternatives, $V_{in} = \max\limits_{\substack{j \in C_n \\ j \neq i}} V_{jn}$, the limit is $1/J_n^*$ for the J_n^* alternatives for which $V_{in} = \max\limits_{j \in C_n} V_{jn}$, $i = 1, ..., J_n^*$, and is zero for the remaining $J_n - J_n^*$ alternatives.

CHAPTER III

METHODOLOGY

3.1 Research Procedures

To achieve the research objectives, the procedure is designed as shown in Figure 3.1. First, a literature of basic information in Phnom Penh, including vehicles and traffic statistics, was reviewed. In addition, the previous studies on bus service in Phnom Penh and other metropolitan areas were examined. After that, a pilot survey was conducted to test the feasibility of the study, the readability and understandability of the questionnaires, and the efficiency of the developed survey forms.

Following the pilot survey, a verification of the questionnaires and the whole structure of the survey was considered. The main data collection was collected with a larger sample size to assure the level of statistical significance. In designing the scenarios, an orthogonal design was used in both pilot and main surveys. After the main survey, a database was created by cleaning and coding the raw data. Several computer programs were considered for data input such as SPSS, Stata/SE 8, and Microsoft Excel. Once the database was ready for analysis, several statistical models were developed. Different models were tested in the present study and results were discussed in terms of the trade-off of the significant attributes.

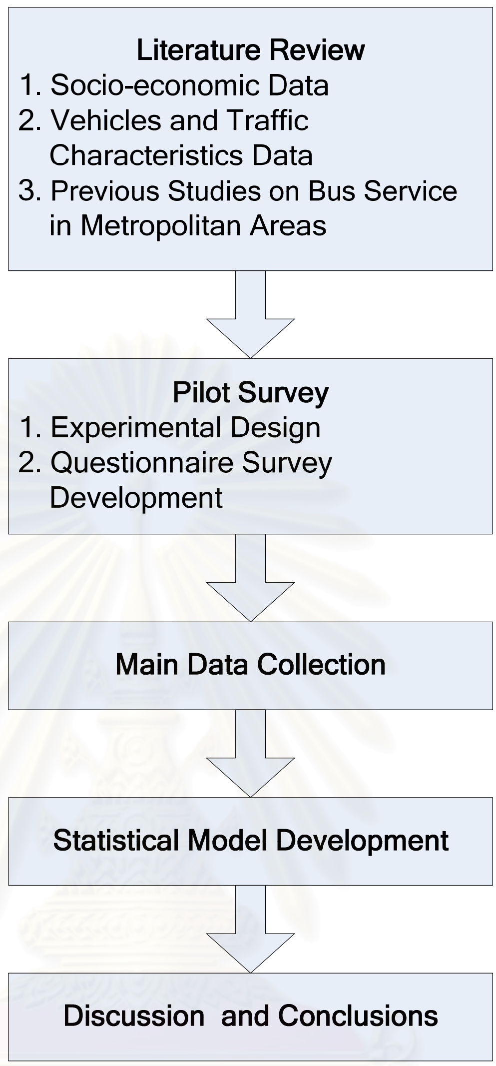


Figure 3.1 Research Procedures

3.2 Pilot Survey

3.2.1 Data Collection

In order to obtain reliable results, a pilot survey is needed. The benefits of conducting the pilot survey are mainly to explore potential flaws of the survey instruments and data collection procedure. In addition, the pilot survey is a guiding tool to the feasibility of the main survey. In this research, passengers' likelihood in using the intra-city bus service was obtained through the pilot survey.

The sample size in this study was determined by Stratified Random Sampling (SRS) technique, in which the sample was composed of small groups of respondents called strata. In stratified random sampling, the entire population was divided into G mutually exclusive and collectively exhaustive groups, each of which called a stratum. After that N_{sg} observations were sampled from each stratum using simple random sampling, in which s denotes the sample, g denotes the subgroup in the population, and $N_s = \sum_{g=1}^{G} N_{sg}$. Therefore, it is important to know the proportion of each stratum or subpopulation compared to the whole sample or whole population to be able to decide on each stratum size (Ben-Akiva, 1985).

For the present study, travel mode and occupation were considered strata. Proportion for each stratum was considered based on the actual proportion of population in the city from a previous JICA study (JICA, 2001). From JICA study, the proportions of students, workers, sellers, and other occupations were 40%, 30%, 20%, and 10%, respectively. In addition, the proportion of travel mode for cars, motorcycles, motodups, and bicycles were found to be 20%, 35%, 20% and 25%, respectively (JICA, 2001). Due to time and budget constraints for the pilot survey, a sample size of 125 respondents was determined. The results of the sample size from the pilot survey are categorized as shown in Table 3.1.

Table 3.1 Sample Size for Pilot Survey

1	Occupation	Student	Worker	Seller	Other	Total
	Percentage	51.2%	26.8%	11.8%	10.2%	100%
	Number of respondents	65	34	15	13	127
2	Mode of Travel	Car	Motorcycle	Motodup	Bicycle & Walking	Total
	Percentage	14.3%	48.4%	9.5%	27.8%	100%
	Number of respondents	18	61	12	35	126

The pilot survey was conducted on the 6th of November, 2006, at the central business district, Phsar Thom Thmey, in Phnom Penh (see Figure 3.2). Five people were hired to conduct the survey. Each of them had been trained with the developed survey forms until they fully understood how to explain the questionnaires to the respondents before conducting a field survey.

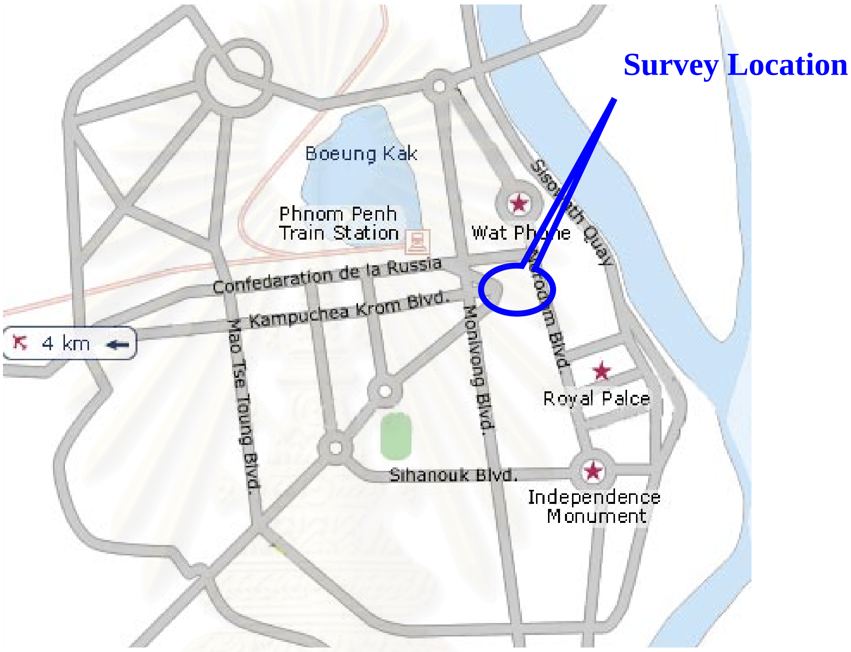


Figure 3.2 Pilot Survey Location

To obtain information needed and to provide data for the analysis of passengers' attitude towards the attributes of the intra-city bus service, a set of questionnaires was designed in the pilot survey. The items asked in the survey form consisted of passengers' socio-economic status, trip characteristics, and the likelihood of using the intra-city bus service under hypothetical scenarios. The two-sheet questionnaire survey form was translated from English into Cambodian. The first page of the survey covered the introduction and three sets of hypothetical scenarios. The second page comprised socio-economic status, trip characteristics, and the likelihood of using the intra-city bus service of respondents. Table 3.2 shows the five attributes with their corresponding levels used in pilot survey scenarios.

From Table 3.2, the three levels in the basic fare and additional fare per kilometer were determined based on the current cost in using the motodup. Waiting time levels were designed according to the bus frequency of 10, 5, and 3 buses per hour. Walking distance levels were designed according to the distance between two bus stops, which was normally considered to be 200 meters for urban areas, and 300 to 500 meters for suburban areas (JICA, 2001). Regarding the bus comfort, three levels, i.e. normal (no fan, no A/C), fan, and air-conditioned, were considered.

Table 3.2 Attributes and their Corresponding Levels

Attributes	Levels		
	Low	Medium	High
Basic Fare (Riel)	300	500	700
Additional Fare Per Kilometer (Riel)	100	200	300
Waiting Time (minute)	3	6	9
Walking Distance (meter)	50	100	200
Bus Comfort	No Fan No A/C	Fan	Air-Conditioned (A/C)

Note: US$1 = 4000 Riel (Exchange rate in November, 2006)

From the experimental setup with five attributes, a full factorial design would generate 243 (3^5) alternatives; however, it was not a practical way to include all these alternatives in the choice set. Thus, a fractional factorial or orthogonal design was used, resulting in a total of 27 alternatives. These alternatives were orthogonally grouped into nine blocks, each of which consisted of three alternatives. Due to limited time of respondents in answering and thinking about each choice, only three blocks were provided for each respondent. To complete a full test, three respondents were needed, each of whom had to answer three scenarios. Thus, there were three different forms of survey to be equally distributed to respondents: Forms A, B, and C as shown in appendix B.

3.2.2 Results of the Pilot Survey

A total of 131 passengers were interviewed during pilot survey. The socio-economic information of surveyed passengers is summarized in Table 3.3.

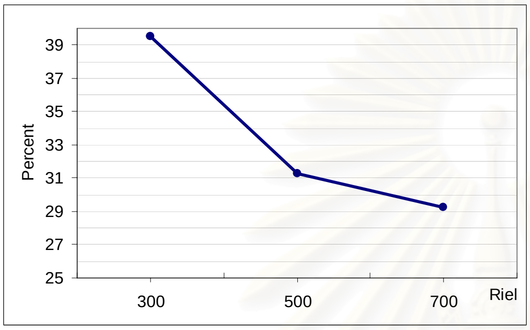
Approximately two thirds of the total respondents were male, and the majority were in the 21 to 30 age group, constituting about half of the total respondents. Half of the respondents were students, while nearly 30 % of the respondents were workers, and the remaining respondents were sellers and others. In terms of education level, more than half of the respondents possessed a degree higher than high school. In addition, the majority of respondents had monthly income less than $80, and more than half of the respondents came from the households of more than five members.

Table 3.3 Summary of Socio-Economic Characteristics for Pilot Survey

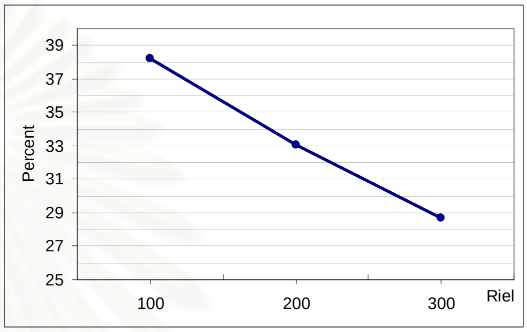
Variables	Levels	Percentage
Gender	Male	60.3
	Female	39.7
Age	< 21	31.3
	21-30	48.1
	31-40	9.9
	41-50	7.6
	> 50	3.1
Occupation	Students	51.2
	Workers	26.8
	Sellers	11.8
	Others	10.2
Education	Lower than High School	7.4
	High School	36.1
	Higher than High School	56.6
Monthly Income	< $80	68.3
	$80-$180	17.5
	$180-$250	9.5
	$250-$400	4.0
	> $400	0.8
Household Size	< 4	8.3
	4	17.4
	5	17.4
	> 5	56.9

Based on responses from the pilot survey, Figure 3.3 presents the bus service attributes' levels and their proportions showing the likelihood of bus usage. From Figure 3.3(a), bus service demand decreased as the basic fare increased. Specifically, nearly 40% of the respondents indicated their intention to use the bus if the basic fare was 300 Riel. Such a figure would reduce to 31% and 29% when the basic fare values were 500 Riel and 700 Riel, respectively. Likewise, from Figure 3.3(b) the demand of the additional fare per kilometer decreased from 38% at 100 Riel rate to 33% at 200

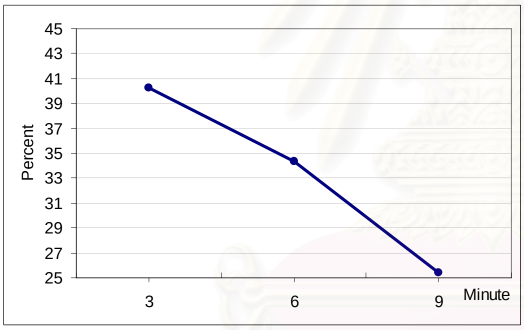
Riel rate and 29% at 300 Riel rate. Figure 3.3(c) indicates that respondents perceived the waiting time negatively, i.e. the demand decreased as the waiting time increased. Walking distance was found insensitive as seen in Figure 3.3(d). The bus comfort was found to be the most significant among all attributes because the demand increased sharply. The bus usage rate was 70% for air-conditioned bus, 18% for bus with fan, and 12% for the bus without fan and air-conditioned.



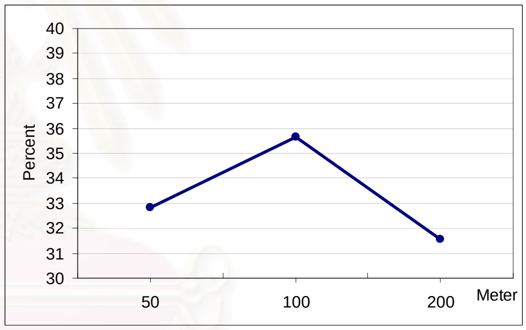
(a) Basic Fare



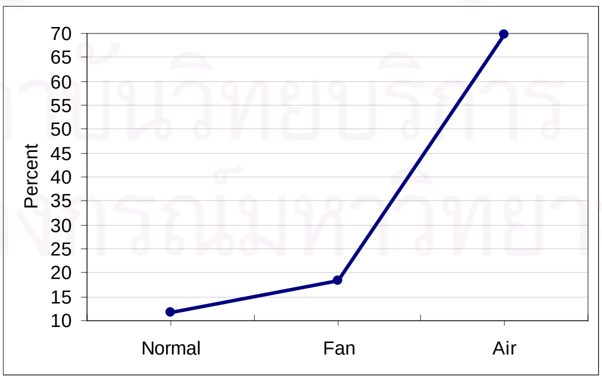
(b) Additional Fare Per Kilometer



(c) Waiting Time



(d) Walking Distance



(e) Bus Comfort

Figure 3.3 Proportions of the Main Attributes' Levels

3.3 Main Survey Design

3.3.1 Modification of the Pilot Survey

From the pilot survey, some problems were found and corrected for the main survey. Firstly, key information obtained from the pilot survey was not complete, while some information was not necessary and could be improved. Secondly, the scenario design was not yet reliable in terms of both the attributes' level and the quality of collected data; thus, some modification of the scenario design was needed. Furthermore, the understanding of respondents on the survey forms was not yet fully satisfied, particularly for the walking distance from /to bus stop. Given the aforementioned issues, the following modifications were considered for the main survey.

3.3.1.1 Modification of Questionnaires

1. Household monthly income: Household monthly income was included and categorized into five groups, namely, less than $50, $50-$150, $150-$250, $250-$350, and more than $350.
2. Residential location: Residential location in terms of the district in Phnom Penh was additionally asked in the main survey.
3. Frequency of bus usage: The frequency of using the intra-city bus service was added to the survey. In addition, respondents were also asked to state their expected frequency of using each of the hypothetical bus lines.

