ISLAMIC UNIVERSITY OF TECHNOLOGY

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A STUDY ON THE RELATIONSHIP BETWEEN DRIVER'S CHARACTERISTICS AND INFORMATION DISPLAYED IN VARIABLE MESSAGE SIGN (VMS)

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DECLARATION

We hereby declare the undergraduate project work reported in this thesis has been performed by us entirely and this work has not been submitted elsewhere for any purpose (except for publication).

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TO

OUR BELOVED PARENTS

ACKNOWLEDGEMENT

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ABSTRACT

A good communication system is the pre-requisite condition for the development of a country. For the last few years, VMS has become an important part of the communication system of the developed country. VMS is not only an issue which is related to the transportation system but also has influence on many social indicators or development.

Bangladesh is a developing country having large population. Its communication system is being improved day by day. For why some works on VMS are being done but it is very small in number. Perhaps due to its intuitive appeal, few studies have been conducted to examine the impact of this VMS on communication system.

The purpose of this study is to investigate the relationship between driver's characteristics and information displayed in variable message sign (VMS). The study was done in Dhaka city, the capital of Bangladesh. A questionnaire survey was conducted to find out drivers different characteristics and their choice of different message type. Using Multinomial Logit Model the survey result was analyzed. From the study we find that, different types of characteristics of the drivers like personal characteristics, driving and accident experience has significant effect on their choice of message. The study will help the policy makers to implement VMS effectively and to ensure the optimum use of VMS.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE:

INTRODUCTION

1.1 Background

Bangladesh, a developing South Asian nation, achieved its freedom of impendence in 1971 through liberation war which has a great importance all over the world for its geographical position. It is the world's eighth-most populous country, with over 160 million people, and among the most densely populated countries. Dhaka, the capital of Bangladesh is one of the oldest and most densely populated cities around the world. As it is the center of economy like business, industry, employment and having all of the facilities available compared to the other cities, people are migrated here and so, total number of population is very much high. A good communication system is a pre-requisite condition for the development of a country. Though we different ways for communication like-land, water, rail and civil aviation, they are not so well planned. According to a report of World Bank, "An efficient transportation system is essential to facilitate economic growth in Bangladesh. The country's economy needs to grow at a sustained 8 percent per year to achieve the first goal of the MDGs: that of halving the proportion of people living under a dollar a day by 2015. To achieve this growth, the transport sector will need to reduce costs and allocate resources among different modes of transport in a more balanced manner. Roads carry over 80 percent of national passenger traffic, providing the backbone of the transport sector in this country of approximately 160 million people". Most of the streets of Dhaka city are designed for only half of the already existing population. So, Dhaka city is in need of a concrete and digitalized transportation system which should comprise of perfectly designed street pattern, signs, signals, street lightening etc. to handle this overburden load of increased population. Moreover Bangladesh is a developing country, one of the major third world countries. And for the development of any country like Bangladesh transportation sector plays an unparallel rule for trade and commerce. Dhaka is the capital of Bangladesh. So an integrated transportation system is an essential element for a city like Dhaka for smooth operation of business and trade.

A term called 'Intelligent transportation system' is now rapidly used in different developed country and city. Variable Message Signs is an integral part of this intelligent transportation system. A Variable Message Sign (VMS) is a sign for the purpose of displaying one of a number of messages that may be changed or switched on or off as required. Variable message signs are used to inform the drivers about road conditions and to educate the divers about proper road use. It is mainly a widely used safety tools. Though variable message signs are now widely used across the world especially in developed country, it is seen in a very less number in Dhaka city where it is of extreme need. But unfortunately, these less number of signs are unnoticed to drivers and mostly not effective due to its unplanned management. Use of increased number of variable message signs in Dhaka city would have been of great benefit to optimize traffic load in roads, to reduce the rate of accidents and to reduce congestion across the road of Dhaka city. In a survey it was found

That almost no research related to VMS has been carried out in Bangladesh. Without any research it is very inconvenient to effectively implement variable message signs in the country. As a result a study regarding effective implementation of variable message signs in Dhaka city is a prime need in the perspective.

1.2 INTRODUCTION TO VARIABLE MESSAGE SIGN

1.2.1 Definition

VMS is an acronym word of Variable Message Sign. It is a road sign capable of displaying variable messages. In other words, A Variable Message Sign (VMS) is a sign for the purpose of displaying one of a number of messages that may be changed or switched on or off as required. After all, it helps the passengers to be informed about the road way conditions. Firstly, it was used in 1960s in the developed countries.

1.2.2 Purpose of Variable Message Signs

In Dynamic Traffic Management, VMS can be used for the following purposes:

a) Control, further to be divided in:

Lane Control

- lane change/closure
- lane merge by use of crosses and arrows

Speed Control

- speed funneling
- speed harmonization
- by using seed indications, with or without red border

Prescriptions
“no overtaking” etc.

VMS for lane and/or speed control purposes are in most cases positioned over the traffic lanes.
Prescription signs are usually placed between two adjacent lanes or at the side of the road.

b) Danger Warning Messages, further to be divided in:

Weather Conditions
- fog
- snow
- ice
- rain
- wind

Incident / accident
Congestion / queue
Road works ahead
Road status
- closures
- slippery road
- icy road (black ice)

Figure 1.1: Purpose of VMS (Danger Warning Messages)

Example B1: UK – Road works ahead

Example B2: NL- Fog

c) Informative Messages, further to be divided in:

- General Informative Messages
- useful traffic information
- Informative Link Messages
- Informative Network Messages
- Informative Rerouting Messages

For informative signs many European countries use large text panels with two or three lines of text, sometimes accompanied by a pictogram. When used for Informative Network Messages, these are sometimes called RIPs (Dynamic Route Information Panels).
A new development is GRIPs (Graphical Route Information Panels), where link or network information is presented in a graphical way.

Figure 1.2: Purpose of VMS(Informative Messages)

Example C1: NL - General Informative Message

Example C2: F - Informative Link Messages

Example C3: NL- Informative Link messages

Example C5: NL - Informative Rerouting Messages

1.3 VMS in Bangladesh

Currently there are only 31 VMS installed across Dhaka city which are mainly classified into two categories:

- big &
- small.

There are 17 VMS under category big and other 14 are under category small.
Sites with category are listed below:

Table 1.1: Locations of VMS installed

Serial no.	Camera site	Category
1	Abdullahpur Check post	Big
2	Gulshan Circle-1	Big
3	Sonargaon Crossing	Big
4	Mohakhali Crossing	Big

5	Progoti Sharani Bisho Road Crossing	Big
6	Farmgate Crossing	Big
7	Agargaon Light Crossing	Big
8	Nightingale Crossing	Big
9	Science Laboratory Crossing	Big
10	Moghbazar Crossing	Big
11	Hotel Sheraton Crossing	Big
12	Gabtali Bus terminal	Big
13	Sydabad Janapath Crossing	Big
14	Sanarpar Check Poing	Big
15	Bangladesh Bank Crossing	Big
16	Joykali Mandir Road	Big
17	East side of Sheraton Hotel	Big

Serial no.	**Camera site**	**Category**
1	Kakoli Crossing	Small
2	Shahbag Crossing	Small
3	Phinix Crossing	Small
4	Manik Mia Avenue (West)	Small
5	Mouchak Crossing	Small
6	Star Gate Crossing	Small
7	Zero Point	Small
8	Dhanmondi 27 no Crossing (West)	Small
9	Mirpur-10 Junction	Small
10	No-1 Buriganga Crossing Check Point	Small
11	Jatrabari Crossing	Small

12	Joykali Mandir	Small
13	Rampura Abul Hotel Crossing	Small
14	Jahangir Road	Small

Out of all these VMSs many VMS board are seen to show faulty messages. Some are totally out of service and one or two has been subjected to theft. All these VMSs are poorly maintained and monitored.

However, only few different messages are shown in all the VMS.
The text shown in different VMS are as follows:

- ✓ "Obey the traffic rules"
- ✓ "Do not change the lane frequently"
- ✓ "Motorcycles are prohibited on pavements"
- ✓ "Obey the legal rules of Police"
- ✓ "Speed Limit 30kmph"
- ✓ "Do not waste excessive amount of water &gas"

Again, no research work related to VMS has been carried out in Bangladesh. The outcome of which is the present poor scenario of VMS already installed and discussed above. So, research work regarding VMS in Dhaka city for effective implementation is of utmost importance.

1.4 Research objective:

The objectives to be achieved by this study are as follows:.