3.3.1.2 Modification of Scenario Design

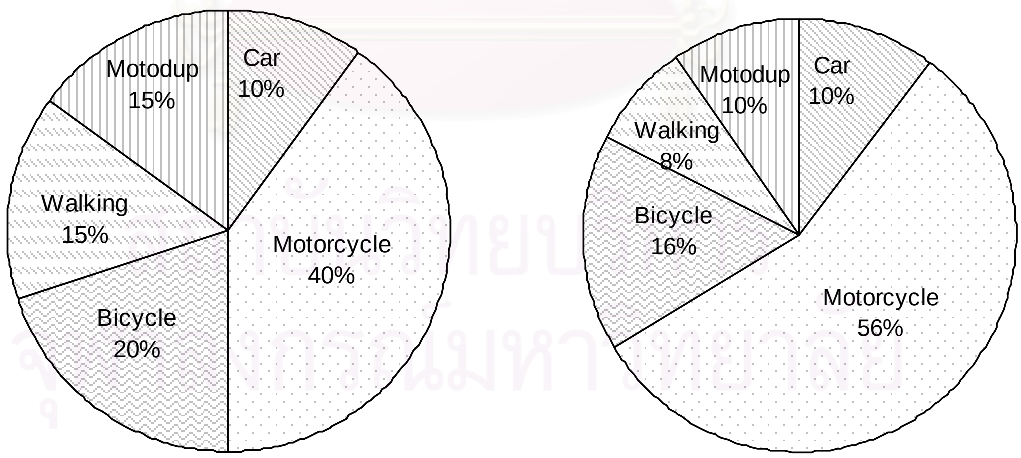
1. Bus fare: A flat-rate fare was considered in the main survey and was designed with four levels, i.e. 900 Riel, 1200 Riel, 1500 Riel, and 1800 Riel (exchange rate as of May, 2007: US$1 = 4,100 Riel).
2. Bus headway: A bus headway of 10 and 20 minutes was considered in the main survey corresponding to the average waiting time of 5 and 10 minutes respectively.

3. Walking time: Two levels of walking time, 4 and 8 minutes, were designed in the main survey. These levels were based on the walking distance of about 250 and 500 meters, respectively (assuming an average walking speed of 4 kilometers per hour). Walking distance depends on the distance between two bus stops.

4. Bus comfort: From the pilot survey results, nearly every passenger avoided choosing the bus without fan and air-conditioned, which was probably due to the hot climate in the city. Therefore, in the main survey bus comfort was reclassified into only two groups, i.e. bus equipped with fan and bus equipped with air-conditioning.

3.3.2 Sample

A sufficient sample size is necessary in order to analyze the data efficiently. Determining a sample size is usually based on several constraints such as time, cost, location of the data collection, etc. In this study, an approximate sample size of 300 was determined for the main survey. The target subjects were travelers along the hypothetical bus lines and within the nearby area.



(a) Expected Distribution (JICA, 2001) (b) Actual Distribution (Main survey)

Figure 3.4 Sampling Distribution

To determine the sample size, stratified random sampling technique was used considering travel mode for the stratum. Based on the proportion from a previous study conducted by JICA, 10% of car, 15% of motodup, 15% of walking, 20% of bicycle, and 40% of motorcycle were considered. A sample size of 30 was considered for the smallest proportion of the mode, which is in this case the number of car. The sample collected from the main survey is shown in Figure 3.4, compared with the sampling distribution from JICA (JICA, 2001).

3.3.3 Data Collection

The main survey was conducted for three days during May 22-24, 2007. Five people were hired to conduct the survey by direct interview on the field. Similar to pilot survey, the surveyors had been trained until they clearly understood the survey forms and were able to explain to the respondents.

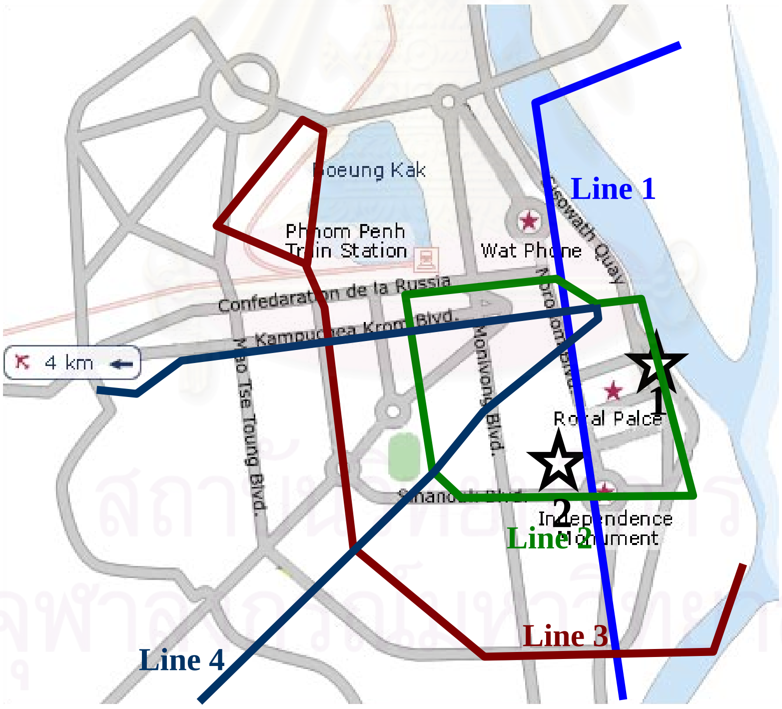


Figure 3.5 Proposed Bus Lines of Phnom Penh

Note: The four bus lines were used consistently with the previous proposed plan conducted by JICA (2001).

The data collection was conducted at two central business areas, Phsar Thom Thmey and Phsar Oreussey, along the proposed bus lines (see Figure 3.5). Phsar

Thom Thmey is located at the center of the city crossed by bus lines 1, 2, and 4, while Phsar Oreussey is located close to lines 1 and 4 and also in the center of the circled line 2. Bus lines indicated in the present survey were previously proposed by JICA (2001) as an immediate action plan. The plan consisted of four lines, 2 circular lines and 2 radial lines, crossing through all main activity areas in the city. Line 1 started from south to north, while line 2 was a circular line centered in the city. Line 3 was a long inner ring road and line 4 started from suburban areas in the south-west of the city.

3.3.4 Survey Questionnaires

The survey questionnaire consisted of two main parts, hypothetical bus scenarios and socio-economic characteristics. In the first section, four attributes were considered, namely, cost, bus headway, walking time and bus comfort. Within each scenario, passengers had to make a decision between their current transport mode and intra-city bus service, and had to select the best alternative in the scenario.

At the beginning of the first page of the survey form, the hypothesis of the intra-city bus service and the objective of the survey were described. Then, passengers' current transportation information, such as travel mode, time, destination, distance and cost were to be identified. Socio-economic characteristics in the second section of the survey form consisted of age, gender, occupation, etc. In addition, trips characteristics such as commuting modes and frequencies of mode usage were solicited. Lastly, the expected frequency of using the bus service and the frequency preferences on each of the proposed bus lines were asked.

The survey form was first drafted in English. A two-way check was conducted for consistency purposes, i.e. the survey was translated into Cambodian and then re-translated back to English. To assure the clarity and understandability of the survey form, a few people were asked to fill in the form before the forms were actually implemented. Appendix A provides questionnaire survey forms of the main survey.

3.3.5 Scenario Design

In the experimental design, four attributes, namely, bus fare, headway, walking time and bus comfort, were considered. With four levels of bus fare and two levels for the other three attributes, a full factorial design would generate 32 ($4x2^3$) alternatives. An orthogonal design was developed and half of the full factorial, i.e. 16 alternatives, was generated. Afterwards, four blocks were created, and all the 16 alternatives were orthogonally assigned to each block, 4 alternatives for one block. These blocks or scenarios were created to divide a large group of alternatives into small group so that they were easier for respondents to compare the alternatives. Only two scenarios were assigned to each respondent. Thus, two respondents were required to complete a full set of scenarios. The two different survey forms, identified as Forms A and B, would be distributed equally during the data collection. The four attributes designed for the scenarios according to their levels are shown in Table 3.4.

Table 3.4 Attributes and their Corresponding Levels

Attributes Levels				
Bus Fare (Riel)	900	1200	1500	1800
Bus headway (minute)	3		6	
Walking Time (minute)	4		8	
Bus Comfort	Fan		Air-Conditioned	

3.4 Summary

In summary, the procedures employed in this research started from the pilot survey. From the results of the pilot survey, the survey form was modified for the main survey. The sample size for both the pilot and main surveys were determined based on stratified random sampling. Proportions of population from JICA study were considered in terms of travel modes and occupation. As a result, a total number of 337 respondents were collected for the main survey. The characteristics of the sample will be described in the next chapter.

CHAPTER IV

DESCRIPTIVE STATISTICS

4.1 Socioeconomic Characteristics

Table 4.1 summarizes several socioeconomic characteristics of the respondents obtained from the main survey. From the table, approximately two thirds of the surveyed respondents were male. More than half of the respondents aged between 21 and 30, while the overall range was from 13 to 70 years. Statistically, the average age was 27 years with a standard deviation of 11. 11 years. In term of occupation, most of the respondents were university students and sellers. In addition, most of the respondents possessed a degree higher than a high school diploma, and 13 percent had a degree lower than a high school diploma.

Table 4.1 Summary of Socioeconomic Characteristics

Socioeconomic Characteristics	Levels	Percentage
Gender	Male	65.8
	Female	34.2
Age	< 21	22
	21-30	57.4
	31-40	7.6
	41-50	6.1
	51-60	5.5
	> 60	1.5
Occupation	High school students	7.3
	University students	46.6
	Sellers	21.2
	Employees	15.9
	Unemployed	4.1
	Others	4.9
Education	Below High School	13.7
	High School	33.7
	Higher than High School	52.6

Figure 4.1 illustrates the distribution of respondents' household monthly income. It can be observed that the average income was in the range between $150 and $250 with a standard deviation of $157 which was much higher than the estimated figure of $115 by JICA (2001).

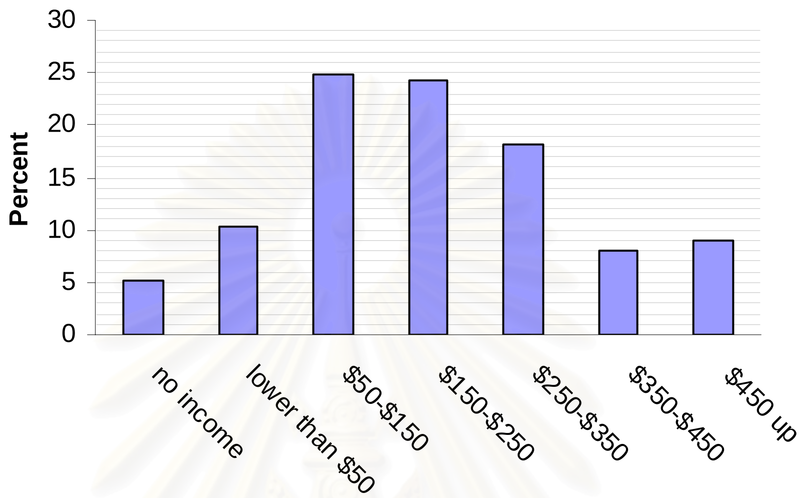


Figure 4.1 Distribution of Household Monthly Incomes

Figure 4.2 shows the distribution of household size. From the survey, the size of all households ranged from 1 to 21 members. A majority of the respondents reported five members in their households. The average household size was 5.8 with a standard deviation of 2.3.

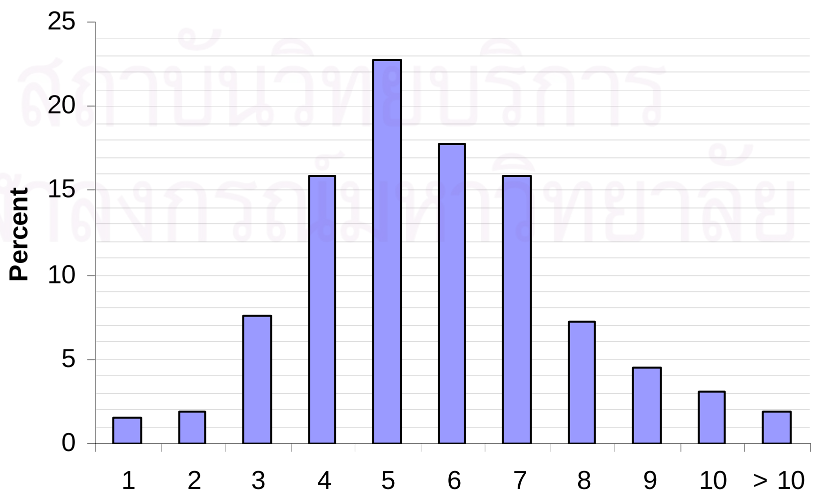


Figure 4.2 Distribution of Household Size

Figure 4.3 shows the summary of the number of vehicles owned in a household. Among the three types of vehicles (car, motorcycle, and bicycle), motorcycle possession was the largest. Some respondents did not have a car or a motorcycle; however, almost 70% of the respondents had one or two motorcycles. Statistically, the average motorcycle possession was 1.82 per household with a standard deviation of 1.23, followed by bicycle possession with the average of 1.28 per household with the standard deviation of 1.19. Lastly, the average car possession was 0.38 per household with a standard deviation of 0.71.

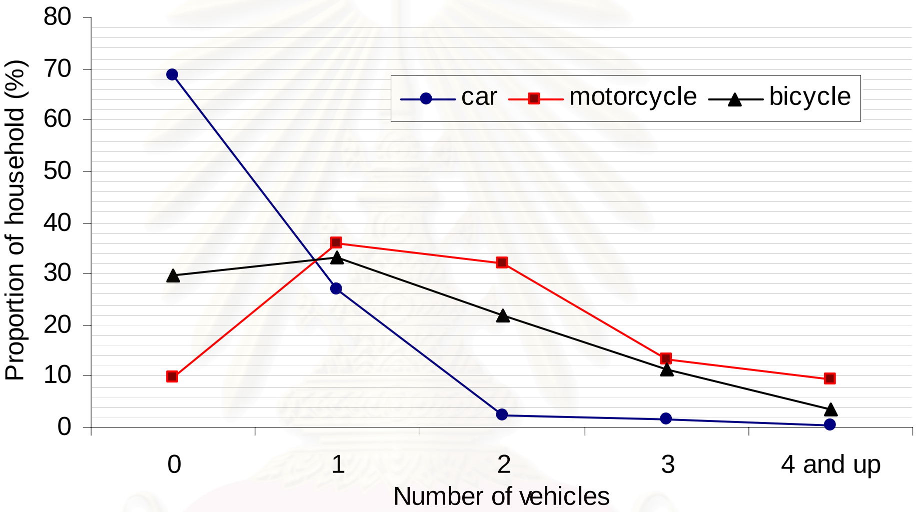
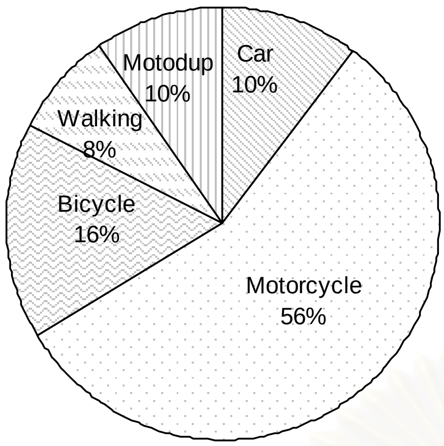


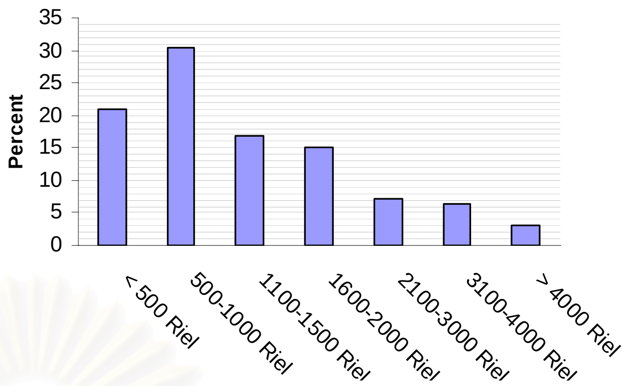
Figure 4.3 Summary of Number of Vehicles in the Household

4.2 Trip Characteristics

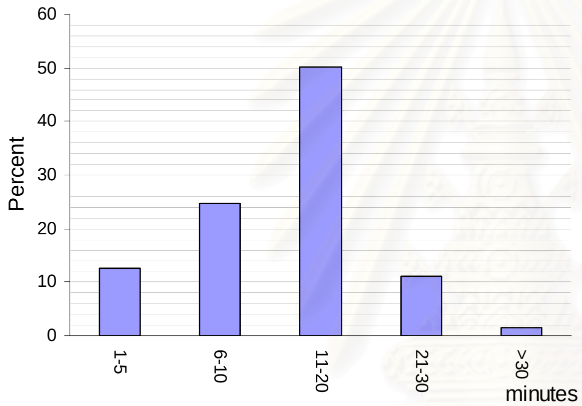
Figure 4.4 shows respondents' current trips characteristics in terms of trip mode, cost, time, and distance. Most of the respondents (56%) were motorcyclists, followed by bicyclists (16%), car users (10%), motodup users (10%), and pedestrians (8%). The average travel cost was 1,493 Riel with a standard deviation of 1, 496 Riel. The average trip time was 15.6 minutes with a standard deviation of 9.5 minutes, and the average trip distance was 4 kilometers with a standard deviation of 6 kilometers.



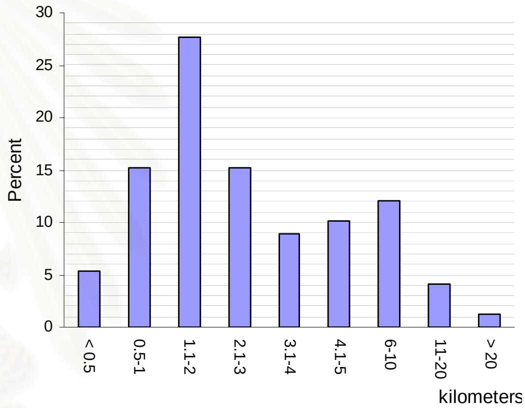
(a) Trip Modes



(b) Trip Cost



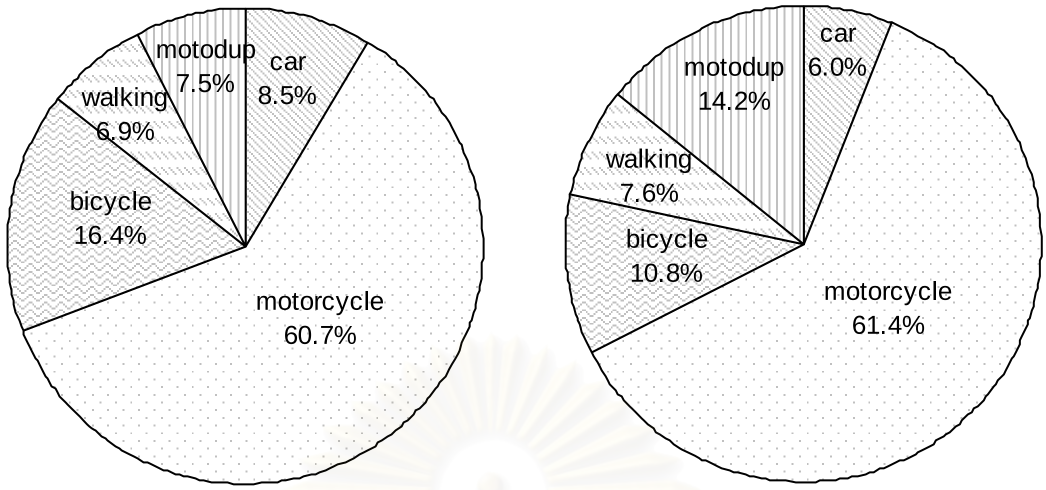
(c) Trip Time



(d) Trip Distance

Figure 4.4 Trip Characteristics

Figure 4.5 presents the distribution of modes for commuting and shopping trips. It can be seen that motorcycle was a predominant mode of transportation for the respondents, and distribution of trip modes for both commuting and shopping trips were not much different from each other.



(a) Work/School Trips (b) Shopping Trips

Figure 4.5 Distributions of Trip Modes

Table 4.2 shows the frequency of transportation modes usage corresponding to respondents' commute trips. The data collected were what transportation modes respondents used during the previous week. From the figures, more than half of the respondents who stated cars, motorcycles or bicycles as their commute modes used their modes every day. On the other hand, 75% of motodup users rarely used motodup during the previous week, i.e. they probably used other transportation modes or they did not travel often during the previous week. In addition, almost 80% of pedestrians walked to work only a few days or less in a week. It was possibly that they walked on the day of the interview, but they normally traveled using other transportation modes.

Table 4.2 Frequency of Mode Usage

Mode	Frequency			
	Everyday	4-5 days/week	2-3 days/week	Rarely
Car 57.7		30.8	7.7	3.8
Motorcycle 80.6		13.7	4	1.7
Bicycle 74		22	2	2
Motodup 0		0	25	75
Walking 4.8		19	42.9	33.3

4.3 Bus Service Scenario

To grasp decision behaviors of the respondents, a set of scenarios consisting of 4 alternatives was designed. Among those alternatives, there were some which had better quality in all the attributes compared with the others. In this case, the better ones, commonly referred to the dominated alternatives, should be chosen if respondents considered the alternatives critically with rationale. On the other hand, there were some alternatives that had the worst quality in all attributes. For rational respondents, they would not choose such alternatives. It was found for the survey results that almost 16% of respondents were irrational. Hence, these responses were removed from the analysis.

Figure 4.6 shows respondents' percentages of frequency of using a bus service. Generally, respondents showed a relatively strong support to the bus service. According to the figure, most respondents (83%) stated that they would use the bus service at least two or three days a week.

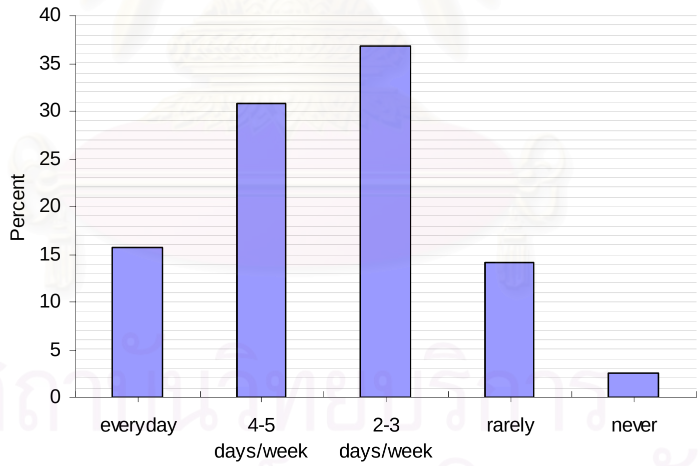


Figure 4.6 Frequency of Bus Usage

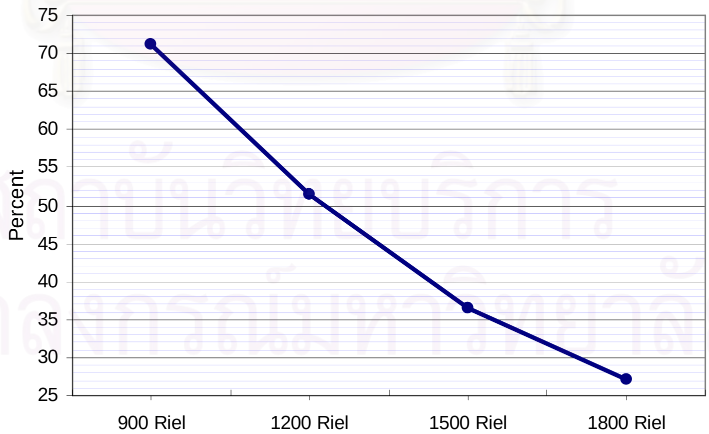
Table 4.3 shows respondents' preferences for bus service by line. According to the table, the preference for each bus line was not much different from one another. To determine the overall ranking of each bus line, the mean value for each line was computed. The lower the mean value was, the higher the rank would be. For example, bus lines 1, 2, and 4 were shown with lower mean; thus, these lines were ranked higher than line 3. On the other hand, line 1 and 4 were ranked num ber one by 32.2% and 32.6% of the total respondents.

Table 4.3 Preferences of Using Bus Service by Line in Percentages

Rank[1]	Line 1	Line 2	Line 3	Line 4
1	32.2	27.5	19.7	32.6
2	19.9	26.2	26.8	19.6
3	21.3	25.8	30.1	22.3
4	26.6	20.5	23.4	25.6
Total	100	100	100	100
Mean	2.4	2.4	2.6	2.4
Standard Deviation	1.2	1.1	1.1	1.2

[1] 1: most frequent use; 4: least frequent use

Figure 4.7 presents the change in the likelihood of bus usage when the bus fare varied. According to Figure 4.7, when the fl at fare was set to 900 Riel, approxim ately 72% of respondents would change from their existing mode to bus. When the fare was 1200 Riel, such proportion was down to 52% only. Moreove r, only 36% of respondents would switch if the flat fare was 1500 Riel. At a maximum flat fare, 1800 Riel, a switching rate of 27% was observed.



US$1 = 4100 Riel (May, 2007)

Figure 4.7 Effect of Bus Fare on the Likelihood of Bus Usage

Figure 4.8 illustrates the proportion of surveyed respondents who would ride the bus based on the frequency of bus service. When there were 3 buses departure per hour, 42% of respondents would change from their existing modes to the bus mode. The proportion of respondents would increase to 51% when the frequency of service was doubled, i.e. 6 buses per hour.

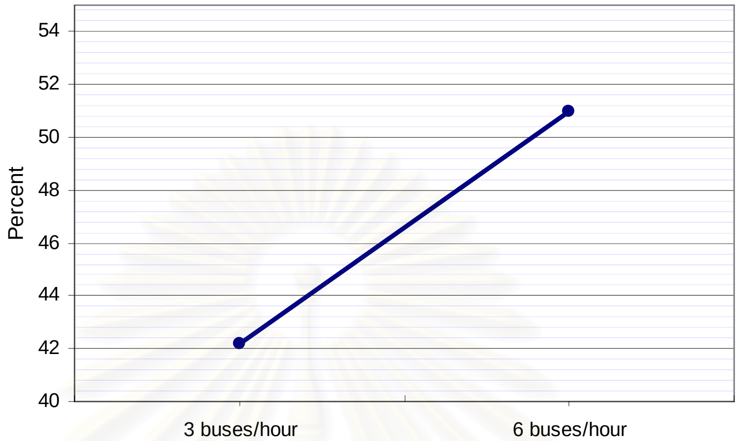


Figure 4.8 Effect of Bus Frequency on the Likelihood of Bus Usage

Figure 4.9 shows the proportion of surveyed respondents who would change to the bus service based on walking time. When respondents had to walk for 4 minutes to a bus stop or from the bus stop to their destinations, approximately 54% of them would switch from their current modes to the bus service. The proportion would decrease to 40% if they were supposed to walk longer, i.e. 8 minutes.

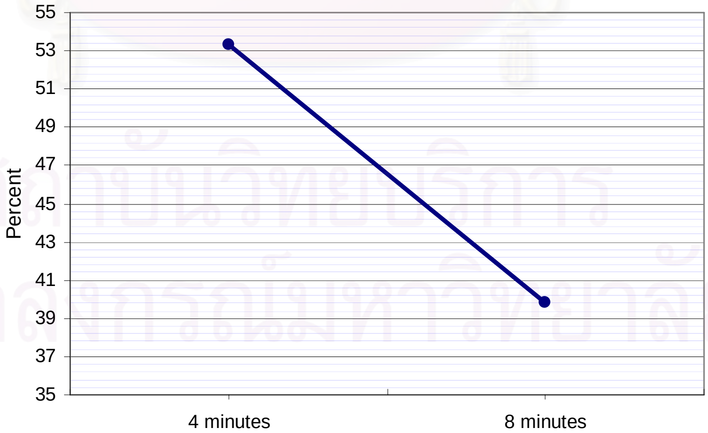


Figure 4.9 Effect of Walking Time on the Likelihood of Bus Usage

Figure 4.10 presents the effect of bus comfort on the likelihood of bus usage. According to Figure 4.10, there would be about 59% of the respondents who would use the bus if the bus was air-conditioned. Moreover, the proportion dropped dramatically to only 35% when the bus was equipped with a fan instead.

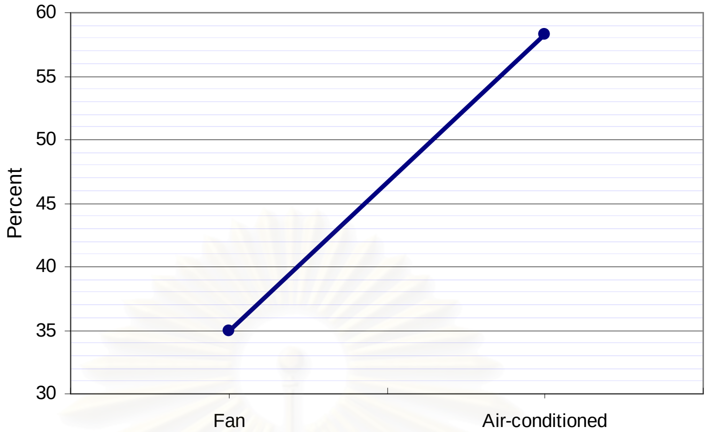


Figure 4.10 Effect of Bus Comfort on the Likelihood of Bus Usage

4.4 Summary

This chapter summarizes the results obtained from the main survey. A sample size of 337 was obtained, comprising 10%, 56%, 10%, 16%, and 8% of cars, motorcycles, motodups, bicycles, and walking, respectively. Most respondents were students and the average household size was 5.8 with an average household monthly income between \$150 and \$250. Results show that respondents spent approximately 1,500 Riel for their trip. The average trip time was found to be 15 minutes and the average trip length was found to be 4 kilometers. Regarding usage of bus lines, lines 1, 2, and 4 were found the most frequently used.

An analysis on the bus service attributes yielded important findings that all attributes presented in the questionnaire were found significant to the passengers. An increase in bus service usage was shown when the bus fare or the walking time decreased. Likewise, it was also shown that when the bus frequency increased or when the air-conditioned buses were used, the likelihood of bus patronage would be increased. In addition, almost 85 % of the passengers stated that they would use the intra-city bus service at least 2 or 3 days a week, while almost 50% of the passengers would use at least 4 or 5 days a week.

CHAPTER V

MODELING ANALYSIS AND RESULTS

5.1 General

In order to study respondents' trade-offs towards bus service attributes and to compare preference between their existing modes and bus service, modeling analysis is necessary. This chapter presents the model development process and results, including, model structure, model specification, model calibration, and statistical tests of the models. In this study, a set of conditional logistic and binary logistic regression models were developed.