1. Determining the factors influencing the choice of message
2. Questionnaire survey of the stake holders (drivers) relating to the factors influencing the choice of message.
3. Study of drivers' behavior, attitude and concern about VMS which determines the proper way of implementing VMS.
4. Selection of the most convenient message after model analysis and statistical evaluation
5. Giving recommendations to the stakeholders with our key findings for the effective implementation of VMS.

1.5 Outline of The Thesis:

1.5.1 Chapter 1-Introduction:

This chapter includes the backround, general idea about VMS, purpose of VMS, current condition of VMS in Bangladesh and objective of the study.

1.5.2 Chapter 2- Literature Review:

Factors associated with driver's characteristics and VMS explored in previous studies are reviewed in this chapter. Important information and finding from these studies are also documented. Moreover, the history of the evolving of different types of messages displayed on VMS across the world is also discussed.

1.5.3 Chapter 3- Data and Methodology:

Chapter three describes the sources of the database used in this study as well as methodology followed in statistical analysis. The methodology used in similar studies is noted and the results obtained in the literatures are critically discussed. Moreover, Survey group, survey location, data collection, questionnaire preparation, goodness of fit are also discussed in this part.

1.5.4 Chapter 4-Model Development and Data Analysis:

This chapter includes overview of our study. Description of model development, calibration, evaluation and explanation of significant variables for each case study are given as well.

1.5.5 Chapter 5- Result:

This chapter describes about the model result from our study. It also includes the interpretation of the result.

1.5.6 Chapter 6- Conclusion:

This chapter includes the conclusion of the background, key points of the result, aim and scope of the study, future scope of this study, limitations. It also attaches a concluding remarks of all of our study.

CHAPTER TWO:

LITERATURE REVIEW

Variable Message Sign (VMS) has influenced to the response of road users in taking decisions related to real time information provided by Advanced Traveller Information Systems (ATIS) in developed and developing countries. Modeling the factors contributing to different decision chosen by drivers in the roads as for example: diversion decisions, route selection, lane changing, speed controlling etc. is a heated and researched topic all over the world. For successful implementation of VMS in roads various factors must be considered on which different researches already been done in different countries worldwide. But in Bangladesh the VMS is introduced very recently. The effective implementation has not been done yet because of lack of researches done related to VMS.

A critical element for the driver's acceptance of VMS is constituted by the meaningfulness of the message provided. Since the drivers are operating under conditions of systematic information overload, the saliency of the message constitutes one of the primary conditions for the position evaluation of the systems. In other words, the delivery of useless alarms or irrelevant information represents real risk for traffic systems. The drivers need to receive only relevant information and only when they need it.

2.1 VMS in brief:

VMS messages may be reactive incident messages e.g. advance warning of a crash; or proactive messages e.g. estimated travel time. VMS comprise two types, Continuous and Discontinuous signs. Continuous signs are similar to fixed signs, the only difference being that they can show various messages by some electromechanical means. For example rotating prism signs, roller blinds, etc. Discontinuous signs create messages using individual elements that can be in one of two states (or more) and can thereby create various messages on the same sign face. For example flip-disk signs, fiber optic signs, LED signs, etc.

2.2 Drivers response to VMS:

A number of previous studies focusing on VMSs and relevant driving behaviors have been conducted. Two typical research methods, questionnaire and computer simulation experiment, have been applied for analyzing main factors that influence drivers' route choices in the VMS environments. Through the questionnaire, it was found that whether drivers accept an item of VMS advice or not is closely associated with drivers' characteristics and their familiarity degree to the road network Generally, the acceptance rates of drivers who are unfamiliar with the road network are higher than the familiar drivers because the familiar drivers may select driving route based on experience rather than guidance information only . The drivers' personal attributes, such as age, gender, driving age, etc., can also significantly affect the driving behaviors in discovering, understanding, and complying with the guidance information as the travel characteristics of selected routes change. Similar to the survey results from questionnaire, the study based on the computer simulation experiment also showed that the factors including characteristics of guidance information and attributes of drivers would affect drivers' route choice.

Chatterjee et al (2002) conducted a survey in London determining response to VMS (not displaying travel time). This survey showed that 80% of drivers considered the information presented on VMS to be useful, 95% correctly understood the abbreviations. A survey of drivers' actual responses to a message activation showed that only one third of drivers saw the information presented to them and 20% of drivers whose survey responses indicated they should divert did divert, although many found the information useful.

Craen and Niet (2002 cited in Nygardhs and Helmers) provided a finding in the Netherlands that: drivers did not pay much attention to general VMS messages for example "drive with consideration" and please be a courteous driver", however there did not seem to be any negative road safety effects.

In one of the few surveys on this topic, drivers in the United Kingdom reported moderate support for other uses; with 21%, 19% & 18% of the respondents respectively suggesting that messages displaying 'keep distance', 'lane discipline' and 'general safety' should be included in future DMS messages, compared to 50% suggesting 'traffic related' messages and 11% who do not want any type of messages (Cooper & Mitchell, 2002).

Lai and Yen (2004) employed questionnaires to investigate driver's attention, preference and response to VMS on freeways in Taiwan. The results indicated that 69.23% of drivers were aware of the existence of VMS while driving on free way

In Paris there are over 350 VMS on the ring motorway. Kronborg (2001) found that 80% of the drivers preferred to be informed of the travel time rather than queue lengths.

Foo and Abdulhai (2006)

Table 2.1: Impacts of "day times" on CMS.

Time	Express CMS "Express and Collector moving Well" to "Express moving Slowly Collector moving Well"	Express CMS "Express and Collector moving Slowly" to "Express and Collector moving Well"
6-noon	5.16%, 325.37vp	-1.67%, -96.51vph
1pm-7pm	6.17%, 352.6vph	-4.23%, -237.94vph

Table shows that time-of-day plays a significant role in determining the impact of a CMS on traffic flow. Drivers tend to react to CMS messages more aggressively in the afternoon than in the morning. This is potentially due to drivers' high familiarity with the morning routes. This results in morning traffic that is more predictable and lower driver reliance on CMS messages in the morning than in the afternoon. Also, drivers may be more fatigued in the afternoon, and hence less patient in congestion.

Foo and Abdulhai (2006) also investigate:

Table 2.2: Reaction of drivers over CMS with the change of year

YEAR	"Express and Collector moving Well" to "Express moving Slowly Collector moving Well"	Express CMS "Express and Collector moving Slowly" to "Express and Collector moving Well"
2003	6.55%, 409.93vph	-5.32%, -309.61vph
2004	5.11%, 310.97vph	-3.31%, -180.62vph
2005	4.75%, 263.36vph	-0.48%, -26.64vph
2006	5.55%, 335.06vph	-3.14%, -177.4vph

The reaction of drivers to the CMS messages is decreasing over time in a very noticeable manner. In 2003, the first message change was able to shift the diversion rate by 6.5% and 410 vph, whereas in 2005, the numbers have dropped to 4.75% and 263 vph – a roughly 30% change for both numbers. The time-effect is even more noticeable for the second message change. These results may be the first to confirm a potential increasing distrust in the messages displayed on the signs. In this case, fewer drivers believe the messages on the signs, resulting in a smaller CMS impact on traffic flow.

From the above descriptions, we can come to some points that the acceptance rates of VMS by unfamiliar drivers with the road network are higher than the familiar drivers. Factors such as age, gender, driving experience etc. can affect the driving behavior. 80% of drivers considered the information presented on VMS to be useful, 95% correctly understood the abbreviations. Drivers did not pay much attention to general VMS messages however there did not seem to be any negative road safety effects. 50% of drivers preferred ‘traffic related' messages. 69.23% of drivers were aware of the existence of VMS while driving on freeway. Drivers tend to react to CMS messages more aggressively in the afternoon than in the morning. The reaction of drivers to the CMS messages is decreasing over time in a very noticeable manner.

2.3 Preferred messages:

Cohn et al.(2004) researched the VMS system in Netherlands, they stated that: There are three main types of VMS information provided by systems in use today in the Netherlands:

1. Queue lengths: these systems provide information on the number of kilometers of queues on the actual route and on alternative routes.

2. Travel time: these systems provide information on travel time in minutes to specific motorway interchanges or destinations.

3. Qualitative information: these systems provide general qualitative information about the condition of the road ahead and are generally used for non-motorway situations. Information such as ‘delay on the A9’ or ‘no delay’ is provided.

A study completed by Transmute provides clear information about the relationship between VMS information and route choice. In this study, the difference in congestion delay (queue length) between two alternative routes (the stimulus for route change) and the change in the ratio between the traffic flows on the two routes (the response) were examined.

Yokoya illustrated that the strategy of publishing the mean velocities on routes through VMS is more efficient than the travel time feedback strategy

Oregon Department of Transportation (2008) researched about the Message Priority: Daily and seasonal occurrences or site specific operations objectives may alter the priority for displaying messages. The standard priority of displayed messages is the following:

1. Drawbridge operations, road or ramp closures, and emergency situations,

2. Incident or crash,

3. Adverse weather or environmental conditions and related regulations such as chain restriction information,

4. Construction or maintenance operations,

5. Amber Alert message (see Supplement D),

6. Traffic operations information associated with special events such as car shows or sports events

7. Travel time information

8. Special public safety messages approved by the State Traffic Engineer

9. Travel-related information directed at individual vehicles such as commercial trucks,

as approved by the State Traffic Engineer

10. Public Service Announcements approved by the State Traffic Engineer.

From Variable Message Sign literature review by Nygardhs and Helmers (2007), Steinhoff et al. (2000) report on experiments supported by the European Commission within the scope of the research project TROPIC, with the aim of developing VMS knowledge in Europe. One investigation was made in order to find out whether the compliance was higher for a speed limit sign displayed with another sign explaining why the speed limit was set. It was concluded that speed limit signs were most often obeyed, but display of extra information justifying the speed limit led to even higher compliance. Warning signs without speed limits were less effective than the combination of speed limit sign and additional information. Another experiment focused on the comprehension of combinations of messages and symbols. Confusion arose between signs indicating the distance to a dangerous area and the spatial extension of some condition. Also, the "lane closed" sign led to confusion. Except for these signs, most drivers correctly interpreted the VMS in 1.0–2.5 s. There was also an experiment of perception at a three-lane-road outside Munich. The signs were displayed above the three traffic lanes with five parallel spaces for messages. Sometimes there were only three speed limit signs, one for each lane, and sometimes they were complemented by two explanatory signs between them. See Figure 1.0

Figure 2.1 Examples of signs displayed above a three-lane-road outside Munich.

The upper signs have a shorter perception time than the lower signs. Steinhoff et al., 2000.

It was found that the more information (for example speed limit signs together with warning signs), the longer the perception time. The shape of the additional information sign had no observable effect on any lane. When different combinations of wet road warnings were investigated it was concluded that the willingness to comply with a speed limit increases when it is displayed together with a sign justifying the speed limit. The drivers want the reason for the speed limit to be explained by a warning sign between the speed limit displays. Symbols were better than pure text messages and redundant information should be avoided. From these tests the conclusions were that:

• Critical safety messages can be perceived by most drivers in real traffic.

• Most drivers favor additional information to the speed limit.

• Additional information does not have a large effect on compliance to speed. An explanation for the last conclusion could be that drivers do not consider the warning reliable. Another explanation could be that speed change is not the best measure of compliance and that the driver instead could have increased attention and more farsighted driving to increase safety.

Use of Variable Message Signs (VMS)-RTA Policy (December 2010), It is important to establish a priority when using VMS to ensure that important or urgent messages

Are communicated clearly and rapidly. The following table illustrates the priorities for VMS application.

Table 2.3: Priorities for applications of VMS

First Priority	Unplanned traffic incidents and unexpected road conditions such as major clashes, closures and diversions, flooding , bush fires and weather affecting road use.
Second Priority	Active planned traffic incidents such as road closures and diversions for road works and special events.
Third Priority	Current information regarding real time traffic conditions such as real-time travel time services.
Fourth Priority	Future planned traffic incidents such as road closures and diversions for upcoming road works and special events and specific road safety campaign messages.
Fifth Priority	General information about road safety and traffic management such as stand by messages: How fast are u going now? Don't queue across intersections.

Wang(2010) in "Employing Graphic-Aided DMS to Assist Elder Drivers' Message Comprehension" stated PI As Shieber found in his study mentioned earlier, effective message design is necessary to allow drivers to respond effectively and ensure the maximum level of comprehension of DMS messages. Wang and Cao conducted a series of driving simulation experiments to study the design and display factors of variable message signs (VMSs) and found that discretely displayed messages demanded less response time than sequentially displayed messages and that single-line message were better than multiple-line messages. In another study, Wang et al. evaluated the effects of message display on drivers' comprehension of and responses to DMSs. By administering a questionnaire survey and driving simulation to driver subjects, they found that drivers preferred and responded more quickly to one-frame messages with minimal flashing, specific wording and no abbreviation, displayed in amber or amber-green color combinations. The flashing and alternating of DMS messages were investigated by Dudek and Ullman, who found that flashing messages took longer for drivers to comprehend. Based on these results, they suggested that one-frame DMS messages should not be flashed and that a single line on a one-frame DMS message should not be flashed. Guerrier and Wachtel found that one frame DMS messages demanded less response time than alternating two frame messages. A survey conducted by Yang, et al. also suggested that static, one-framed messages with more specific wording and no abbreviations were the most preferred display formats by drivers. The U.S. Department of Transportation has established the standard for DMS and VMS messages that limits the number of phases (frames) per message to two phases. It also recommends that the message should be in capital letters with a desirable letter size. Message signs should be limited to no more than three lines, with no more than 20 characters per line. The general policies, guidelines, and observations mentioned in the literature reviews contained above were taken into consideration during the creation and development of the computer-based survey and driving simulation. In particular, general observations mentioned in the literature review concerning elder drivers' understanding of DMS messages and drivers reaction to different colors and types of DMS messages were relevant toward the design of the computer based survey and driving simulation. The next chapter describes in more detail the formulation and development of both the computer based survey and the video based driving simulation, along with the relevant factors involved.

In a nutshell it can be said, we should give more concentration on queue length, travel time and qualitative information during the setting of any vms message on the road side. The strategy of publishing the mean velocities on routes through VMS is more efficient than the travel time feedback strategy. The main prior able things for displaying any messages are road or ramp closure, crash, weather, constructions, travel time information, public safety etc. Speed limit signs were most often obeyed, but display of extra information justifying the speed limit led to even higher compliance. The more is the information the longer the perception time. Critical safety messages can be perceived by most drivers in real traffic. Speed change is not the best measure of compliance. Discretely displayed messages demanded less response time than sequentially displayed messages and that single-line message were better than multiple-line messages. Flashing messages took longer for drivers to comprehend. One frame DMS messages demanded less response time than alternating two frame messages. The message should be in capital letters with a desirable letter size. Message signs should be limited to no more than three lines, with no more than 20 characters per line.

2.4 Impact of different factors on diver's decision from VMS:

Cooper and Swayer (2003) evaluated the fog warning systems on the M25 London orbital motorway in which a text message "FOG" when fog was formed. An overall reduction in mean vehicles speed of about 1.8 miles per hour (3 km/h) was found when the signals were switched on. The author concluded that the speed reductions indicates that drivers are alerted to the presence of fog ahead, which means that drivers are more likely to respond more quickly to hazards.

Hogema and Host (1997) found same phenomena using variable fog warning sign in Netherlands where drivers reduced their speed up to 8-10 km/h in mean speed. The sign used was "MIST".

A field study of Rama and Kulmala (2000) has shown the Variable Message Signwarning of slippery road conditions and the Variable Message Signrecommending a minimum headway between vehicles both had positive effects in terms of driver behavior. More specifically, the slippery road condition reduced the mean speed by 1-2km/h. The minimum headways of less than 1.5 s by 28-47%. In addition, the minimum headway sign reduced the mean speed by 1km/h.

Ng and Chan (2007) stated the problem of non-recognition of road signs has many aspects which are of great importance in traffic safety. Considering all signs on a test road and eye-movement technique and recognition rate method, a temporal analysis has been conducted for two techniques of driving: driving with the time necessary to see, read and recognize each type of road sign, and free driving to determine the actual time the driver spends reading these signs. The actual time spent provides recognition rates, totally and partially, and also rates of non-recognition. Many of the factors involved were investigated and the analysis was designed to estimate the effect of these factors separately. For a more practical use of the results, a set of probabilistic models has been estimated to characterize the different distributions of fixation durations. Next, the parameters of these models were used to develop a method for measuring the efficiency-level index of the road sign system.

Möri and Abdel-Halim(1981) said guess ability of a sign varied with the five design features of; familiarity, concreteness, simplicity, meaningfulness, and semantic closeness of the sign. Semantic closeness was the best predictor of guess ability score, followed by familiarity, meaningfulness, concreteness, and simplicity. In order to design more user-friendly traffic signs and effective ways of using them, it is suggested that designers develop and evaluate signs according to the relative importance of the five sign features.