5.2 Model Test and Calibration

A statistical software package, Stata/ SE 08, was used to calibrate both the conditional logistic and binary logistic regression. The calibration process was based on the maximum likelihood method. Figure 5.1 shows the general procedure of model development.

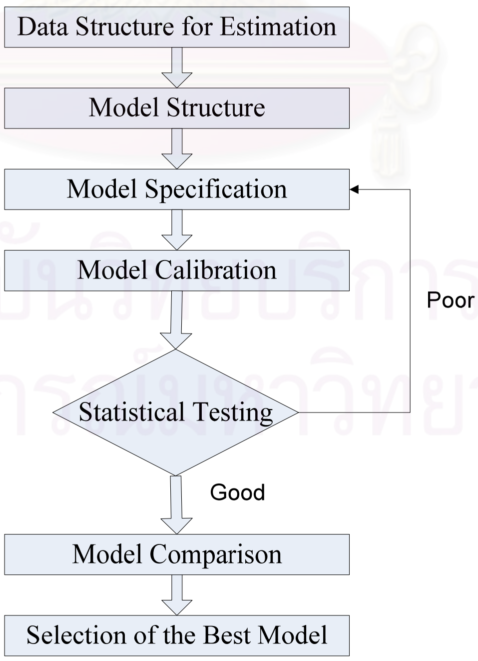


Figure 5.1 Flowchart of Model Development

5.2.1 Data Structure for Estimation

Prior to model development, the data obtained from the survey was cleaned and input into a single file for Stata/SE . All information obtained from the survey was processed and kept in the database. Such inform ation included respondents' trip characteristics, socioeconomic characteristics, preference in using the bus service, and especially the stated p reference d ata from bus service scenario s. Each piece of information was rep resented in a num erical f orm data with d ifferent types of measurement (scale, nominal, ordinal) according to its natural value; for instance, the variable *b_air* would value *1* if it was an a ir-conditioned bus and *0* otherwise. Descriptions of all the variables used in the modeling are shown in Table 5.1.

Table 5.1 Descriptions of Variables

No.	Variable	Measure	Value	Description
1	*car*	dummy	0/1	Car as mode of travel (0: others; 1: car)
2	*moto*	dummy	0/1	Motorcycle as mode of travel (0: others; 1: motorcycle)
3	*motodup*	dummy	0/1	Motodup as mode of travel (0: others; 1: motodup)
4	*bicycle*	dummy	0/1	Bicycle as mode of travel (0: others; 1: bicycle)
5	*walking*	dummy	0/1	Walking as mode of travel (0: others; 1: walking)
6	*motorize*	dummy	0/1	Motorized vehicles as mode of travel (0: non-motorized vehicles; 1: motorized vehicles)
7	*diffcost*	scale	integer	Difference between bus fare and trip cost, measured in Riel
8	*b_cost*	scale	integer	Bus fare in Riel
9	*bheadway*	scale	integer	Bus headway in minutes
10	*b_walk*	scale	integer	Walking time to the bus stop in minutes
11	*b_air*	dummy	0/1	Bus comfort (0: fan; 1: air-conditioned)
12	*age*	scale	integer	Age of respondent
13	*gender*	dummy	0/1	Gender of respondent (0: female; 1: male)
14	*downtown*	dummy	0/1	= 1 if the residential location of the respondent is in the downtown areas (i.e. Done Penh and 7Makara) = 0 otherwise
15	*high_edu*	dummy	0/1	= 1 if the respondent's education level is Bachelor's or higher; = 0 otherwise
16	*high_inc*	dummy	0/1	= 1 if respondent's household monthly income is \$250-\$350 and above; = 0 otherwise
17	*dcmotori*	Dummy	0/1	A dummy variable created for difference in cost interacted with motorized users.

5.2.2 Model Structure

Two types of models were developed: conditional logistic and binary logistic regression. The conditional logistic regressions, or multinomial logit models, were developed for the objective of trade-off analysis. Applying bus service attributes only, several models were developed, classifying by each mode of travel. The binary logistic regressions, or binary logit models, were developed as mode-choice models to compare between the proposed bus and respondents' existing mode of travel. Different model structures were developed and calibrated using different combinations of variables.

5.2.3 Model Specification

In model construction, a number of variables were analyzed based on relevant statistical test, goodness of fit, and likelihood estimation of the models. The independent variables in the models were believed to be able to explain the respondents' decision behaviors. For the trade-off model, only bus service attributes were considered. For the mode-choice models, the specifications of the independent variables can be described as follows:

5.2.3.1 Generic Variables

- Difference in cost: the difference between bus fare and trip cost. This variable was created assuming that the trip cost and bus fare valued the same (the same marginal utility).

5.2.3.2 Mode Specific Variables

1. Existing modes' variables

- Trip mode: This variable was generated as dummy variables. It was the mode that respondents used at the time of the interview, including, car, motorcycle, bicycle, motodup, and walking. These variables correspond to *car*, *moto*, *motodup*, *bicycle*, and *walking* listed in Table 5.1.

2. Bus service's variables

- Bus headway (*bheadway*): a scale variable. This variable was the time interval between the departure of two buses. In the survey, two levels, 10 and 20 minutes, were tested.

- Walking time (*b_walk*): a scale variable. This variable was the walking time from home to the nearest bus stop. In the survey, two levels, 4 and 8 minutes, were tested.

- Bus comfort (*b_air*): a dummy variable. This variable represented the comfort of the bus, which valued *1* if it was an air-conditioned bus and *0* otherwise.

3. Interaction variable

- Travel mode multiplied by difference in cost: the interactions between existing modes and difference in cost were considered. This variable was created under the assumption that the effect of the difference in cost would vary across modes of travel.

5.2.4 Model Calibration

The coefficients of all independent variables were obtained through running the regressions in software package, Stata/SE 08. Each developed model was calibrated on the basis of sign test, t-statistic value, and the likelihood method until the best model was obtained. All statistical tests used in the calibration were discussed in the following part.

5.2.5 Statistical Testing

5.2.5.1 Sign test

If the sign of the calibrated coefficient was different from a priori belief, the variable would then be removed from the model. For example, from a priori belief the coefficient of bus fare should be negative, i.e. the preference for bus service would decrease as the bus fare increased. In this case, the dependent variable which was a decision to ride the bus was coded *1* for choosing bus and *0* otherwise. A priori belief on the signs of each independent variable was shown in Table 5.2.

5.2.5.2 T-Test

The t-test was used to test the hypothesis that any of $\beta_k = 0$ at some confidence level. If the t-test value was greater than the critical t-test, such the null hypothesis could then be rejected. At 95% of confidence level, the critical t-test value is 1.96. However, the variable can still be kept in the model as long as we have a strong belief that this variable is important.

Table 5.2 A Priori Belief on the Signs of Explanatory Variables

Variable Names	A priori Belief	Expected Signs
Difference in cost	Respondents would have a lower tendency towards bus service if the difference between bus fare and current trip is high	–
Bus fare	Respondents would have a lower tendency towards bus service if bus fare increases	–
Bus headway	Respondents would have a lower tendency towards bus service if bus headway increases	–
Walking time	Respondents would have a lower tendency towards bus service if their walking time to the bus stop increases	–
Bus comfort	As air-conditioned bus valued 1 and bus with fan valued 0, a positive sign was expected, indicating preference towards an air-conditioned bus	+
Age	No strong a priori belief.	+ / –
Gender	It was believed that female respondents would prefer riding a bus than male. A negative sign was thus expected.	–
Downtown	Respondents living in downtown areas were more likely to use bus.	+
High education	No strong a priori belief.	+ / –
Motorized users	Respondents who currently use motorized transport (such as motocycle, car, and motodup) are less likely to use the bus service.	–
Interaction between difference in cost and motorized users	Difference in bus fare and current travel cost has less effect on motorized users.	+

5.2.5.3 Likelihood Ratio Test

Likelihood ratio test is a statistical test that is used to test between restricted and unrestricted models under the null hypothesis that all β_k added to the restricted model are equal to zero. For large sample size, the null hypothesis can be described as $-2\left[LL\left(\beta_R\right)-LL\left(\beta_{UR}\right)\right]$, which is χ^2 distributed with K degree of freedom, where K is the number of restrictions. The test is conducted by comparing the obtained value of χ^2 with the critical value at some significance level. If χ^2 is greater than the critical value, it implied that the null hypothesis can be rejected and that the restrictions did not apply, i.e. all β_k are not zero.

5.2.5.4 Goodness-of-fit Test

The goodness-of-fit (ρ^2) is used to measure the fraction of an initial log likelihood value explained by the model. The value of goodness-of-fit ranged from 0 to 1, and a value close to 1 indicates a good fit. The value of ρ^2 will always increase upon adding more variables into the model. In this case, the adjusted likelihood ratio index ($\bar{\rho}^2$) is more appropriate since it subtracts number of restricted variables (K) from $LL(\hat{\beta})$. The values of ρ^2 and $\bar{\rho}^2$ can be computed using the following equations:

$$\rho^2 = 1 - \frac{LL(\hat{\beta})}{LL(0)} \tag{5.1}$$

$$\bar{\rho}^2 = 1 - \frac{LL(\hat{\beta}) - K}{LL(0)} \tag{5.2}$$

5.3 Modeling Results

5.3.1 Models for Trade-off Analysis

In response to the objective of the study, a conditional logistic regression was developed for separate travel modes, including, car, motorcycle, motodup, bicycle, and walking. A pooled model consisting of all modes was also developed for market segmentation test. This procedure was conducted to search for systematic variations of taste parameters among modes of users in order to include them explicitly in the specification of the variables. The variables' coefficients of each model and their corresponding t-statistic values are shown in Table 5.3.

According to Table 5.3, all variables have correct signs as a priori belief and their t-statistic values are also acceptable. It can be observed that the coefficients of each variable are almost equal across each travel mode. For bus comfort, pedestrians were found the least influenced comparing with other users. In short, for all users, bus fare was found the most important factor, while bus headway was the least but still significant. The statistical values of each model were shown in Table 5.4. From the table, the values of ρ^2 indicate the good fit of the models.

Table 5.3 Trade-off Models by Modes

Variables Car		Motorbike	Motodup	Bicycle	Walking	Pooled
Bus fare (Riel)	-0.0027 (-4.40)	-0.0026 (-11.48)	-0.0031 (-5.26)	-0.0037 (-5.67)	-0.0033 (-4.25)	-0.0028 (-15.61)
Bus headway (minute)	-0.0699 (-2.16)	-0.0873 (-6.13)	-0.0669 (-2.08)	-0.0596 (-2.24)	-0.1193 (-3.22)	-0.0774 (-7.68)
Walking time (minute)	-0.3415 (-3.01)	-0.2204 (-5.51)	-0.2159 (-2.02)	-0.5191 (-4.01)	-0.4223 (-2.68)	-0.2753 (-8.43)
Bus Comfort[1]	1.0211 (3.38)	1.2563 (9.16)	0.9221 (3.00)	0.9902 (4.31)	0.6269 (1.91)	1.0903 (11.39)

[1]1: air-conditioned bus; 0: bus with fan
Note: Figures in parentheses indicate the t-statistic values.

Table 5.4 Statistical Values of the Models

Models Car		Motorcycle	Motodup	Bicycle	Walking	Pooled
$LL(0)$ -83.18		-492.10	-81.79	-141.41	-69.31	-890.00
$LL(\hat{\beta})$ -58.57		-335.41	-55.15	-89.74	-46.33	-609.38
ρ^2 0.29	6	0.318	0.326	0.365	0.332	0.315
No. of observations	240	1,420	236	408	200	2,568

Test of Taste Variation

The behavior of an individual in the group may be different from one another. To account for such variation across the population, a test of taste variations is needed to estimate the significance of the variation among subgroup of the population. The appropriate test statistic is the likelihood ratio test, which is given by:

$$-2\left[LL_N(\hat{\beta}) - \sum_{g=1}^{G} LL_{N_g}(\hat{\beta}^g)\right]$$

where N_g denotes the sample size of market segment $g = 1,...,G$; G is the number of market segments; $\sum_{g=1}^{G} N_g = N$, N is the full sample size; $LL_N(\hat{\beta})$ is the log likelihood for the restricted model that is estimated on the pooled data set with a single vector of coefficients $\hat{\beta}$; and $LL_{N_g}(\hat{\beta}^g)$ is the maximum likelihood of the model estimated with the gth subset of the data. The null hypothesis test statistic is χ^2 distributed with the degrees of freedom equal to the number of restrictions, $\sum_{g=1}^{G} K_g - K$, where K_g is the number of coefficients in the gth market segment model (Ben-Akiva and Lerman, 1985).

If the null hypothesis can be rejected, which implies that the variation between market segment is significant, further exploration can be conducted to test whether the rejection of the joint hypothesis can be attributed to individual, or subgroup of the population. This can be done by asymptotic t-test of equality of individual coefficients between two market segments

$$\frac{\hat{\beta}_k^1 - \hat{\beta}_k^2}{\left[\mathrm{var}(\hat{\beta}_k^1) + \mathrm{var}(\hat{\beta}_k^2)\right]^{0.5}}$$

In this study, the variation on valuing bus service attributes from each travel mode is interested. From statistical values of the models in Table 5.4, the values of the likelihood ratio test can be computed as shown in Table 5.5 . From the table, the test statistic value of 48.36 was greater than the critical chi-square value of 26.3 with 16 degrees of freedom. Therefore, the null hypothesis that all coefficients are equal can be rejected at 95% level of significance. It can be concluded that there was different taste across modes.

Table 5.5 Test of Taste Variations among Travel Modes

	car	motorcycle	motodup	bicycle	walking	pooled	Test statistic
$LL(\hat{\beta})$	-58.57	-335.41	-55.15	-89.74	-46.33	-609.38	48.36

The asymptotic t-test was conducted afterwards as shown in Table 5.6. From Table 5.6, only three t-test values were significant, i.e. walking time for motorcyclist and bicyclist, bus comfort for motorcyclist and pedestrian, and walking time for motodup user and bicyclist. These differences, if deemed important in the application of the models, could be considered for model reestimation using the full sample with each of these coefficients replaced with the coefficients specific to travel modes (Ben-Akiva and Lerman, 1985). However, due to the nature of the data in the present study, the analysis of monetary equivalents of each attribute will be based on separate models presented in Table 5.3.

Table 5.6 Asymptotic t Test of Equality of Individual Coefficients

Mode Pairs	Bus fare	Bus headway	Walking time	Bus comfort
Car-motocycle	-0.15	0.49	-1.01	-0.71
Car-motodup	0.47	-0.07	-0.81	0.23
Car-bicycle	1.11	-0.25	1.03	0.07
Car-walking	0.61	1.01	0.42	0.88
Motocycle-motodup	0.79	-0.58	-0.04	0.99
Motorcycle-bicycle	1.58	-0.92	2.21*	0.81
Motorcycle-walking	0.86	0.81	1.24	1.77*
Motodup-bicycle	0.68	-0.17	1.81*	-0.16
Motodup-walking	0.20	1.07	1.08	0.66
Bicycle-walking	-0.39	1.31	-0.48	0.82

*significant at 90% significance level

Table 5.7 presents monetary equivalents for each attribute, classifying by travel modes. It can be observed that the value of walking time for car user was approximately 126 Riel/minute, and the value of waiting time for car user was around 52 Riel/minute. The value of waiting time in this case was assumed to be double of the value of bus headway since the average waiting time was considered half of the bus headway. Comparing the value of walking time of 126 Riel/minute with the value of time for car users in Bangkok of 0.86 baht/minute (Gwilliam, 1997) and 0.23 baht/minute (Nurcharissa, 2007), the value of time in this study (1 Baht ~ 100 Riel as of May, 2007) was relatively higher than expected. This was obviously due to the difference in comfort between walking time and travel time spent in the car.