In an abridgement of the above comprehension it seems that drivers are more likely to respond more quickly to hazards. Drivers reduced their speed seeing any warning signs. The Variable Message Sign recommending a minimum headway between vehicles both had positive effects in terms of driver behavior. The minimum headway sign reduced the mean speed by 1km/h. Guess ability of a sign varied with the five design features of; familiarity, concreteness, simplicity, meaningfulness, and semantic closeness of the sign.

2.5 VMS used across the world:

VMS has become a part of modern transportation system, especially in the developed countries. The messages may vary from country to country depending on the nature, usage of roads and according to the demands of drivers. Various types messages, used in the different countries, are given below:

MESSAGE	LOCATION	LINK
1.GAMES LANES OPEN TO ALL TRAFFIC	Southampton Row, London, UK.	http://londonist.com/2012/07/gridlock-could-mean-red-light-for-zil-lanes.php
2. TIME TO M5 J17 12 MINS	Birmingham, UK.	http://www.roadtraffic-technology.com/news/newsmvis-develops-new-solar-powered-variable-message-sign-system
3.BRIDGES CLOSED	Tay Road Bridge, Dundee, UK.	http://www.thecourier.co.uk/lifestyle/motoring/call-to-ensure-that-variable-road-signs-give-the-right-message-1.27345
4. MAJOR GAS WORKS BRIXTON HILL 9 APRIL DELAYS EXPECTED	Toole Street, London, UK.	http://www.ukmts.com/case-studies/
5. FOR STADIUM TAKE FIRST RIGHT	Wimberley Stadium, UK.	http://www.ukmts.com/case-studies/
6.DO NOT DRIVE WHILST ON YOUR MOBILE PHONE	Wolver Hampton City Council, UK.	http://www.datadisplayuk.com/wolverhampton-city-council-vms
7. TO J55 (IPSWICH) 39 MILES 40 MINS	Snail well, Cambridgeshire, UK.	http://www.geograph.org.uk/photo/3843585
8.EXPECT POLICE ACTIVITY	White Plains, NY, USA.	http://www.newrochelletalk.com/content/bronx-man-charged-60000-theft-batteries-roadside-signs-tours-local-court-system
9.TRAVEL TIME TO SF DWNTWN 10 MIN	Oakland, California, USA.	http://en.wikipedia.org/wiki/File:Electronic_message_sign_with_travel_time.jpg

CARQ BRDG 21 MIN		
10.ACCIDENT AHEAD 2 RIGHT LANES BLOCKED	Florida, USA.	http://www.ops.fhwa.dot.gov/publications/manag_demand_tis/travelinfo.htm
11.REPORT DRUNK DRIVERS CALL 911	California, USA	http://fotservis.typepad.com/.shared/image.html?/photos/uncategorized/wn_drdr.jpg
12.NEW YORK CITY CLOSED TO ALL TRAFFIC	New york, USA.	http://ntl.bts.gov/lib/jpodocs/repts_te/14129.htm
13.SPEED MONITORED BY LASER AND RADAR	New york, USA.	http://www.fhwa.dot.gov/publications/publicroads/04sep/04.cfm
14.ALL CROSSINGS TO NEW YORK CLOSED	New york, USA.	http://www.ops.fhwa.dot.gov/publications/manag_demand_tis/travelinfo.htm
15. SPEED LIMIT 65	California, USA.	http://www.skyscrapercity.com/showthread.php?t=520442&page=2
16.REDUCE SPEED CONSTRUCTION/CONGESTION/ACCIDENT	New Jersey Turnpike, USA.	http://commons.wikimedia.org/wiki/File:MN_Changeable_Message_Sign.jpg
17. Stalled vehicle at HWY 280 in all lanes Saint Paul, Minnesota	Saint Paul, Minnesota, USA.	http://commons.wikimedia.org/wiki/File:MN_Changeable_Message_Sign.jpg
18. SMOKE AHEAD	Yellowstone National Park, Wyoming, USA.	http://www.marcelhuijserphotography.com/roadsigns/h453E4070#h453e4070

19. BUCKLE UP & DRIVE SAFELY	Rocky hill Fire Dept, USA.	http://www.data-display.com/rocky-hill-fire-department-signs
20. Don’t Overload Electrical outlets	Massapequa Fire dept, USA.	http://www.data-display.com/massapequa-fire-department-display
21. LINCON TUNNEL 2+ PEOPLE/CAR START DRI 6AM	New york, USA.	http://ops.fhwa.dot.gov/freewaymgmt/publications/frwy_mgmt_handbook/chapter8_01.htm
22. LEFT LANE CLOSED ONCOMING BUSES	Long island Expressway, New york, USA.	http://ops.fhwa.dot.gov/freewaymgmt/publications/frwy_mgmt_handbook/chapter8_01.html
23. TRUCKS RIGHT LANE ONLY	Long island Expressway, New york, USA.	http://ops.fhwa.dot.gov/freewaymgmt/publications/frwy_mgmt_handbook/chapter8_01.html
24.BUS LANES IN OPERATION	Sydney, Australia.	http://www.sydneycyclist.com/forum/topics/variable-message-signs
25. OPERATING BETWEEN.. SCHOOL ZONES	Sydney, Australia.	http://www.sydneycyclist.com/forum/topics/variable-message-signs
26.CLEARWAYS IN OPERATION	Sydney, Australia.	http://www.sydneycyclist.com/forum/topics/variable-message-signs
27.REPORT TRAFFIC INCIDENTS 131700	Sydney, Australia.	http://www.sydneycyclist.com/forum/topics/variable-message-signs
28.DO NOT QUEUE ACROSSS INTERSECTION	Sydney, Australia.	http://www.sydneycyclist.com/forum/topics/variable-message-signs
29.SEAT BELTS SAVE TRUCIES TOO	Sydney, Australia.	http://www.sydneycyclist.com/forum/topics/variable-message-signs

30.ETAG SAVE TIME AND HASSLE	Sydney, Australia.	http://www.sydneycyclist.com/forum/topics/variable-message-signs
31.NO DANGEROUS GOODS IN TUNNELS	Sydney, Australia.	http://www.sydneycyclist.com/forum/topics/variable-message-signs
32.BRIDGE WORKS 4K AHED	Victoria, Australia.	http://www.ferret.com.au/c/kennards-hire/variable-message-signs-from-kennards-hire-enhance-road-safety-on-m80-project-n896851
33. SLOW DOWN WATCH OUT KIDS ABOUT	Hilltop Road Public School Merrylands NSW 2160, Australia.	http://www.electronicsigns.com.au/epages/elel8494.sf/en_AU/?ObjectPath=/Shops/elel8494/Categories/01/SL01
34. FREEWAY TIME TO DOWNTON 8 MIN AIRPORT 3 MIN	Toronto street highway, Ontario, Canada.	http://www.ledsite.ca/Toronto/LED/Message_Signs/Electronic_Displays/Transportation/Intelligent_System/ITS.html
35.TIME TO DOWNTOWN 14 MIN VIA I-43	Toronto street highway, Ontario, Canada.	http://www.ledsite.ca/Toronto/LED/Message_Signs/Electronic_Displays/Transportation/Intelligent_System/ITS.html
36.M50 TOLL PAY BY 8PM TOMORROW www.eflow.ie	Dublin, Ireland.	http://www.data-display.com/roads-authority-message-display
37.ACCESS TO T.K. BRIDGE LANE CLOSED	Ocean bridge expressway, Hong Kong.	http://formolight.blogspot.com/

38.TSUNAMI ALERT LISTEN TO RADIO	Dominion Post Wellington, New Zealand.	http://www.armitagegrp.com/new-zealand-transport-agency-national-variable-message-sign-contract/
39.BARRIER MACHINE IN OPERATION LANE 5 CLOSING	Auckland Harbor Bridge, New Zealand.	http://www.nzta.govt.nz/projects/ahb/gallery.html
40.USE PUBLIC TRANSPORT	Cape town, South Africa.	http://streetwise.kittelson.com/posts/88-transportation-at-the-fifa-2010-world-cup-in-south-africa

CHAPTE

2.6 Types of VMS:

After analyzing different thesis papers, journals and other reliable sources and messages that are displayed in the VMS across the world we have classified VMS into three categories. Such as:

- Real Time Information Message Sign
- Active Plan Traffic Message Sign
- Cautionary Message Sign

Real Time Information Message Sign:

This type of messages inform the travelers, passengers or drivers about the actual distance from one place to another or how much times it will to go from one place to another places.

Examples of Real Time Information Message:

1. Time To M5 J17 12 Mins
2. To J55 (Ipswich) 39 Miles 40 Mins
3. Travel Time To Sf Dwntwn 10 Min Carq Brdg 21 Mins
4. Lincon Tunnel People/Car Start Dri 6 Am

5. Operating Between School Zones
6. Freeway Time To Downton 8 Min Airport 3 Min
7. Time To Downtown 14 Min Via I-43

Figure 2.2: Real Time Information Message

Active Plan Traffic Message:

This type of message will help the travelers or passengers or drivers to use the alternate road for any sudden happenings like accident, traffic jam, foggy weather or any kind of constructional works.

Figure 2.3: Active Plan Traffic Message Sign

Examples:

1. Games Lanes Open To All Traffic
2. Bridges Closed
3. Major Gas Works

   Brixton Hill 9 April

Delays Expected

4. For Stadium Take First Right

5. Accident Ahead 2 Right Lanes Blocked

6. New York City Closed To All Traffic

7. All Crossings To New York Closed

Cautionary Message Sign:

This will contain the messages which are related to the caution or safety measures.

Figure 2.4: Cautionary Message Sign

Examples:

1. Do Not Drive Whilst On Your Mobile Phone

2. Expect Police Activity

3. Report Drunk Drivers Call 911

4. Speed Monitored By Laser And Radar

5. Smoke Ahead

6. Buckle Up & Drive Safely

7. Don’t Overload Electrical Outlets

8. Do Not Queue Acrosss Intersection

9. Seat Belts Save Trucies Too

CHAPTER THREE

DATA AND METHODOLOGY

This chapter describes the data collection procedure, formulation of data and the methodology used in the analysis of data in this study. The main steps in the methodology are presented first.

3.1 Main Steps in Methodology:

In order to achieve the objective of the study, at first we need to select suitable survey method and identify the factors or the characteristics of the drivers affecting their choice of different message which will be displayed on the VMS. The factors will be used to prepare a questionnaire. A questionnaire survey will be conducted in different locations to find out the factor values of characteristics. Suitable statistical model need to be selected for the analysis of the survey data. The result of the final model will be analyzed to find out the critical factors contributing the choice of different messages.

3.2 Survey Methods:

Statistical Surveys are undertaken in order to gain inferences of statistical data from a selected group of people or population. This inferences are reflected through the questions used in survey.

Survey Methods and Practices", published by Statistics Canada in 2003 revealed survey this way ‘’A survey is any activity that collects information in an organized and methodical manner about characteristics of interest from some or all units of a population using well-defined concepts, methods and procedures, and compiles such information into a useful summary form”. Survey is conducted through series of steps like

- ✓ Formulation of the Statement of Objectives
- ✓ Selection of a survey frame
- ✓ Determination of the sample design
- ✓ Questionnaire design
- ✓ Data collection
- ✓ Data capture and coding
- ✓ Editing and imputation
- ✓ Estimation
- ✓ Data analysis
- ✓ Data dissemination
- ✓ Documentation

Our study includes a simple questionnaire survey and will focus on the steps that are directly relevant to this research.

3.3 Survey Frame Selection:

In a sample survey, data are collected for only a fraction (typically a very small fraction) of units of the population. One of the ways to identify and contact the units of survey population is a survey frame which is called sample frame for a sample survey (Statistics Canada, 2003). Ultimately, it defines the survey population through a set of information. A frame should include some or all items which are listed below:

• Identification data (name, address, identification number)

• Contact data (mailing address, telephone number)

• Classification data

• Maintenance data

• Linkage data

3.4 Survey Group:

The aim was to identify the optimum messages which will be displayed on VMS. Most of the people who rely on the current traffic facilities are drivers. As VMS is totally a new concept for controlling traffic in Dhaka city, comparing the behaviors and attitudes towards it was necessary. For achieving a safer driving environment, thoughts and attitudes of this survey group was also necessary for an improved comprehension. Among Driver group a certain majority portion were passenger car drivers. We selected both professional and non-professional drivers as survey group.

3.5 Factors influencing the choice of message:

The main stakeholders of the roads are drivers. The drivers have to stay in the road all the year round and their livings are dependent on this. So, drivers are the main beneficial for any kind of development of the roads or the main sufferers for any damage or adverse conditions of the roads. Some factors are included which may influence driver's life and their way of driving. The procedure of choosing factors is given below:

- classification of factors into three categories-personal life, accidental experience and vehicular characteristics
- Identification of all variables related to driver's personal life
- Identification of all variables related to driver's accidental experience

- Identification of all variables related to vehicular characteristics
- Combination of all the factors
- Analysis of all the factors
- Elimination of the irrelevant factors
- Sort out of the relevant factors related to the drivers and VMS
- Preparing a data sheet having the factors influencing the choice of VMS

3.6 Questionnaire Preparation:

The result of a research or survey is largely dependent on how effectively you are collecting yours data because this data will give you the result of that particular survey. but if you want to get all the information properly, you must have to ask the survey groups properly. For why, we will have to prepare an effective and well planned questionnaire.

Questionnaire is a set or group of questions formed to gather information from respondents on particular matter or subject. Questionnaires play a vital role in the data collection process since they have a major impact on data quality and influence the image that the statistical agency projects to the public.

Questions can be raised by two ways. Open ended questions and close ended questions. Open ended questions allows the responded to answer independent of any limitation. Respondent does not have to be confined on given options. On the other hand close ended questions are provided along with several options. This limit the answer of the respondent but on the contrary helps to gather the required piece of information in a rational way.

In this study design of close ended questionnaire was based on factors of VMS that has been deliberately placed and discussed in several researches. These factors convey the effectiveness of VMS. Set of questions were based on these factors. We have prepared our questionnaire based on the relevant factors like personal life, accidental experience and vehicular characteristics.

A sample of our questionnaire which we used during the survey is given below:

1) What type of message do you prefer?

- Real time information message
- Active planned traffic message
- Cautionary message

Personal profile: **Name:** **Gender:** • Male • Female **1. Age:** • Less than 20 • 20-30 • 30-40 • 40-50 • 50-65 • More than 65 **2. Educational Qualification:** • Primary • Secondary • Higher secondary/higher **3. Marital status:** • Married • unmarried **4. No of family member:** • 3 or less • 4-5 • More than 5	**5. Income:** • Less than 15K • 15-25K • 25-35K • 35-45K • More than 45k **6. No of earning member:** • None • One • More than one **7. No of children:** • None • 1 or 2 • More than 2 **8. Monthly expenditure:** • 10k-15k • 15-25k • Greater than 25k **9. Have you noticed any VMS previously?** • Yes • no **10. Which place it was?** **11. Profession** • Driving (not owned) • Others ➢ Self-driven (Not owned) ➢ Nonprofessional (Owned the Car)
Driving Experience 1. **Driving experience:** • 3yrs or less • 4-10yrs • More than 10yrs **2. Use of seat belt** • Yes • not	**8. Average no of hours spending for congestion per day:** • Less than 1 hr • 1-2hrs • Greater than 2 hrs **9. Daily mileage?** • less than 50 • 50-100 • 100-200 • greater than 200

3. No of trips per day?

- 1
- 1-3
- Greater than 3

4. No of working days in a week

5. Weekly Frequency of Highway Usage?

- less than 6
- 6-10
- 10-20
- greater than 20

6. Duration of delay faced daily:

- less than 1 hr
- 1-2hr
- greater than 2 hr

7. Type of root using

- Inter city
- Inter district

10. Average vehicle speed daily?

- less than 50 km/hr
- 50-70
- more than 70 km/hr

11. type of delay faced?

- accident related
- congestion related
- roadwork related

12. Trip purposes in most cases:

- Work
- School
- Shopping/leisure
- others

13. Having any police case

- yes
- no

14. Average driving hours per day:

Accident experience

1. Have you witnessed any crash or not?

- Yes
  - Major
  - Minor
- no

2. Number of accident you faced?

3. Have you been injured or not?

- **Yes**
- **no**

4. How it was occurred?

- Collision with vehicle
- Collision with obstacle

5. Were you responsible for it?

- Yes
- No

6. Was any of your family members injured in accident?

- Yes
- No

7. Have you lost any of your family members due to accident?

- Yes
- No

8. Have you faced any FIR due to accident?

- Yes
- No

3.7 Data collection:

Data collection is one of the most important and also a challenging part to get a successful result for a survey. Moreover, a successful data is largely dependent on:

- Approach of the questioner
- Question pattern
- Depth of knowledge
- Patience
- Communication skill

In this study collection of data for questionnaire is made through personal interviews. Other methods of interview like Telephone interview was not possible as conducting and explaining questions having several transportation engineering terms was bit difficult. Personal interview helped to collect actual data and response from the respondents. Data has been collected from several places. Data from drivers were collected from places like

- Bashundhara City Shopping Mall
- North Tower, Uttara
- Bangobondhu International Conference Center
- Banani
- IUT premises

We have chosen these places as because all of these places are the gathering places of all classes of people and from these places, we took the survey report of both professional and non-professional drivers.