In addition, comparing the value of waiting time of 52 Riel/minute with 0.23 Baht/minute for car users in Bangkok considering the difference in economics and GDP of both countries, the calculated value of time was still relatively high. For comparative purposes, the value of time for car drivers in UK was £26.43/hour (Mackie et al., 2003), equivalent to 28.7 Baht/minute (£1 ~ 65 Baht as of May, 2007). In Malaysia, the value of time for car drivers was found to be roughly 0.86 RM/minute (1 RM ~ 10 Baht as of May, 2007) (Kamba et al., 2007).

Table 5.7 Monetary Equivalents for Bus Service Attributes

Attribute	Car	Motorcycle	Motodup	Bicycle	Walking	Pooled
Bus headway (Riel/minutes)	26	34	22	16	36	28
Walking time (Reil/minutes)	126	85	70	140	128	98
Air-conditioned bus (Riel)	378	483	297	268	190	389

A useful way in interpreting the above model is to express the utility of each attribute in terms of monetary equivalents. The trade-offs for each user can be interpreted as follows:

1. One minute decrease in bus headway was equivalent to an average of 28 Riel (~0.08/0.0028) decrease in bus fare for all users. In other words, a respondent was willing to pay for an additional 28 Riel of bus fare in order to have one minute decrease in bus headway.

2. A one-minute decrease in walking time was equivalent to an average 98 Riel (~0.28/0.0028) decrease in bus fare for all users. In other words, a respondent was willing to pay for an additional 98 Riel of bus fare to save one minute in walking to the bus stop. The exception is for bicyclists, in which one minute decrease in their walking time cost 140 Riel (~0.52/0.0037).

3. A change from a bus equipped with a fan to an air-conditioned bus was equivalent to an average 389 Riel (~1.09/0.0028) decrease in bus fare. In other words, a respondent was willing to pay for an additional 389 Riel of bus fare in order to ride in an air-conditioned bus. The exception is for pedestrians, in which they valued an air-conditioned bus for 190 Riel (~0.63/0.0033), which was approximately half of the value given by other users.

5.3.2 Models for Modal Split (Bus vs. Existing mode)

To compare the preference of bus and respondents' existing travel modes, several binary logistic regressions were developed. Two models were developed with different model specification. The first model consisted of generic variable and mode specific variables, while the second model added the interaction variables between difference in cost and existing modes.

Table 5.8 describes the specification of the first developed model. From the table, the cost difference between bus and current travel mode was shown to be negative, showing that when all else being equal respondents would be more likely to use the current mode when the bus fare was set higher than the current travel cost. Likewise, for bus headway and walking time, the higher these values, the fewer respondents would ride the bus. In contrast, respondents would be more willing to ride the bus if it was an air-conditioned bus. In addition, the model shows that car users, motorcyclists, and motodup users would prefer bus comparing with those who used bicycle or walked.

Table 5.8 Binary Model 1**A**

Number	Variable name	Coefficient estimate	*t* statistic
1 Constant		1.248	4.86
Generic variable			
2	Difference in cost	-0.00024	-3.22
Mode specific variables			
3 Bus	headway	-0.0395	-4.21
4 Walking	time	-0.1487	-6.72
5 Bus	comfort	1.0304	11.02
6 Car		-0.7731	-2.30
7 Motorc	ycle	-0.4708	-2.46
8 Motodu	p	-0.8116	-3.46
Summary statistics			
Number of observations = 2264			
$LL(0)$ = -1569.29			
$LL(\hat{\beta})$ = -1444.77			
$-2\left[LL(0)-LL(\hat{\beta})\right]$ = 249.03			
ρ^2 = 0.079			
$\bar{\rho}^2$ = 0.074			

It can be noticed from Table 5.8 that the coefficients of mode dummy variables were relatively close. Therefore, it is appropriate to conduct a hypothesis testing to see whether the difference between each dummy's coefficients can be rejected. In this case, an asymptotic t-test can be applied to test the null hypothesis $\hat{\beta}_1 = \hat{\beta}_2$. The null hypothesis can be rejected if the t-test value is greater than the critical t-test value; and then $\hat{\beta}_1$ and $\hat{\beta}_2$ cannot be combined. The t-test was calculated from:

$$\frac{\hat{\beta}_1 - \hat{\beta}_2}{\sqrt{\text{var}(\hat{\beta}_1 - \hat{\beta}_2)}}$$

Where $$\text{var}(\hat{\beta}_1 - \hat{\beta}_2) = \text{var}(\hat{\beta}_1) + \text{var}(\hat{\beta}_2) - 2\,\text{cov}(\hat{\beta}_1, \hat{\beta}_2) \tag{5.3}$$

Table 5.9 Asymptotic T-Test

Test $\beta(\text{car}) = \beta(\text{motodup})$					
$\beta(\text{car})$	$\beta(\text{motodup})$	cov(car, motodup)	Var $\beta(\text{car})$ var	$\beta(\text{motodup})$	t-test
-0.77 -0	.81	-0.01	0.11	0.05	0.09
Test $\beta(\text{car}) = \beta(\text{moto})$					
$\beta(\text{car})$	$\beta(\text{motorcycle})$	cov(car, motorcycle)	var $\beta(\text{car})$ var	$\beta(\text{motorcycle})$	t-test
-0.77 -0	.47	-0.06	0.11	0.04	-0.58
Test $\beta(\text{motorcycle}) = \beta(\text{motodup})$					
$\beta(\text{motorcycle})$	$\beta(\text{motodup})$	Cov(motorcycle, motodup)	Var $\beta(\text{motorcycle})$ Var	$\beta(\text{motodup})$	t-test
-0.47 -0	.81	-0.06	0.04	0.05	0.73

The result was shown in Table 5.9 . From the table, the test statistics were all smaller than the critical value of 1.96 at 95% significance level, implying that the null hypothesis could not be rejected. Thus, these dummies were then combined into one dummy representing motorized users. Table 5.10 presents the modeling results. From the table, current motorized users would be less likely to use bus comparing with the current non-motorized user.

Table 5.10 Binary Model 1

Number	Variable name	Coefficient estimate	*t* statistic
1 Constant		1.207	4.85
Generic variable			
2	Difference in cost	-0.00021	-3.41
Mode specific variables			
3 Bus	headway	-0.0394	-4.22
4 Walking	time	-0.1482	-6.72
5 Bus	comfort	1.0272	11.02
6 Motorize		-0.5036	-2.70
Summary statistics			
Number of observations = 2264			
$LL(0) = -1569.29$			
$LL(\hat{\beta}) = -1448.40$			
$-2\left[LL(0) - LL(\hat{\beta})\right] = 241.78$			
$\rho^2 = 0.077$			
$\bar{\rho}^2 = 0.072$			

In this study, we hypothesized that there might be an interaction effect between the difference in cost and travel modes. Therefore, it is of interest to test such an interaction effect in the model. Table 5.11 presents the modeling results when an interaction was added. We found that the interaction has a positive effect on the decision to ride the bus.

Table 5.11 Binary Model 2

Number	Variable name	Coefficient estimate	*t* statistic
1 Constant		2.333	4.66
Generic variable			
2	Difference in cost	-0.00114	-3.13
Mode specific variables			
3 Bus	headway	-0.0396	-4.21
4 Walking	time	-0.1499	-6.73
5 Bus	comfort	1.0372	10.99
6 Motorize		-1.6063	-3.36
Interaction variables			
7	Difference in cost for motorized users	0.00096 2.60	
Summary statistics Number of observations = 2264 $LL(0)$ = -1569.29 $LL(\hat{\beta})$ = -1437.32 $-2\left[LL(0)-LL(\hat{\beta})\right]$ = 263.94 ρ^2 = 0.084 $\bar{\rho}^2$ = 0.077			

To compare between the two models in Table 5.10 and Table 5.11, several statistics values were observed and statistical test was conducted. From Table 5.12, the value of the adjusted likelihood ratio index of the second model appeared higher, implying that the second model could be a better model. Table 5.13 shows the estimation result of the likelihood ratio test, in which Model 1 was regarded as the restricted model and Model 2 as an unrestricted model. From the estimation results, the likelihood ratio value was higher than the critical χ^2 value, which could be implied that the null hypothesis that the added parameter β_k are equal to zero could be rejected at 99.5% significance level. Therefore, from the test the second model can be considered better than the first model.

Table 5.12 Statistical Values of the Models

Models	Model 1	Model 2
Initial log-likelihood $LL(0)$	-1565.66	-1565.66
Log-likelihood at convergence $LL(\hat{\beta})$	-1444.77	-1433.66
Likelihood ratio index ρ^2	0.077	0.084
Adjusted likelihood ratio index $\bar{\rho}^2$	0.073	0.078
Number of observation	2264	2264
% Correct predicted	63.65	63.74

Table 5.13 Likelihood Ratio Test

Models	Model 1	Model 2
	Restricted	Unrestricted
Log-likelihood at convergence $LL(\hat{\beta})$	-1448.40	-1437.32
Likelihood ratio test $-2\left[LL(\beta_R)-LL(\beta_U)\right]$	22.16	
Number of restriction	1	
χ^2-critical at 99.5%	7.88	

From the best model, the utility function could be written as follows:

$$V_{\text{bus}} = 2.333 - 0.0011\times(\text{bus fare}) - 0.04\times(\text{bus headway}) - 0.15\times(\text{walking time}) + 1.04\times(\text{comfort})$$

$$V_{\text{existing}} = -0.0011\times(\text{trip cost}) + \left[1.61 - 0.00096\times(\text{cost difference})\right]\times(\text{motorize})$$

All of the coefficients in the utility function are reasonable. From the utility function for bus, respondents would be less likely to use the bus when the bus fare and bus headway are substantial and when they have to spend a long time walking to the bus stop. On the contrary, if the bus is air-conditioned, respondents would be more likely to use the bus. From the utility function for existing travel modes, when the current trip cost is high, respondents would be more likely to switch to the bus. In addition, if a respondent was a motorized user, he or she would have a higher tendency to use his or her existing travel mode comparing with the non-motorized users. This result was quite reasonable since most of the current motorized users can presumably travel with more comfort, while bicyclists and pedestrians were seeking for a more comfortable travel mode. From the results, it can be also observed that for a motorized user, he or she would not consider trip cost much in deciding whether to use bus or not. In other words, a one unit increase in trip cost would not make much difference for a motorized user in terms of the probability of switching to the bus service.

To compare the preference between existing modes and bus, a set of utility values for both competing modes were computed. Two scenarios were assumed. In the first scenario, the bus fare was assumed to be equal to the travel cost of the current mode. In the second scenario, an average cost for the motorized mode was substituted in the developed utility function. The utility values were computed for the 32 bus service alternatives used in the survey. Results of both scenarios are shown in Table 5.14 and Table 5.15, respectively.

From Table 5.14 for the same cost between bus and existing modes, almost one-third of motorized users would prefer bus. The table also revealed that non-motorized users would always use bus. This can be explained by the fact that it is impossible for the assumption that bus fare be equal to trip cost of existing modes, since non-motorized users currently do not have any significant travel cost. In addition, bus service alternatives that motorized users chose were mostly those related to air-conditioned bus.

In Table 5.5 we assumed the average motorized trip cost of 1862 Riel, and non-motorized trip cost to be zero. From the survey results, the cost of existing motorized trips was often higher than the hypothetical bus fare. However, the bus demand for motorized users did not vary through cost. As can be seen from the table, one-third of motorized users chose to ride bus. From the table, almost half of the 32 alternatives of bus service would be preferred by non-motorized users. The decrease in the demand from the first assumption from Table 5.4 was due to the substantial difference in cost between bus fare and non-motorized trip cost.

Table 5.14 Utility Values (Assumed Equal Cost)

Bus fare	Bus headway	Walking time	Bus comfort	Utility for bus	Utility for motorized modes	Utility for non-motorized modes
900	10	4	0	0.35	0.62	-0.99
900	20	4	0	-0.05	0.62	-0.99
900	10	8	0	-0.25	0.62	-0.99
900	20	8	0	-0.65	0.62	-0.99
900	10	4	1	1.38	0.62	-0.99
900	20	4	1	0.99	0.62	-0.99
900	10	8	1	0.78	0.62	-0.99
900	20	8	1	0.39	0.62	-0.99
1200	10	4	0	0.02	0.29	-1.32
1200	20	4	0	-0.38	0.29	-1.32
1200	10	8	0	-0.58	0.29	-1.32
1200	20	8	0	-0.98	0.29	-1.32
1200	10	4	1	1.05	0.29	-1.32
1200	20	4	1	0.66	0.29	-1.32
1200	10	8	1	0.45	0.29	-1.32
1200	20	8	1	0.06	0.29	-1.32
1500	10	4	0	-0.31	-0.04	-1.65
1500	20	4	0	-0.71	-0.04	-1.65
1500	10	8	0	-0.91	-0.04	-1.65
1500	20	8	0	-1.31	-0.04	-1.65
1500	10	4	1	0.72	-0.04	-1.65
1500	20	4	1	0.33	-0.04	-1.65
1500	10	8	1	0.12	-0.04	-1.65
1500	20	8	1	-0.27	-0.04	-1.65
1800	10	4	0	-0.64	-0.37	-1.98
1800	20	4	0	-1.04	-0.37	-1.98
1800	10	8	0	-1.24	-0.37	-1.98
1800	20	8	0	-1.64	-0.37	-1.98
1800	10	4	1	0.39	-0.37	-1.98
1800	20	4	1	0.00	-0.37	-1.98
1800	10	8	1	-0.21	-0.37	-1.98
1800	20	8	1	-0.60	-0.37	-1.98

Table 5.15 Utility Values (Actual Cost)

Bus fare	Bus headway	Walking time	Bus comfort	Utility for bus	Utility for motorized modes	Utility for non-motorized modes
900 10		4	0	0.35	0.48	0
900 20		4	0	-0.05	0.48	0
900 10		8	0	-0.25	0.48	0
900 20		8	0	-0.65	0.48	0
900 10		4	1	1.38	0.48	0
900 20		4	1	0.99	0.48	0
900 10		8	1	0.78	0.48	0
900 20		8	1	0.39	0.48	0
1200 10		4	0	0.02	0.19	0
1200 20		4	0	-0.38	0.19	0
1200 10		8	0	-0.58	0.19	0
1200 20		8	0	-0.98	0.19	0
1200 10		4	1	1.05	0.19	0
1200 20		4	1	0.66	0.19	0
1200 10		8	1	0.45	0.19	0
1200 20		8	1	0.06	0.19	0
1500 10		4	0	-0.31	-0.09	0
1500 20		4	0	-0.71	-0.09	0
1500 10		8	0	-0.91	-0.09	0
1500 20		8	0	-1.31	-0.09	0
1500 10		4	1	0.72	-0.09	0
1500 20		4	1	0.33	-0.09	0
1500 10		8	1	0.12	-0.09	0
1500 20		8	1	-0.27	-0.09	0
1800 10		4	0	-0.64	-0.38	0
1800 20		4	0	-1.04	-0.38	0
1800 10		8	0	-1.24	-0.38	0
1800 20		8	0	-1.64	-0.38	0
1800 10		4	1	0.39	-0.38	0
1800 20		4	1	0.00	-0.38	0
1800 10		8	1	-0.21	-0.38	0
1800 20		8	1	-0.60	-0.38	0

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

This study addresses the analysis of bus service attributes in the context of bus service planning in the city of Phnom Penh, where currently lacks a formal public transport mode. A pilot survey was conducted as a preliminary study on the feasibility of stated preference research. Afterwards, a main survey was further conducted during May 22-24, 2007 to collect the information on respondents' socioeconomic and trip characteristics, likelihood in using the bus service, and their behavior towards the bus service in the future. Based on a total of 337 respondents, the data obtained from the survey was input into a database and was analyzed using both descriptive statistics and statistical modeling techniques in order to discover passengers' decision making characteristics towards riding the bus.

The main objectives of this study included the trade-off analysis. It was found that passengers in Phnom Penh had a positive attitude towards intra-city bus service. Survey results indicated that the demand for such service is remarkably high. Particularly, from the obtained data almost half of the bus service alternatives were chosen, i.e. respondents chose to ride bus if such alternatives existed.

Among the respondents, non-motorized users were found to be the potential users for bus service. When the bus fare was set to be equal to the cost of existing modes, all non-motorized users would obviously use bus, and only one-third of motorized users would use bus. However, in reality the cost will not be the same, i.e. the existing motorized trip cost is often higher than the bus fare, while the existing non-motorized trip does not have significant cost. When average trip cost for motorized trip was substituted, it was found that bus demand for motorized users did not vary implying that motorized users did not take much into account for the fare. On the other hand, only half of the non-motorized users would use bus due to the substantial difference in their trip cost and bus fare. Noticeably, most of the bus service alternatives, which were chosen, were related to air-conditioned bus.

In terms of bus service attributes, bus fare, and comfort were found to be the most important and significant aspects for passengers in Phnom Penh. A bus fare level of 1200 Riel was acceptable for half of the respondents. From the trade-off analysis, respondents could accept a higher fare rate considering trade-offs with other factors such as bus comfort, walking time, and bus headway. For instance, a respondent would be willing to pay an additional 98 Riel provided that he or she could save one minute in walking to the bus stop. Meanwhile, they would be willing to pay an additional 28 Riel if the bus headway was decreased by one minute. Also, except for pedestrians, respondents would pay an extra 389 Riel for a ride in an air-conditioned bus.

The value of time in this study was characterized by the value of walking time and the value of waiting time. Obviously, the analysis showed that the value of walking time was higher than the value of waiting time. The difference in these values of time was clearly related to the comfort reason. The average value of walking time in this study was found to be approximately 100 Riel/minute for all users, and the value of waiting time was found to be approximately 50 Riel/minute. These values of time were relatively higher than the expected value comparing with the value of time for car users in Bangkok of 0.86 baht/minute (Gwilliam, 1997) and 0.23 baht/minute (Nurcharissa, 2007).

In short, this study have revealed the Phnom Penh passengers' behaviors in terms of the trade-offs between bus service attributes, and preference between bus service and existing travel modes. Contribution of the results from the present study is hoped to shed some light on intra-city bus service planning in terms of service, demand and fare. In addition, the analysis results can be additionally used for future research and study on transportation planning in order to establish an appropriate service of an intra-city bus system in Phnom Penh.

6.2 Recommendations

Due to time constraint, the scope of the present research is limited to only passengers' characteristic and attitudes toward the bus service. Further studies are obviously needed in order to plan a bus service. From the study results and personal viewpoints, several recommendations can be made as follows:

1. From the second model (modal split), some trip characteristics of passengers were found inconsistent with their decision making. This was probably due to insufficient data. Therefore, a larger sample size is encouraged in the further study.
2. The master plan for transportation system in Phnom Penh studied by JICA should be implemented as soon as possible. A bus service, one of the project's plans, can be established based on the outputs of this study in term of bus service attributes, namely, bus fare, headway, walking time, and bus comfort.
3. Further research is needed regarding the feasibility of the service, fare policy, and bus capacity. From the previous JICA study, the financial feasibility was impossible; thus, this issue should be revisited based on the bus fare level and its demand as presented in this study. In such situation when the financial feasibility of the intra-city bus service is impossible, the government should consider subsidies for the service as long as the economic feasibility was possible as already investigated in JICA study.

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APPENDICES

Appendix A

Main Survey Forms

<u>សន្មតថា :</u> រថយន្តក្រុងដំណើរការ ពីម៉ោង ៦ ព្រឹក ដល់ ម៉ោង ៧ល្ងាច ។

រថយន្តក្រុងឈប់ រាល់ចំងាយ ៣០០ម៉ែត្រម្តង ក្នុងទីប្រជុំជន និង ៥០០ម៉ែត្រម្តងនៅជាយក្រុង ។

<u>ចំណាំ:</u> ខ្សែរថយន្តក្រុង និងម៉ោងដំណើរការទាំងនេះ ត្រូវបានស្នើរដោយអង្គការ JICA នៅឆ្នាំ 2001 ។

A

អ្នកសំភាស : ....   ទីកន្លែង :..................
កាលបរិច្ឆេទ : ....ឧសភា ២០០៧ AM/PM

ការសិក្សាសេវាកម្មរថយន្តក្រុងក្នុងទីក្រុងភ្នំពេញ

1. សូមផ្តល់នូវពត៌មាន អំពីការធ្វើដំណើររបស់លោកអ្នកអំបាញ់មិញនេះ

មធ្យោបាយធ្វើដំណើរ: ☐ រថយន្ត ☐ ម៉ូតូ ☐ ម៉ូតូឌុប ☐ កង់ ☐ ដើរ

ទិសដៅ: ☐ ធ្វើការ ☐ សាលារៀន ☐ ទិញអីវ៉ាន់ ☐ ផ្សេងៗ សូមបញ្ជាក់ ....

ថ្លៃធ្វើដំណើរ: .... រៀល   រយៈពេលធ្វើដំណើរ: .... នាទី   ចំងាយធ្វើដំណើរ: .... គីឡូម៉ែត្រ

2. ឧបមាថា មានរថយន្តក្រុងចរាចរណ៍ក្នុងទីក្រុងភ្នំពេញ ចំនួន៤ខ្សែ ដូចឃើញក្នុងរូបភាព។ ដូច្នេះ យើងខ្ញុំត្រូវការស្ទង់មតិរបស់លោកអ្នក ដើម្បីនឹងផ្តល់នូវ សេវាកម្មមួយដែលមានលក្ខណៈសមស្រប និងជាទីពេញចិត្តដល់លោកអ្នក ។ សូមមេត្តា ពិចារណានូវជំរើសមួយចំនួន ដូចខាងក្រោម ថាតើលោកអ្នក នឹងប្រើប្រាស់សេវារថយន្តក្រុង ដែរឬទេ ?

	ជំរើស	ថ្លៃជិះ (៛)	ភាពញឹកញាប់នៃសេវាកម្ម	រយៈពេលដើរទៅកាន់ស្ថានីយជិះ (នាទី)	ភាពងាយស្រួល	ការសំរេចចិត្ត (សូមគូស √)	
ឈុតទី ១	1	900	3 រថយន្តក្រុង/ម៉ោង	4	កង្ហារ	○ប្រើប្រាស់	○មិនប្រើប្រាស់
	2	1200	6 រថយន្តក្រុង/ម៉ោង	4	ម៉ាស៊ីនត្រជាក់	○ប្រើប្រាស់	○មិនប្រើប្រាស់
	3	1800	3 រថយន្តក្រុង/ម៉ោង	8	កង្ហារ	○ប្រើប្រាស់	○មិនប្រើប្រាស់
	4	1500	6 រថយន្តក្រុង/ម៉ោង	8	ម៉ាស៊ីនត្រជាក់	○ប្រើប្រាស់	○មិនប្រើប្រាស់

ដោយប្រៀបធៀបជំរើសទាំងអស់ខាងលើ ខ្ញុំគិតថាជំរើសដែលល្អជាងគេគឺជំរើសទី ☐

សន្មតថា ជំរើសដែលលោកអ្នកបានជ្រើសរើសខាងលើ អាចផ្តល់ជូនបាន តើលោកអ្នកមានបំណងនឹងប្តូរមកជិះរថយន្តក្រុង ដែរឬទេ ?

☐ ប្រាកដជាមិនជិះ ☐ ប្រហែលជាមិនជិះ ☐ មិនច្បាស់ ☐ ប្រហែលជាជិះ ☐ ប្រាកដជាជិះ

	ជំរើស	ថ្លៃជិះ (៛)	ភាពញឹកញាប់នៃសេវាកម្ម	រយៈពេលដើរទៅកាន់ស្ថានីយជិះ (នាទី)	ភាពងាយស្រួល	ការសំរេចចិត្ត (សូមគូស √)	
ឈុតទី ២	5	1500	3 រថយន្តក្រុង/ម៉ោង	4	កង្ហារ	○ប្រើប្រាស់	○មិនប្រើប្រាស់
	6	900	6 រថយន្តក្រុង/ម៉ោង	8	ម៉ាស៊ីនត្រជាក់	○ប្រើប្រាស់	○មិនប្រើប្រាស់
	7	1200	3 រថយន្តក្រុង/ម៉ោង	8	កង្ហារ	○ប្រើប្រាស់	○មិនប្រើប្រាស់
	8	1800	6 រថយន្តក្រុង/ម៉ោង	4	ម៉ាស៊ីនត្រជាក់	○ប្រើប្រាស់	○មិនប្រើប្រាស់

ដោយប្រៀបធៀបជំរើសទាំងអស់ខាងលើ ខ្ញុំគិតថាជំរើសដែលល្អជាងគេគឺជំរើសទី ☐

សន្មតថា ជំរើសដែលលោកអ្នកបានជ្រើសរើសខាងលើ អាចផ្តល់ជូនបាន តើលោកអ្នកមានបំណងនឹងប្តូរមកជិះរថយន្តក្រុង ដែរឬទេ ?

☐ ប្រាកដជាមិនជិះ ☐ ប្រហែលជាមិនជិះ ☐ មិនច្បាស់ ☐ ប្រហែលជាជិះ ☐ ប្រាកដជាជិះ

ចុងបញ្ចប់ បើប្រៀបធៀប រវាងឈុតទាំងពីរ តើជំរើសណាមួយ ដែលលោកអ្នកគិតថា ល្អជាងគេ ?   ជំរើសទី ☐

អ្នកសំភាស : ………. ទីកន្លែង : ………………
កាលបរិច្ឆេទ : ….. ……ឧសភា ២០០៧ AM/PM

ការសិក្សាសេវាកម្មរថយន្តក្រុងក្នុងទីក្រុងភ្នំពេញ

1. សូមផ្តល់នូវព័ត៌មាន អំពីការធ្វើដំណើររបស់លោកអ្នក អំបាញ់មិញនេះ

មធ្យោបាយធ្វើដំណើរ: ☐ រថយន្ត ☐ ម៉ូតូ ☐ ម៉ូតូឌុប ☐ កង់ ☐ ដើរ

ទិសដៅ: ☐ ធ្វើការ ☐ សាលារៀន ☐ ទិញឥវ៉ាន់ ☐ ផ្សេងៗ សូមបញ្ជាក់ …………

ថ្លៃធ្វើដំណើរ: ………… រៀល រយៈពេលធ្វើដំណើរ: ……… នាទី ចំងាយធ្វើដំណើរ: ……….. គីឡូម៉ែត្រ

2. ឧបមាថា មានរថយន្តក្រុងចរាចរណ៍ក្នុងទីក្រុងភ្នំពេញ ចំនួន៤ខ្សែ ដូចឃើញក្នុងរូបភាព។ ដូច្នេះ យើងខ្ញុំត្រូវការសុំមតិរបស់លោកអ្នក ដើម្បីនឹងផ្តល់នូវ សេវាកម្មមួយដែលមានលក្ខណៈសមស្រប និងជាទីពេញចិត្តដល់លោកអ្នក ។ សូមមេត្តា ពិចារណានូវជំរើសមួយចំនួន ដូចខាងក្រោម ថាតើលោកអ្នក នឹងប្រើប្រាស់សេវារថយន្តក្រុង ដែរឬទេ ?

	ជំរើស	ថ្លៃជិះ (រ)	ភាពញឹកញាប់នៃសេវាកម្ម	រយៈពេលដើរទៅកាន់ស្ថានីយជិះ (នាទី)	ភាពងាយស្រួល	ការសំរេចចិត្ត (សូមគូស √)	
ឈុតទី ១	1	1800	6 រថយន្តក្រុង/ម៉ោង	4	កង្ហារ	○ប្រើប្រាស់	○មិនប្រើប្រាស់
	2	900	6 រថយន្តក្រុង/ម៉ោង	8	កង្ហារ	○ប្រើប្រាស់	○មិនប្រើប្រាស់
	3	1500	3 រថយន្តក្រុង/ម៉ោង	4	ម៉ាស៊ីនត្រជាក់	○ប្រើប្រាស់	○មិនប្រើប្រាស់
	4	1200	3 រថយន្តក្រុង/ម៉ោង	8	ម៉ាស៊ីនត្រជាក់	○ប្រើប្រាស់	○មិនប្រើប្រាស់

ដោយប្រៀបធៀបជំរើសទាំងអស់ខាងលើ ខ្ញុំគិតថាជំរើសដែលល្អជាងគេគឺជំរើសទី ☐

សន្មតថា ជំរើសដែលលោកអ្នកបានជ្រើសរើសខាងលើ អាចផ្តល់ជូនបាន តើលោកអ្នកមានបំណងនឹងប្តូរមកជិះរថយន្តក្រុង ដែរឬទេ ?

☐ ប្រាកដជាមិនជិះ ☐ ប្រហែលជាមិនជិះ ☐ មិនច្បាស់ ☐ ប្រហែលជាជិះ ☐ ប្រាកដជាជិះ

	ជំរើស	ថ្លៃជិះ (រ)	ភាពញឹកញាប់នៃសេវាកម្ម	រយៈពេលដើរទៅកាន់ស្ថានីយជិះ (នាទី)	ភាពងាយស្រួល	ការសំរេចចិត្ត (សូមគូស √)	
ឈុតទី ២	5	1800	3 រថយន្តក្រុង/ម៉ោង	8	ម៉ាស៊ីនត្រជាក់	○ប្រើប្រាស់	○មិនប្រើប្រាស់
	6	900	3 រថយន្តក្រុង/ម៉ោង	4	ម៉ាស៊ីនត្រជាក់	○ប្រើប្រាស់	○មិនប្រើប្រាស់
	7	1200	6 រថយន្តក្រុង/ម៉ោង	4	កង្ហារ	○ប្រើប្រាស់	○មិនប្រើប្រាស់
	8	1500	6 រថយន្តក្រុង/ម៉ោង	8	កង្ហារ	○ប្រើប្រាស់	○មិនប្រើប្រាស់

ដោយប្រៀបធៀបជំរើសទាំងអស់ខាងលើ ខ្ញុំគិតថាជំរើសដែលល្អជាងគេគឺជំរើសទី ☐

សន្មតថា ជំរើសដែលលោកអ្នកបានជ្រើសរើសខាងលើ អាចផ្តល់ជូនបាន តើលោកអ្នកមានបំណងនឹងប្តូរមកជិះរថយន្តក្រុង ដែរឬទេ ?