We have collected 200 samples of data from professional and non-professional drivers.

3.8 Data Coding

Data coding comprises assigning numerical values to collected responses which is further used to facilitate analysis by putting the numerical values into an analysis method. Upon coding text material for content analysis, raters must classify each code into an appropriate category of a cross-reference matrix. Relying on computer software to determine a frequency or word count can lead to inaccuracies. For the convenience of data modeling, we have assigned our categorical variable in different numerical numbers like:

For message type:

1=Real Time Information
2=Active Planned Traffic Message
3=cautionary Message
And for the continuous variable, we have used 1 for significant variable and 0 for insignificant variable. Like:

Age:

- Up to 30
- 30-50
- More than 50

Here, age is between 30 to 50 years is significant, so, age 30-50= 1
And rest of the ages categories like up to 30 and more than 50 will be 0

3.9 Appropriate Model Selection:

To analyze the data we need to select appropriate model. From literature review we see that we got three message types which are real time, active planned and cautionary message signs. These message types are our dependent variable which will be predicted by the independent factors. We see that all the dependent variables are categorical. Categorical means where the variables can't be ordered. We use multinomial logit models when we have multiple categories but cannot order them. Here the order of categories is unimportant. Multinomial logit model is equivalent to simultaneous estimation of multiple logits where each of the categories is compared to one selected so-called base category. But if we would estimate them separately, we would lose information, as each logit would be estimated on a different sample (selected category plus base category, with all other categories omitted from analyses). To avoid that, we use multinomial logit model.

3.9.1 Multinomial Logit Model (MNL):

Shankar et al. (1996) and Ulfarsson and Mannering (2004) developed a probabilistic model of discrete crash severities conditioned on a crash having occurred. The probability of the nth crash having a severity level i, is given by:

$$P_{ni} = P(U_{ni} \geq U_{n'}), \forall\, i' \in I, i' \neq i$$

Where U_{ni} is a function determining the severity, and I is a set of all possible, mutually exclusive severity categories.

It is assumed that a road user will experience the injury severity with the largest U_{ni}. If we assume U_{ni}
has a linear-in-parameters form, it can be expressed as:

$$U_{ni} = \beta_i x_n + \epsilon_{ni}$$

Where β_i is a vector of coefficients to be estimated for severity outcome i
x_n is a vector of exogenous variables for crash n
ϵ_{ni} is the random component or error term
McFadden (1981) has shown that if ϵ_{ni} is assumed to have a generalized extreme value distribution, then we have the multinomial logit model which is given by:

$$P_{ni} = \frac{e^{\beta_{i'} x_n}}{\sum_{i'=1}' e^{\beta_{i'} x_n}}$$

The coefficients can be estimated by the method of maximum likelihood. As the explanatory variables x_n do not vary across injuries and are not injury-specific, the I − 1 log-odds ratios of the model become:

$$\ln\left(\frac{P_{ni}}{P_{nI}}\right) = \beta_i x_n - \beta_I x_n = (\beta_i - \beta_I) x_n \; for \; i = 1, \ldots . I - 1$$

Only the difference in coefficients is identifiable and the coefficients are therefore identifiable only up to an additive constant. To resolve this indeterminacy, the coefficients of one outcome (the base case) are set to zero (Greene, 1997). In this study, the non-injury or property-damage-only crashes will be used as the base case.

Since the multinomial logit model is a non-linear model, the estimated coefficients of the independent variables do not represent their effects on the dependent variable. One common method used to find the effect of a risk factor is to compute its relative risk ratio (RRR). In this study, since the non-injury crashes are used as the base case, the RRR of a risk factor is computed relative to this case. From equation (3.34), we can see that the relative probability of i = 2 (injury crash) to the base outcome (non-injury crash) is:

$$\frac{P_r(i=2)}{P_r(i=1)} = e^{x\beta^{(2)}}$$

Since most of the independent variables are dichotomous variables, the ratio of the relative risk is then given by:

$$RRR = e^{\beta_i^{(2)}}$$

The RRR of an independent variable, (For example, type of route using) represents the increase in likelihood (RRR > 1) or decrease in likelihood (RRR < 1) of a particular message type (for example, real time or cautionary message type) relative to the active planned message type.

3.10 Goodness of Fit of the Model:

The goodness of Fit (GOF) of a statistical model describes how well it fits into a set of observations. GOF indices summarize the discrepancy between the observed values and the values expected under a statistical model. GOF statistics are GOF indices with known sampling distributions, usually obtained using an asymptotic methods, that are used in statistical hypothesis testing. As large sample approximations may behave poorly in small samples, a great deal Of research using simulation studies has been devoted to Investigate under which conditions the asymptotic p-values Of GOF statistics are accurate (i.e., how large the sample Size must be for models of different sizes. Evaluation of goodness of fit will be done with the help of two statistics:

1. Likelihood Ratio Test
2. Log-likelihood Ratio Index

3.10.1 The likelihood ratio test statistic is:

$$X^2 = -2[LL(\beta_r) - LL(\beta_u)]$$

Where, $LL(\beta_r)$ is the log likelihood at convergence of the ―restricted‖ model
$LL(\beta_u)$ Is the log likelihood at convergence of the unrestricted model.

The test statistic is χ^2 distributed with the degrees of freedom equal to the difference in the numbers of parameters in the restricted and unrestricted model.

3.10.2 Log-likelihood ratio index:

To measure the overall goodness of the models, the log-likelihood ratio index will be calculated. The R^2as a goodness-of-fit measure for OLS estimator has been used by traffic safety engineers and researchers for many years. However, since count data models are nonlinear, there is noR^2. Instead, the common practice is to use a ―pseudo R^2 statistic, which is often known as log-likelihood ratio index (Ben-Akiva and Lerman, 1985) which is given by:

$$\rho^2 = 1 - \frac{L(\beta)}{L(0)}$$

$L(\beta)$ is the log-likelihood value of the fitted model

$L(\beta)$ is log-likelihood value of the model only with constant term.

Everything else being equal, a specification with a higher maximum value of log-likelihood function is considered to be better. The lowest value of log-likelihood function corresponds to the model with constant term only and is considered the worst case. The value of R^2 is between 0 and 1, the better models approaching the latter. Like the R^2statistic, it has the undesirable characteristic that for same data set, it will increase whenever new variables are added to the model. To overcome this disadvantage Ben-Akiva and Lerman (1985) incorporated a correction for the number of covariates, ρ, to give the adjusted log-likelihood ratio index as

$$\rho^2 = 1 - \frac{L(\beta) - p}{L(0)}$$

CHAPTER FOUR:

MODEL DEVELOPMENT AND DATA ANALYSIS

4.1 Overview:

The main objective of the study is to select the most convenient Variable Message Sign. Besides this we will also determine the factors influencing the choice of messages. As we know that the main beneficiaries or sufferers due to the road conditions are drivers. So we have selected passenger car drivers as survey group. We identified some factors which may have influence on the drivers to choice of different messages.

4.2 Model Development:

As we mentioned earlier that we have used Multinomial Logit Model for analysis of data. The reasons for choosing this model and mathematical formulations of this model is presented and discussed in previous chapter. After conducting the survey and data coding of the variables relating to the factors we used final data sheet for STATA analysis. We considered active planned traffic message as the base case. Based on data analysis in stata 70 variables form 34 factors were considered in this study. Then after some preliminary analysis we got 19 variables from 18 factors. Among 19 significant variables we got 7 for real time message sign and 12 for cautionary message sign.