☐ ប្រាកដជាមិនជិះ ☐ ប្រហែលជាមិនជិះ ☐ មិនច្បាស់ ☐ ប្រហែលជាជិះ ☐ ប្រាកដជាជិះ

ចុងបញ្ចប់ បើប្រៀបធៀប រវាងឈុតទាំងពីរ តើជំរើសណាមួយ ដែលលោកអ្នកគិតថា ល្អជាងគេ ? ជំរើសទី ☐

3. សូមបំពេញនូវព័ត៌មានមួយចំនួនដូចខាងក្រោមអំពីខ្លួនអ្នក :

3.1 អាយុ _____ ភេទ : ☐ ប្រុស ☐ ស្រី

3.2 ផ្ទះរបស់អ្នកនៅក្នុងខណ្ឌ : ☐ ដូនពេញ ☐ ៧មករា ☐ ទួលគោក
☐ ចំការមន ☐ ឫស្សីកែវ ☐ ជាយក្រុង

3.3 មុខរបរ ☐ សិស្សវិទ្យាល័យ ☐ សិស្សមហាវិទ្យាល័យ ☐ អ្នកលក់ដូរ
☐ អ្នកធ្វើការ ☐ អ្នកគ្មានការងារ ☐ ផ្សេងៗ សូមបញ្ជាក់___________

3.4 កំរិតវប្បធម៌ ☐ ទាបជាងបឋមសិក្សា ☐ បឋមសិក្សា ☐ វិទ្យាល័យ
☐ បរិញ្ញាបត្រ ☐ ក្រោយ បរិញ្ញាបត្រ

3.5 បៀវត្សប្រចាំខែ ☐ គ្មាន ☐ តិចជាង $50 ☐ $50-$150 ☐ $150-$250
☐ $250-$350 ☐ $350-$450 ☐ ច្រើនជាង $450

3.6 បៀវត្សប្រចាំខែក្នុងគ្រួសារ ☐ គ្មាន ☐ តិចជាង $50 ☐ $50-$150 ☐ $150-$250
☐ $250-$350 ☐ $350-$450 ☐ ច្រើនជាង $450

3.7 តើមានសមាជិកប៉ុន្មាន នាក់នៅក្នុងគ្រួសាររបស់លោកអ្នក (រួមទាំងខ្លួនអ្នក) ______

3.8 តើអ្នកមានឡានទេនៅក្នុង ផ្ទះ ? ☐ អត់ ☐ មាន មានប៉ុន្មាន? _____

3.9 តើអ្នកបាន ម៉ូតូ ទេ នៅក្នុង ផ្ទះ ? ☐ អត់ ☐ មាន មានប៉ុន្មាន? _____

3.10 តើអ្នកមានកង់ទេនៅក្នុង ផ្ទះ ? ☐ អត់ ☐ មាន មានប៉ុន្មាន? _____

3.11 តាមធម្មតាលោកអ្នកធ្វើដំណើរ ពី ផ្ទះ ទៅកន្លែងធ្វើការ ដោយសារអ្វី ?

☐ ឡាន ☐ ម៉ូតូ ☐ កង់ ☐ ដើរ ☐ ម៉ូតូឌុប

3.12 តាមធម្មតាលោកអ្នកធ្វើដំណើរ ទៅទិញអីវ៉ាន់ ដោយសារអ្វី ?

☐ ឡាន ☐ ម៉ូតូ ☐ កង់ ☐ ដើរ ☐ ម៉ូតូឌុប

3.13 ក្នុងមួយសប្តាហ៍កន្លងទៅនេះ តើលោកអ្នកបានប្រើប្រាស់មធ្យោបាយអ្វីខ្លះ ? ប៉ុន្មានដង ?

ឡាន: ☐ រៀងរាល់ ថ្ងៃ ☐ 4-5 ថ្ងៃ/ 1 សប្តាហ៍ ☐ 2-3 ថ្ងៃ /1 សប្តាហ៍ ☐ កំរ ☐ អត់សោះ

ម៉ូតូ: ☐ រៀងរាល់ ថ្ងៃ ☐ 4-5 ថ្ងៃ/ 1 សប្តាហ៍ ☐ 2-3 ថ្ងៃ /1 សប្តាហ៍ ☐ កំរ ☐ អត់សោះ

កង់: ☐ រៀងរាល់ ថ្ងៃ ☐ 4-5 ថ្ងៃ/ 1 សប្តាហ៍ ☐ 2-3 ថ្ងៃ /1 សប្តាហ៍ ☐ កំរ ☐ អត់សោះ

ម៉ូតូឌុប: ☐ រៀងរាល់ ថ្ងៃ ☐ 4-5 ថ្ងៃ/ 1 សប្តាហ៍ ☐ 2-3 ថ្ងៃ /1 សប្តាហ៍ ☐ កំរ ☐ អត់សោះ

ដើរ: ☐ រៀងរាល់ ថ្ងៃ ☐ 4-5 ថ្ងៃ/ 1 សប្តាហ៍ ☐ 2-3 ថ្ងៃ /1 សប្តាហ៍ ☐ កំរ ☐ អត់សោះ

3.14 ឧបមាថា មានការបំរើសេវារថយន្តក្រុង ក្នុងទីក្រុងភ្នំពេញ តើលោកអ្នកនឹងជិះ ប៉ុន្មានដង ?

☐ រៀងរាល់ ថ្ងៃ ☐ 4-5 ថ្ងៃ/ 1 សប្តាហ៍ ☐ 2-3 ថ្ងៃ /1 សប្តាហ៍ ☐ កំរ ☐ អត់សោះ

3.15 សូមដាក់តាមលេខរៀងនូវ ខ្សែរថយន្តក្រុងដែលលោកអ្នក ប្រើប្រាស់ញឹកញាប់ (លេខ 1 = ប្រើប្រាស់ញឹកញាប់ជាងគេ លេខ 4 = ប្រើប្រាស់តិចជាងគេ)

___ខ្សែទី១ ___ ខ្សែទី២ ___ ខ្សែទី៣ ___ ខ្សែទី៤

Interviewer ………. Location………………
Survey Date………… May 2007 AM/PM

A

Bus Service Study in Phnom Penh

1. Please provide information about your current trip.

Transport mode ☐ Private car ☐ Motorbike ☐ Motorcycle taxi ☐ Bicycle ☐ Walk

Trip purpose ☐ Work ☐ School ☐ Shopping ☐ Others (specify)…………

Travel cost …… riel Travel time……minutes Travel distance……... kilometer

2. Suppose there is a bus system running in Phnom Penh with 4 lines in service (see map). Many features of the service will be designed; thus, we would like to ask you some questions for better understanding your preference. Please consider each scenario.

Bus Scenario 1

Alternative	Cost (៛)	Bus Frequency	Walking Time (minute)	Comfort	Your decision
1	900	3 buses/hour	4	Fan	○ Will use ○ Will not use
2	1200	6 buses/hour	4	Air	○ Will use ○ Will not use
3	1800	3 buses/hour	8	Fan	○ Will use ○ Will not use
4	1500	6 buses/hour	8	Air	○ Will use ○ Will not use

Comparing these above alternatives, I think the best alternative is Alternative ☐

Suppose your best bus alternative is available for the same trip, how likely will you use the bus instead of the transport mode that you just made today?

☐ Very unlikely ☐ Unlikely ☐ Not sure ☐ Likely ☐ Very likely

Bus Scenario 2

Alternative	Cost (៛)	Bus Frequency	Walking Time (minute)	Comfort	Your decision
5	1500	3 buses/hour	4	Fan	○ Will use ○ Will not use
6	900	6 buses/hour	8	Air	○ Will use ○ Will not use
7	1200	3 buses/hour	8	Fan	○ Will use ○ Will not use
8	1800	6 buses/hour	4	Air	○ Will use ○ Will not use

Comparing these above alternatives, I think the best alternative is Alternative ☐

Suppose your best bus alternative is available for the same trip, how likely will you use the bus instead of the transport mode that you just made today?

☐ Very unlikely ☐ Unlikely ☐ Not sure ☐ Likely ☐ Very likely

Lastly, comparing both scenarios 1 and 2, the most preferred alternative for you is alternative ☐

Interviewer	Location..................
Survey Date...........	May 2007 AM/PM

B

Bus Service Study in Phnom Penh

1. Please provide information about your current trip.

Transport mode ☐ Private car ☐ Motorbike ☐ Motorcycle taxi ☐ Bicycle ☐ Walk

Trip purpose ☐Work ☐ School ☐ Shopping ☐ Others (specify)............

Travel cost ...... riel Travel time......minutes Travel distance......... kilometer

2. Suppose there is a bus system running in Phnom Penh with 4 lines in service (see map). Many features of the service will be designed; thus, we would like to ask you some questions for better understanding your preference. Please consider each scenario.

Bus Scenario 1

Alternative	Cost (៛)	Bus Frequency	Walking Time (minute)	Comfort	Your decision
1	1800	6 buses/hour	4	Fan	○ Will use ○ Will not use
2	900	6 buses/hour	8	Fan	○ Will use ○ Will not use
3	1500	3 buses/hour	4	Air	○ Will use ○ Will not use
4	1200	3 buses/hour	8	Air	○ Will use ○ Will not use

Comparing these above alternatives, I think the best alternative is Alternative ☐

Suppose your best bus alternative is available for the same trip, <u>how likely will you use the bus</u> instead of the transport mode that you just made today?

☐ Very unlikely ☐ Unlikely ☐ Not sure ☐ Likely ☐ Very likely

Bus Scenario 2

Alternative	Cost (៛)	Bus Frequency	Walking Time (minute)	Comfort	Your decision
5	1800	3 buses/hour	8	Air	○ Will use ○ Will not use
6	900	3 buses/hour	4	Air	○ Will use ○ Will not use
7	1200	6 buses/hour	4	Fan	○ Will use ○ Will not use
8	1500	6 buses/hour	8	Fan	○ Will use ○ Will not use

Comparing these above alternatives, I think the best alternative is Alternative ☐

Suppose your best bus alternative is available for the same trip, <u>how likely will you use the bus</u> instead of the transport mode that you just made today?

☐ Very unlikely ☐ Unlikely ☐ Not sure ☐ Likely ☐ Very likely

Lastly, comparing both scenarios 1 and 2, the most preferred alternative for you is alternative ☐

3. Please fill in the following:

1) Age _____ Gender: ☐ Male ☐ Female

2) District of your home: ☐ Done Penh ☐ 7 Makara ☐ Tuol Kork
☐ Chamkar Morn ☐ Reussey Keo ☐ Suburban

3) Occupation ☐ High school student ☐ University student ☐ Seller ☐ Employee
☐ Unemployed ☐ Others, please specify_________________

4) Education ☐ Uneducated ☐ Primary school ☐ High school
☐ Bachelor's ☐ Higher than Bachelor's

5) Monthly income ☐ None ☐ Less than $50 ☐ $50-$150 ☐ $150-$250
☐ $250-$350 ☐ $350-$450 ☐ Higher than $450

6) Household monthly income ☐ None ☐ Less than $50 ☐ $50-$150 ☐ $150-$250
☐ $250-$350 ☐ $350-$450 ☐ Higher than $450

7) How many members are there in your household (including yourself) ______

8) Do you have cars in your household? ☐ No ☐ Yes, how many? _____

9) Do you have motorcycles in your household? ☐ No ☐ Yes, how many? _____

10) Do you have bicycles in your household? ☐ No ☐ Yes, how many? _____

11) How do you usually commute from home to work/school?
☐ Private car ☐ Private motorbike ☐ Bicycle ☐ Walking ☐ Motorcycle taxi

12) How do you usually go shopping?
☐ Private car ☐ Private motorbike ☐ Bicycle ☐ Walking ☐ Motorcycle taxi

13) Within the last week, how often did you use the following modes of transport?

Private car:	☐ Everyday	☐ 4-5 days/ week	☐ 2-3 days/week	☐ Rarely	☐ Never
Motorbike:	☐ Everyday	☐ 4-5 days/ week	☐ 2-3 days/week	☐ Rarely	☐ Never
Bicycle:	☐ Everyday	☐ 4-5 days/ week	☐ 2-3 days/week	☐ Rarely	☐ Never
Motorcycle taxi:	☐ Everyday	☐ 4-5 days/ week	☐ 2-3 days/week	☐ Rarely	☐ Never

14) If there is a city bus service in Phnom Penh, how often would you use it?
☐ Everyday ☐ 4-5 days/ week ☐ 2-3 days/week ☐ Rarely ☐ Never

15) Please rank the bus service line (from 1 = use the most to 4 = use the least)
___Line 1 ___Line 2 ___Line 3 ___Line 4

Appendix B

Pilot Survey Forms

សេវាកម្មរថយន្តក្រុងក្នុងទីក្រុងភ្នំពេញ

អ្នកសំភាស :	កាលបរិច្ឆេទ :
ទីកន្លែង :	ម៉ោង :

ឧទាហរណ៍ថា មានការបំរើសេវារថយន្តក្រុងក្នុងទីក្រុងភ្នំពេញ។ ដូច្នេះ យើងខ្ញុំត្រូវការស្ទង់មតិរបស់លោកអ្នក ដើម្បីនឹងផ្តល់នូវសេវាកម្មមួយដែលមានលក្ខណៈសមស្របនិងជាទីពេញចិត្តរបស់លោកអ្នក ។ សូមមេត្តាសហការណ៍ ជួយផ្តល់នូវចំលើយ ពិតប្រាកដទៅនឹងសំនួរមួយចំនួនដូចខាងក្រោមនេះ។

1. ចូរជ្រើសរើសដោយគូស(√) នូវជំរើស មួយក្នុងចំនោមជំរើស បី ដូចខាងក្រោម :

ឈុតទី 1

	ថ្លៃឡើងជិះដំបូង (៛)	ថ្លៃជិះក្នុង1 km (៛)	រយៈពេលរង់ចាំ (នាទី)	ចំងាយដើរទៅកាន់ស្ថានីយជិះ (ម៉ែត្រ)	ភាពងាយស្រួល
☐ ជំរើសទី 1	300	100	3	50	ម៉ាស៊ីនត្រជាក់
☐ ជំរើសទី 2	500	200	6	200	កង្ហារ
☐ ជំរើសទី 3	700	300	9	100	ធម្មតា

ឈុតទី 2

	ថ្លៃឡើងជិះដំបូង (៛)	ថ្លៃជិះក្នុង1 km (៛)	រយៈពេលរង់ចាំ (នាទី)	ចំងាយដើរទៅកាន់ស្ថានីយជិះ (ម៉ែត្រ)	ភាពងាយស្រួល
☐ ជំរើសទី 1	500	300	6	50	ម៉ាស៊ីនត្រជាក់
☐ ជំរើសទី 2	300	200	3	100	ធម្មតា
☐ ជំរើសទី 3	700	100	9	200	កង្ហារ

ឈុតទី 3

	ថ្លៃឡើងជិះដំបូង (៛)	ថ្លៃជិះក្នុង1 km (៛)	រយៈពេលរង់ចាំ (នាទី)	ចំងាយដើរទៅកាន់ស្ថានីយជិះ (ម៉ែត្រ)	ភាពងាយស្រួល
☐ ជំរើសទី 1	500	100	6	100	ធម្មតា
☐ ជំរើសទី 2	300	300	3	200	កង្ហារ
☐ ជំរើសទី 3	700	200	9	50	ម៉ាស៊ីនត្រជាក់

សេវាកម្មរថយន្តក្រុងក្នុងទីក្រុងភ្នំពេញ

អ្នកសំភាស :	កាលបរិច្ឆេទ :
ទីកន្លែង :	ម៉ោង :

ឧទាហរណ៍ថា មានការបំរើសេវារថយន្តក្រុងក្នុងទីក្រុងភ្នំពេញ។ ដូច្នេះ យើងខ្ញុំត្រូវការស្ទង់មតិរបស់លោកអ្នក ដើម្បីនឹងផ្តល់នូវសេវាកម្មមួយដែលមានលក្ខណៈសមស្របនិងជាទីពេញចិត្តដល់លោកអ្នក ។ សូមមេត្តាសហការណ៍ ជួយផ្តល់នូវចំលើយ ពិតប្រាកដទៅនឹងសំនួរមួយចំនួនដូចខាងក្រោមនេះ ។

1. ចូរជ្រើសរើសដោយគូស(√) នូវជំរើស មួយក្នុងចំណោមជំរើស បី ដូចខាងក្រោម :