Table 4.1: Summary Statistics

Variables	Description	Mean	Std Dev
Age			
Up to 30	1= Up to 30,otherwise=0	0.4421	0.4980
30-50	1=30-50,otherwise=0	0.5105	0.5012
More than 50	1= More than50,otherwise=0	0.0474	0.2130
Income			
Less than	1= Less	0.3895	0.4889

15K	than15K,otherwise=0		
15-25K	1=15-25K,otherwise=0	0.3684	0.4837
25-35K	1=25-35K,otherwise=0	0.03158	0.1753
35-45K	1=35-45K,otherwise=0	0.0947	0.2936
More than 45k	1= More than45k,otherwise=0	0.1158	0.3208
No of earning member			
None	1=None, otherwise=0	0.3211	0.4681
One	1=One, otherwise=0	0.5421	0.4995
More than one	1=More than one, otherwise=0	0.1316	0.3389
Use of seat belt			
Yes	1=yes,	0.9263	0.2619
not	0=No		
No of working days in a week			
4 to 5	1=4-5,otherwise=0	0.2842	0.4522
6	1=6,otherwise=0	0.6	0.4912
7	1=7,otherwise=0	0.1211	0.3271
Weekly Frequency of Highway Usage			
1-10	1=1-10,otherwise=0	0.9158	0.2784
10-20	1=10-20,otherwise=0	0.0526	0.2239
Type of Route Using			
Inter City	1=intercity	0.8579	0.3501
Inter District	0=interdistrict		
Average no of hours spending for congestion per day			

Upto 2hrs	1=upto2hr,otherwise=0	0.7	0.4595
Greater than 2 hrs	1= Greater than 2 hrs,otherwise=0	0.3105	0.4639
Average vehicle speed			
Less than 50	1=Less than 50,otherwise=0	0.4053	0.4922
50 to 70	1=50 to 70,otherwise=0	0.5421	0.4995
Greater than 50	1= Grater than 50,otherwise=0	0.0526	0.2239

Type of delay faced			
Accident Related	1= accident related, otherwise=0	0.0211	0.1440
Congestion Related	1= congestion related, otherwise=0	0.9526	0.2130
Roadwork Related	1= roadwork related, otherwise=0	0.0368	0.1889
Having any police case			
yes no	1=yes 0=no	0.5053	0.5013
Average driving hours per day			
4 to 5	1= Four to five ,otherwise=0	0.3632	0.4822
Greater than 5	1= Greater than five, otherwise=0	0.6316	0.4837

Have you witnessed any crash or not			
Major	1=Major, otherwise=0	0.5421	0.4995
Minor	1=Minor, otherwise=0	0.3632	0.4822
None	1=None, otherwise=0	0.0947	0.2936
Number of accident you faced			
0 1 2 3 4 5 6	1=0,otherwise=0 1=1,otherwise=0 1=2,otherwise=0 1=3,otherwise=0 1=4,otherwise=0 1=5,otherwise=0 1=6,otherwise=0	1.0316	1.3008
Have you been injured or not			
Yes No	1=yes 0=no	0.1842	0.3887
How accident was occurred			
Collision with Vehicle	1= collision with vehicle, otherwise=0	0.0526	0.2239
Collision with Obstacle	1=,otherwise=0	0.5053	0.5013
Never Faced	1=,otherwise=0	0.4474	0.4985
Was any of your family members injured in accident			

Yes No	1=Yes 0=NO	0.0789	0.2704
Daily mileage			
Less than 50	1= less than 50,otherwise=0	0.6895	0.4639
Greater than 50	1= greater than 50 ,otherwise=0	0.3210	0.4681
No.of trips			
Greater than 3	= Greater than 3,otherwise=0	0.3632	0.4821
Less than 3	1= Less than 3,otherwise=0	0.6368	0.4822

Here, for example the age of the drivers is captured by three variables: age up to 30, 30 to 50 and more than 50. Note that the mean of a variable simply represents the proportion of the sample belonging to the particular category. Therefore, the mean of the age up to 30 variables is 0.4421053 which indicates that 44.21% of the sample has belonging age up to 30.

Also, several of the contributing factors are recorded in terms of percentage shares of the different categories. Since categorical data always sum to one or 100%, one of the categories has to be omitted from the model and used as a reference or base case by which the estimates of other categorical variables are compared. For example, to estimate the effects of age on cautionary message selection, the categorical variable for real time information message type is omitted and the estimated coefficients of the other two types are interpreted as relative to the real time information message. In case of interpreting the model results, the positive sign of the estimated coefficients β indicate the higher chances of cautionary message selection as the value of the associated variables increases while negative signs suggest the converse.

CHAPTER FIVE:

RESULT

5.1 Model Result:

The estimation results of the MNL model are presented in Table 5.1 and 5.2. As discussed earlier, one of the message categories has to be selected as a base case. The results are therefore reported for two categories: one for the likelihood of real time and one for the likelihood of cautionary message. The estimated coefficients and relative risk ratios (RRR) therefore show the effects of a variable on the likelihood of a real time or cautionary respectively.

Table 5.1: MNL estimates for Cautionary Variable message Sign

Multinomial logistic regression
Number of observation = 190
Prob > chi2 = 0.0001
Wald chi2 (19) = 52.66
Log likelihood = -141.43589

Variables	Coefficient	Std error	P value	Risk Ratio
Age				
30-50	0.9239	0.4458	0.038	2.5190
More than 50	3.5538	1.3135	0.007	34.944
Income				
15-25K	-1.7972	0.5482	0.001	0.1657
More than 45 k	2.076	0.8955	0.020	7.9728
No of earning member				
None	1.7567	0.7256	0.015	5.7943
One	2.0393	0.7221	0.005	7.685671
Average no of hours spending for congestion per day				
Up to 2 hrs	-1.0306	0.4852	0.034	0.3567
Have you witnessed any crash or not				

Minor	-1.1341	0.4377	0.010	0.3216
Have you been injured or not				
Yes No	2.7190	0.7285	0.000	15.1657
Was any of your family members injured in accident				
Yes No	2.6508	1.1504	0.021	14.1648
Daily mileage				
Greater than 50	0.8027	0.4629	0.083	2.2316
No.of trips				
Less than 3	-1.2298	0.4772	0.010	0.2923

Table 5.2: MNL estimates for Real Time message Sign

Multinomial logistic regression
Number of observation = 190
Prob > chi2 = 0.0001
Wald chi2(19) = 52.66
Log likelihood = -141.43589

Variables	Std Error	coefficient	P value	Risk Ratio
Weekly Frequency of Highway Usage				
10-20	1.4279	3.2637	0.022	26.1482
Type of route using				
Inter city	1.2750	2.2112	0.083	9.1267
Inter district				
Average vehicle speed				
Less than 50	1.0045	-2.0379	0.042	0.1302
50 to 70	0.9646	-1.6675	0.084	0.1887
Was any of your family members injured in accident				

Yes No	2.5207	1.2436	0.043	12.4374
Number of Accident faced	0.2986	-0.6425	0.031	0.5260
Income				
More than 45k	0.9166	1.6386	0.074	5.1482

Overall, the model fitted the data fairly well, with a large chi-square statistic and very small p-value for the goodness-of-fit. As shown in Table 5.1 and 5.2, the factors that have a significant effect on the likelihood of cautionary are quite different from the factors that have a significant effect on the likelihood of real time information, indicating that the choice of a multinomial logit is justified.

5.2 Interpretation of Result:

Discussion of result:

After a lot of iterations in stata, we have come to a conclusion of 19 significant variables. In which 7 are significant for Real Time Information message and remaining 12 are for Cautionary message.

The significant variables are given below in the following table:

Significant Variable For Real Time	**Significant variable For Cautionary Message**
1.Weekly Frequency of Highway Usage 10-20	1.Age 30-50
2. Type of route using	2. Age>50
3.Average vehicle speed Less than 50	3. Income 15-25k
4. Average vehicle speed 50-70	4. Income >45k

5. Was any of your family members injured in accident	5. No of earning member none
6. Was any of your family members injured in accident	6. No of earning member one
7.Income> 45k	7. Average no of hours spending for congestion per day Up to 2 hrs.
	8. Have you witnessed any crash or not(minor)
	9. Have you been injured or not
	10. Was any of your family members injured in accident
	11. Daily mileage>50 Mph
	12. No.of trips <3

Reasons Behind the selection of a specific message:

We have considered Active Planned Message as the baseline and thus we have compared the other 2 category i,e Real Time Information and Cautionary Message with respect to Active Planned message.
As described in the methodology we have come to the conclusion which message is more preferable and this varies from sample to sample.

A) Weekly highway users are going for real time rather than active planned because

- Most of them are professional
- Most of them have a time limit of their work so they prefer time related information rather than safety.

B) Drivers using highways 10-20 times per week are selecting real time message rather than drivers using highways 1-10 because

- They are regular highway user

C) Intercity route users are selecting real time information rather than active planned Because

- Congestion of city roads drives them to select real time info
- To get to the desired destination within the shortest possible time

D) Drivers driving car at an average speed less than 50 selects real time message less than drivers driving at average speed between 50 -70 and both selecting less than drivers driving at average speed greater than 70

- They prefer safety more.
- They are not in hurry to get to their destination as early as possible.