ឈុតទី 1

	ថ្លៃឡើងជិះដំបូង (៛)	ថ្លៃជិះក្នុង1 km (៛)	រយៈពេលរង់ចាំ (នាទី)	ចំងាយដើរទៅកាន់ស្ថានីយជិះ (ម៉ែត្រ)	ភាពងាយស្រួល
☐ ជំរើសទី 1	300	200	6	100	ម៉ាស៊ីនត្រជាក់
☐ ជំរើសទី 2	700	100	3	200	ធម្មតា
☐ ជំរើសទី 3	500	300	9	50	កង្ហារ

ឈុតទី 2

	ថ្លៃឡើងជិះដំបូង (៛)	ថ្លៃជិះក្នុង1 km (៛)	រយៈពេលរង់ចាំ (នាទី)	ចំងាយដើរទៅកាន់ស្ថានីយជិះ (ម៉ែត្រ)	ភាពងាយស្រួល
☐ ជំរើសទី 1	300	300	6	200	ធម្មតា
☐ ជំរើសទី 2	700	200	3	50	កង្ហារ
☐ ជំរើសទី 3	500	100	9	100	ម៉ាស៊ីនត្រជាក់

ឈុតទី 3

	ថ្លៃឡើងជិះដំបូង (៛)	ថ្លៃជិះក្នុង1 km (៛)	រយៈពេលរង់ចាំ (នាទី)	ចំងាយដើរទៅកាន់ស្ថានីយជិះ (ម៉ែត្រ)	ភាពងាយស្រួល
☐ ជំរើសទី 1	300	100	6	50	កង្ហារ
☐ ជំរើសទី 2	700	300	3	100	ម៉ាស៊ីនត្រជាក់
☐ ជំរើសទី 3	500	200	9	200	ធម្មតា

សេវាកម្មរថយន្តក្រុងក្នុងទីក្រុងភ្នំពេញ

អ្នកសំភាស :	កាលបរិច្ឆេទ :
ទីកន្លែង :	ម៉ោង :

ឧទាហរណ៍ថា មានការបំរើសេវារថយន្តក្រុងក្នុងទីក្រុងភ្នំពេញ។ ដូច្នេះ យើងខ្ញុំត្រូវការស្ទង់មតិរបស់លោកអ្នក ដើម្បីនឹងផ្តល់នូវសេវាកម្មមួយដែលមានលក្ខណៈសមស្របនិងជាទីពេញចិត្តដល់លោកអ្នក ។ សូមមេត្តាសហការណ៍ ជួយផ្តល់នូវចំលើយ ពិតប្រាកដទៅនឹងសំនួរមួយចំនួនដូចខាងក្រោមនេះ។

1. ចូរជ្រើសរើសដោយគូស(√) នូវជំរើស មួយក្នុងចំនោមជំរើស បី ដូចខាងក្រោម :

ឈុតទី 1

	ថ្លៃឡើងជិះដំបូង (រ)	ថ្លៃជិះក្នុង1 km (រ)	រយៈពេលរង់ចាំ (នាទី)	ចំងាយដើរទៅកាន់ស្ថានីយជិះ (ម៉ែត្រ)	ភាពងាយស្រួល
☐ ជំរើសទី 1	700	200	6	50	ធម្មតា
☐ ជំរើសទី 2	300	300	9	200	ម៉ាស៊ីនត្រជាក់
☐ ជំរើសទី 3	500	100	3	100	កង្ហារ

ឈុតទី 2

	ថ្លៃឡើងជិះដំបូង (រ)	ថ្លៃជិះក្នុង1 km (រ)	រយៈពេលរង់ចាំ (នាទី)	ចំងាយដើរទៅកាន់ស្ថានីយជិះ (ម៉ែត្រ)	ភាពងាយស្រួល
☐ ជំរើសទី 1	300	100	9	50	ធម្មតា
☐ ជំរើសទី 2	700	300	6	100	កង្ហារ
☐ ជំរើសទី 3	500	200	3	200	ម៉ាស៊ីនត្រជាក់

ឈុតទី 3

	ថ្លៃឡើងជិះដំបូង (រ)	ថ្លៃជិះក្នុង1 km (រ)	រយៈពេលរង់ចាំ (នាទី)	ចំងាយដើរទៅកាន់ស្ថានីយជិះ (ម៉ែត្រ)	ភាពងាយស្រួល
☐ ជំរើសទី 1	500	300	3	50	ធម្មតា
☐ ជំរើសទី 2	700	100	6	200	ម៉ាស៊ីនត្រជាក់
☐ ជំរើសទី 3	300	200	9	100	កង្ហារ

2. ចូរបំពេញនូវពត៌មានមួយចំនួនដូចខាងក្រោមអំពីខ្លួនអ្នក :

2.1 អាយុ _____

2.2 ភេទ ☐ ប្រុស ☐ ស្រី

2.3 មុខរបរ ☐ សិស្សបឋមសិក្សា ☐ សិស្សវិទ្យាល័យ ☐ សិស្សមហាវិទ្យាល័យ ☐ អ្នកធ្វើការ
☐ អ្នកលក់ដូរ ☐ អ្នកគ្មានការងារ ☐ ផ្សេងៗ ចូរបញ្ជាក់____________

2.4 កំរិតវប្បធម៌ ☐ ទាបជាងបឋមសិក្សា ☐ បឋមសិក្សា ☐ វិទ្យាល័យ
☐ បរិញ្ញាបត្រ ☐ ក្រោយ បរិញ្ញាបត្រ

2.5 របៀវត្សប្រចាំខែ ☐ គ្មាន ☐ តិចជាង $50 ☐ $50-$80 ☐ $80-$120
☐ $120-$180 ☐ $180-$250 ☐ $250-$400 ☐ ច្រើនជាង $400

2.6 តើមានសមាជិកប៉ុន្មាន នាក់នៅក្នុងគ្រួសាររបស់លោកអ្នក (រួមទាំងខ្លួនអ្នក) ______

2.7 តើអ្នកមានឡានទេនៅក្នុង ផ្ទះ ? ☐ អត់ ☐ មាន មានប៉ុន្មាន? _____

2.8 តើអ្នកមាន ម៉ូតូ ទេ នៅក្នុង ផ្ទះ ? ☐ អត់ ☐ មាន មានប៉ុន្មាន? _____

2.9 តើអ្នកមានកង់ទេនៅក្នុង ផ្ទះ ? ☐ អត់ ☐ មាន មានប៉ុន្មាន? _____

2.10 តាមធម្មតាលោកអ្នកធ្វើដំណើរ ពី ផ្ទះ ទៅកន្លែងធ្វើការ ដោយសារអ្វី ?

☐ ឡាន ☐ ម៉ូតូ ☐ កង់ ☐ ដើរ ☐ ម៉ូតូឌុប

2.11 តាមធម្មតាលោកអ្នកធ្វើដំណើរ ទៅទិញអីវ៉ាន់ ដោយសារអ្វី ?

☐ ឡាន ☐ ម៉ូតូ ☐ កង់ ☐ ដើរ ☐ ម៉ូតូឌុប

2.12 ក្នុងមួយសប្តាហ៍កន្លងទៅនេះ លោកអ្នកបានប្រើប្រាស់មធ្យោបាយអ្វី ? ប៉ុន្មានដង ?

ឡាន: ☐ រៀងរាល់ ថ្ងៃ ☐ 4-5 ថ្ងៃ/ 1 សប្តាហ៍ ☐ 2-3 ថ្ងៃ /1 សប្តាហ៍ ☐ កំរ ☐ អត់សោះ

ម៉ូតូ: ☐ រៀងរាល់ ថ្ងៃ ☐ 4-5 ថ្ងៃ/ 1 សប្តាហ៍ ☐ 2-3 ថ្ងៃ /1 សប្តាហ៍ ☐ កំរ ☐ អត់សោះ

កង់: ☐ រៀងរាល់ ថ្ងៃ ☐ 4-5 ថ្ងៃ/ 1 សប្តាហ៍ ☐ 2-3 ថ្ងៃ /1 សប្តាហ៍ ☐ កំរ ☐ អត់សោះ

ម៉ូតូឌុប: ☐ រៀងរាល់ ថ្ងៃ ☐ 4-5 ថ្ងៃ/ 1 សប្តាហ៍ ☐ 2-3 ថ្ងៃ /1 សប្តាហ៍ ☐ កំរ ☐ អត់សោះ

2.13 ឧទាហរណ៍ថា មានការបំរើសេវារថយន្តក្រុងក្នុងទីក្រុងភ្នំពេញ តើលោកអ្នកមានទស្សន យ៉ាងណាដែរចំពោះការប្រើប្រាស់សេវាកម្មនេះ ?

☐ ប្រាកដជាមិនជិះ ☐ ប្រហែលជាមិនជិះ ☐ មិនច្បាស់ ☐ ប្រហែលជាជិះ ☐ ប្រាកដជាជិះ

2.14 ចូរដាក់តាមលេខរៀងនូវ កត្តាមួយចំនួនដូចខាងក្រោមនេះ ទៅតាមភាពសំខាន់របស់វា ដែលលោកអ្នកយល់ឃើញ (លេខ 1 = សំខាន់ជាងគេ លេខ 7 = មិន សំខាន់ទាល់តែសោះ)

_____ ថ្លៃជិះ _____ ភាពញឹកញាប់នៃសេវាកម្ម _____ ភាពងាយស្រួលក្នុងការជិះ

_____ ចំងាយដើរទៅកាន់ ស្ថានីយជិះ _____ ភាពស្អាតនៃរថយន្តក្រុង _____ ល្បឿន _____ កន្លែងអង្គុយ

A

Preliminary Data Survey

Bus Service in Phnom Penh

Interviewer:	Survey Date:
Location:	Survey Time:

Suppose there is a bus system running in Phnom Penh. Many characteristics of the service can be listed; thus, we would like to ask you some questions for better understanding your preference and helping regulate the service's characteristics properly.

1. For each scenario, please select (√) your preferred choice.

Scenario 1

	Get-in cost (riel)	Cost per km (riel)	Waiting time (minutes)	Walking distance (m)	Comfort
☐ Alternative 1	300	100	3	50	Air
☐ Alternative 2	500	200	6	200	Fan
☐ Alternative 3	700	300	9	100	Normal

Scenario 2

	Get-in cost (riel)	Cost per km (riel)	Waiting time (minutes)	Walking distance (m)	Comfort
☐ Alternative 1	500	300	6	50	Air
☐ Alternative 2	300	200	3	100	Normal
☐ Alternative 3	700	100	9	200	Fan

Scenario 3

	Get-in cost (riel)	Cost per km (riel)	Waiting time (minutes)	Walking distance (m)	Comfort
☐ Alternative 1	500	100	6	100	Normal
☐ Alternative 2	300	300	3	200	Fan
☐ Alternative 3	700	200	9	50	Air

B

Bus Service in Phnom Penh

Interviewer:	Survey Date:
Location:	Survey Time:

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1. For each scenario, please select (√) your preferred choice.

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	Get-in cost (riel)	Cost per km (riel)	Waiting time (mn)	Walking distance (m)	Comfort
☐ Alternative 1	300	200	6	100	Air
☐ Alternative 2	700	100	3	200	Normal
☐ Alternative 3	500	300	9	50	Fan

Scenario 2

	Get-in cost (riel)	Cost per km (riel)	Waiting time (mn)	Walking distance (m)	Comfort
☐ Alternative 1	300	300	6	200	Normal
☐ Alternative 2	700	200	3	50	Fan
☐ Alternative 3	500	100	9	100	Air

Scenario 3

	Get-in cost (riel)	Cost per km (riel)	Waiting time (mn)	Walking distance (m)	Comfort
☐ Alternative 1	300	100	6	50	Fan
☐ Alternative 2	700	300	3	100	Air
☐ Alternative 3	500	200	9	200	Normal

Bus Service in Phnom Penh

Interviewer:	Survey Date:
Location:	Survey Time:

Suppose there is a bus system running in Phnom Penh. Many characteristics of the service can be listed; thus, we would like to ask you some questions for better understanding your preference and helping regulate the service's characteristics properly.

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Scenario 2

	Get-in cost (riel)	Cost per km (riel)	Waiting time (mn)	Walking distance (m)	Comfort
☐ Alternative 1	300	100	9	50	Normal
☐ Alternative 2	700	300	6	100	Fan
☐ Alternative 3	500	200	3	200	Air

Scenario 3

	Get-in cost (riel)	Cost per km (riel)	Waiting time (mn)	Walking distance (m)	Comfort
☐ Alternative 1	500	300	3	50	Normal
☐ Alternative 2	700	100	6	200	Air
☐ Alternative 3	300	200	9	100	Fan

2. Please fill in your personal characteristics as listed the following:

2.1 Age _____

2.2 Gender ☐ Male ☐ Female

2.3 Occupation ☐ Primary school student ☐ High school student ☐ University school student ☐ Employee ☐ Seller ☐ Unemployed ☐ Others, please specify_________________

2.4 Education ☐ Uneducated ☐ Primary school ☐ High school ☐ Bachelor's ☐ Higher than Bachelor's

2.5 Monthly income ☐ None ☐ Less than $50 ☐ $50-$80 ☐ $80-$120 ☐ $120-$180 ☐ $180-$250 ☐ $250-$400 ☐ More than $400

2.6 How many members are there in your household (including yourself) ______

2.7 Do you have cars in your household? ☐ No ☐ Yes, how many? _____

2.8 Do you have motorcycles in your household? ☐ No ☐ Yes, how many? _____

2.9 Do you have bicycles in your household? ☐ No ☐ Yes, how many? _____

2.10 How do you usually commute from home to work/school?
☐ Private car ☐ Private motorbike ☐ Bicycle ☐ Walking ☐ Motorcycle taxi

2.11 How do you usually go shopping?
☐ Private car ☐ Private motorbike ☐ Bicycle ☐ Walking ☐ Motorcycle taxi

2.12 Within the last week, how often did you use the following modes of transport?

Private car:	☐ Everyday	☐ 4-5 days/ week	☐ 2-3 days/week	☐ Rarely	☐ Never
Motorbike:	☐ Everyday	☐ 4-5 days/ week	☐ 2-3 days/week	☐ Rarely	☐ Never
Bicycle:	☐ Everyday	☐ 4-5 days/ week	☐ 2-3 days/week	☐ Rarely	☐ Never
Motorcycle taxi:	☐ Everyday	☐ 4-5 days/ week	☐ 2-3 days/week	☐ Rarely	☐ Never

2.13 If there is a city bus service in Phnom Penh, how likely will you use it?
☐ Very unlikely ☐ Unlikely ☐ Not sure ☐ Likely ☐ Very likely

2.14 If there is a city bus service in Phnom Penh, please rank the following factors from 1 to 7, where 1= most important factor to you and 7 = least important to you.

_____Fare _____Comfort _____Walking distance

_____ Bus cleanliness ______ Speed _____Seat availability

_____Service frequency

BIBLIOGRAPHY

UNG Meng Hong was born in 1983 in Prey Tortung, a small town in Kampong Cham province, Cambodia. When he finished high school, he came to Phnom Penh, the capital city of Cambodia, and then he passed the entrance to study in ITC (Institute of Technology of Cambodia) where he earned his Bachelor of Engineering in 2005. He stayed in the campus' dormitory in the period of his study in Phnom Penh until he graduated. He studied in Department of Rural Engineering, Institute of Technology of Cambodia in the field of Geotechnical Engineering. Soon after he graduated, he was awarded AUN/SEED-Net scholarship to continue his study in Department of Civil Engineering, Faculty of Engineering, Chulalongkorn University, Bangkok, Thailand in 2005. His research interest is in transportation planning.