E) Drivers who had family members injured before in accidents selects cautionary rather than active planned

- They know the impact of accident and how bad it is
- They become safety minded after this incident
- They prefer safety more than time to reach a destination

F) Total number of accidents faced by a driver: Higher number of accidents prones to selection of Cautionary rather than active planned

- They become safety minded as they have the fear of experiencing accidents
- They prefer safety rather than time

G) Drivers incoming more than 45k selects cautionary more than active planned also selects more than other income criteria

- They are mostly nonprofessional (their income is not based on driving or reaching a destination within a fixed time limit)
- They are safety minded as their earning is not based on driving
- They have no hurry to get to a destination

H) Drivers incoming between 15-25k selects cautionary less than active planned

- They are most professional (income based on driving)
- Most of their income is based on no. of trips per day so they are in hurry
- They prefer time more than safety and they want to know of incidents on roads that might slow them down

I) Drivers aged more than 50 selects cautionary more than drivers of other age Criteria as because

- They are experienced

- They have more fear of accidents
- They prefer safety than time
- They know how bad accidents cam impact a person's life, property and family

J) Drivers having at least one earning member selects cautionary more rather than drivers having no earning member

- He has a backup earning member so he is no hurry to finish his work and earn more
- He prefers safety rather than time
- He is safety minded

K) Average hour spent by a driver in congestion: Drivers who spent more hours in traffic congestion select real time rather than active planned

- To avoid Congestion
- He prefers time more than safety
- To get to his desired destination within fastest possible time

L) Drivers witnessing minor crashes than major crashes select cautionary less but in compare with drivers witnessing no crash, drivers witnessing minor crashes selects less cautionary than active planned

- Have no major impact on driver's mind to think about safety
- Have no major ideas related to the dangerous impacts of an accident and prefers time than safety.

M) Drivers having daily mileage greater than 50 selects cautionary more than drivers having daily mileage less than 50

- Most of them are highway user so are more conscious about safety
- Spends more time driving so more conscious about safety

N) Drivers giving trips less than 3 selects cautionary less than real time than drivers giving more trips

- Most of them are nonprofessional and thinks about time less
- Prefers safety over time.

CHAPTER SIX:
CONCLUSION

6.1 Research outcomes:

6.1.1 Background Rationale:

Intelligent transportation system has been widely used to increase efficiency in transportation system and provide more safety. This study develops results and recommendations for effective implementation of messages displayed on VMS in terms of Dhaka city to contribute controlling and facilitating a hazard free traffic system by using VMS as a part of intelligent transportation system. Researches shows that VMS can be an effective tool in several purposes i.e. route guidance and can increase driver's diversion rate significantly by providing warning messages about the traffic conditions on the road. Once installed VMS acts as a communicating device by which transportation authorities can transform useful messages to drivers on a particular road (Richard Tay & Alexandre G. de Barros, 2007).

6.1.2 Aim and Scope of study:

The aim of this study is to implement VMS effectively with proper messages as an integral part of transport system in Dhaka city which includes study of the perceptions of mainly survey groups: drivers (both professional and non-professional) leading to find out differences in their perceptions, finding out reason for different perception and finally suggesting recommendations with our findings through this study. Thus this study will help to implement VMS more effectively considering the perceptions of drivers. As there were no significant study on VMS in terms of Bangladesh our study seek the scope to reveal effectiveness to integrate VMS more effectively. Only a total no of 31 VMS are installed as a part of Digitalization of existing traffic management system for a test purpose only. That is why current VMS possess only a few different types of messages which have mentioned earlier. Considering the above facts our study recommends possible solution and suggestion for implementing an effective VMS system in Dhaka city.

6.1.3 Methodology:

With accordance to the aim of this study collecting data and perception of the main stakeholders mainly drivers was mandatory to conduct analysis and bring out a final result with suggestion. For collecting data questionnaire was made as described before based on

Socio economic condition of the survey groups and different factors extracted from previous researches. Our main targeted survey groups were Drivers, both professionals and non-professionals. We collected our data from survey groups at different locations of Dhaka city. Then that data was coded. Then, we get our research results using Multinomial Logit Model analyzed by STATA.

6.1.4 Discussion of the result:

Several statistical data has been accumulated from socio-economic questions of questionnaire survey. We have chosen the passenger car drivers of both professional and nonprofessional as our survey group. We have identified some factors related to the driver's characteristics for the preparation of the questionnaire. We found that only a few number of VMS is noticed by drivers. So this represent current number of VMS in Dhaka city is not well planned. Moreover these don't contain appropriate messages. This study will help the policy makers to implement the VMS containing appropriate messages. In chapter 5, the interpretation of this study has been discussed. If we go through the summary of that result, we see that the people whose income is higher (greater than 45K), weekly frequency of highway is 10 to 20, previously their family member was injured or died, they have chosen Real Time Information Message as they are very much conscious about their time and their earning is very high. So they have no way to waste any time.

Again, the drivers whose age is more than 30 they have chosen Cautionary Message Sign because mostly they are the only earning sources and their family members are dependent on them. Again, the drivers having age more than 50 have chosen Cautionary Message sign because they previously faced many accidents or crashes. Again middle earners and higher earners have also chosen Cautionary Message Sign as because of their safety precautions. The drivers who faced accident or crashes previously and whose family members injured or died due to accident, they have chosen Cautionary Message Sign.

6.1.5 Recommendations:

The results of this study will provide policy makers as well as transportation engineers and planners with important information for selecting the most appropriate street pattern or urban form for development of new communities. The information is particularly useful for over populated and densely populated cities like Dhaka, which has experienced great growth over the past decade because of industrialization and urbanization. If the results of this study are summarized, this study suggests that proper, effective and most convenient message should be displayed on VMS according to the demand.

This study also indicates that Cautionary messages are more preferred than other messages due to its safety reasons. And again it is also true that safety is the pre-requisite conditions in the transportation system.so, proper, effective and convenient messages should be displayed on VMS.

6.2 Limitation of the Study:

Everything has its own limitations. Our study is not beyond the limitations. Starting with limited scope for reviewing past studies as there were almost no study regarding VMS in Bangladesh. This intrudes few lacking in an effective study. We have collected our data only in Dhaka city and we have chosen our survey groups only passenger car drivers. So if we did it in a wide range, it would ensure more accuracy. Again most of the drivers of our country are not literate. It creates some problems or illusions towards drivers. Many of them assumed it as legal actions against them. That is why sometimes they adopted a different expression rather than presenting the right expression towards a question.

6.3 Future scope of study:

This study can be extended in different ways. Many new technologies and methods of VMS are emerging day to day. For example a new type of VMS named the swap sign, has been developed by the Danish Road Directorate (Vithen & Sillesen, 2009). Again in England, predictive traffic information is given to road users by VMS (Burton, Crosthwaite, Simpson, & Billington, 2008). Thus future research should concentrate to work on several factors that may emerge due to new technologies and methods of presenting VMS and conduct to collect views and perceptions of more effective groups of people if exist any. In a report published by Vägverket (Bylin et al., 2004) a knowledge base on how road users experience VMS is wanted, along with more knowledge about how the operators experience managing the signs. What problems and possibilities do the operators perceive? What kind of support do the operators need for managing the VMS in the best way? How VMS can be used or connected with the security agencies? How VMS can be used for safety issues? Thus answers of such further questions can be placed in further analysis and study.

6.4 Concluding Remarks:

Bangladesh is small country having a large number of populations. Its communication system is developing day by day.

Over decades VMS is constantly being used as an integral part of transportation system in many countries. Our country has started to get the glimpse of benefits from VMS very recently. Although very few VMS are installed in Dhaka no significant research is made on this. As increasing traffic volume is constantly making a huge problem in transportation system in Dhaka, VMS should be implied to help reducing this problem in great extent. A number of VMS is installed in some important points of Dhaka city. Most of them show only speed limit informative message without following an interesting way of displaying which may attract the road users to follow. Some other factors are come also aside to consider like font size, visibility, screen size, light intensity, height of the display etc. which are deliberately become the reason for improper VMS.

In USA, UK along with some other European country many significant researches were carried out on VMS whereas Bangladesh is still lacking behind on this research. So our study mainly focuses on effective implementation of VMS in Dhaka city and discuss the factors in a rational way along with some surveys and case studies.

To make it effective and increase the efficiency of the road network several factors should be considered with proper solution. Our study proceed through a series consisting collecting data of existing VMS facility in Dhaka city, conducting a survey among three major groups that relate to transportation system inherently, analyzing their perception with a statistical analysis method, bring out possible reasons of variations in perception and thus finally suggesting final recommendation. Our recommendation that has been constructed from our analysis is based on three points. Issues that have to be included, issues that should be excluded and finally some special considerations. This recommendation would help extract the benefits from implementing VMS in Dhaka city. Our study thus poses a guideline inducing the perceptions and requirement of the road users to the decision makers consisting transportation authorities and others for implementing an effective VMS system in Dhaka city.

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