THESIS APPROVAL

GRADUATE SCHOOL, KASETSART UNIVERSITY

Master of Engineering (Civil Engineering)

DEGREE

Civil Engineering — **FIELD**

Civil Engineering — **DEPARTMENT**

TITLE: Determining Speed Limits on Rural Two-lane Highways in Bangladesh

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THESIS

DETERMINING SPEED LIMITS ON RURAL TWO-LANE HIGHWAYS IN BANGLADESH

MD. MOHIBUL HAQUE

A Thesis Submitted in Partial Fulfillment of
the Requirements for the Degree of
Master of Engineering (Civil Engineering)
Graduate School, Kasetsart University
2012

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Md. Mohibul Haque 2012: Determining Speed Limits on Rural Two-lane Highways in Bangladesh. Master of Engineering (Civil Engineering), Major Field: Civil Engineering, Department of Civil Engineering. Thesis Advisor: Assistant Professor Varameth Vichiensan, Ph.D. 164 pages.

Speed management is a central element of any road safety strategy to achieve appropriate speeds on all parts of the road network. The primary method of managing travel speed is by imposing speed limits. Various methods have been proposed to establish speed limits. These methods vary from arbitrary judgment and legislative statute to prevailing speed to more or less engineering analysis. Presently integrated approach is used for setting speed limit in which the interests and needs of all the stockholders are considered. But the speed-limits choice set is naturally discrete. Thus in this thesis a multinomial logit (MNL) discrete choice model for selecting speed limit is presented for rural two-lane highways in which roadside characteristics considered as attributes. The effect of the other factors such as vehicle, road user, weather condition and crash probability on speed limits was out of scope of this study.

The model was developed using as a case study 30 km of two different rural national highways in Bangladesh. The choice on speed limits of ten traffic experts was collected for each 200 m segment for estimation of the MNL. The attributes were collected to describe the built-up characteristics of the different segments of the road and its surrounding environment. External data set of another 10 km of same roads was selected to verify the model validation. The model was adjusted well to the data and an external data set was shown consistent with the expert judgment.

Attributes of the roadside characteristics those have lateral constraints with higher significance indicate the choice of lower speed limits. From this study it was concluded that it would not be possible to attain maximum speed limit (80 km/hr) at the most parts of the roads.

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ACKNOWLEDGEMENTS

The author would like to express his deepest thanks and gratitude to his thesis advisor Asst. Prof. Dr. Varameth Vichiensan for his guidance, advises, moral support and all valuable efforts for the accomplishment of this study**.**

The writer also wishes to sincerely thank to Assoc. Prof. Dr. Chavalek Vanichavetin, for his fruitful recommendations and suggestions and for serving as co-advisor of his thesis.

The author is heartfelt thank to the all academic and non academic staff in International Graduate Program in Civil Engineering (IPCE), Kasetsart University for their invaluable and commendable cooperation.

The author extends his gratitude to Roads and Highways Department, Bangladesh for giving him opportunity to conduct the study and Thailand International Development Cooperation Agency (TICA) for granting full scholarship.

The writer is also grateful to experts on road design and safety of Bangladesh who participated in the reported experiment.

The author especially appreciated his parents, wife Naziat Sharin Ahmed and daughter Werida Maliyat Haque for their continuing encouragements.

Finally, the author would like to dedicate this work to his father Mahabub Hossain who passed away forever during this study.

Md. Mohibul Haque

May 2012

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LIST OF ABBREVIATIONS

AADT	=	Average Annual Daily Traffic
ch	=	chainage
GDP	=	Gross Domestic Product
km	=	kilometer
km/h	=	kilometer per hour
km/hr	=	kilometer per hour
LRP	=	Local Reference Point
m	=	meter
mi	=	mile
mi/h	=	mile per hour
MNL	=	Multinomial logit
%	=	percentage

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DETERMINING SPEED LIMITS ON RURAL TWO-LANE HIGHWAYS IN BANGLADESH

INTRODUCTION

General

Transport infrastructure plays a central role to economic and social development of a country or region. The economic growth of a country depends on the well–maintained transportation network. Roads are every community's economical life line. Facilitating the constant movement of people and goods, roads are essential to modern living. Therefore, to meet the transportation needs of the future, governments around the world are under constant pressure to expand road system to cope up with the increasing volumes of traffic. But along with the expansion of the road transportation system we have to be considered the environmental, safety and economical issues.

Speed is the central factor in any consideration of the trade-off between safety and mobility within the road transport system. This is because speed affects every part of the system. Roads are generally designed to safely facilitate travel at a specific speed. Vehicles are designed to allow people and goods to move at a range of different speeds depending on the circumstance. And people constantly make choices about the speed they drive a vehicle on a road. But speed lies at the very heart of the road toll in Bangladesh, and indeed in every other country in the world. It is a core contributing factor to road crashes and the resulting death and injury toll. Therefore, with greater motorization and economic development there is an increasing demand to build roads to a higher standard in order to reduce journey times and congestion. This means higher speeds – but with higher speeds the numbers and severity of accidents will increase for all types of road user unless appropriate action is taken.

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Thus speed management, should be a central element of any road safety strategy, aims to achieve appropriate speeds on all parts of the road network. Speed management can be defined as a set of measures to limit the negative effects of speeds in the transport system. There are numerous strategies for managing driving speeds. The primary method of managing travel speed is by imposing speed limits. The speed limits may be defined as setting an appropriate speed for a section of road taking into account safety, mobility and environmental considerations and the impact of the chosen speed on the quality of life for the people living alongside the road. Appropriate speed differs from one type of road to another and recognizes the different weight to be given to the various elements on the different parts of the road network (OECD, 2006). Speed limits have a limiting function by which it is possible to establishing an upper bound on speeds for aim to reduce both the probability of crashes. Speed limits also have a coordinating function which reduces dispersion in driving speeds (TRB, 1998). The posted speed limits thus inform motorists the maximum legal driving speeds considered reasonable and safe for a road class under favorable conditions of good weather, free-flowing traffic, and good visibility.

Various methods are used to establish speed limits. These methods vary from arbitrary judgment and legislative statute to prevailing speed to more or less engineering analysis. There are no fixed rules or formulas for defining appropriate speed limits on a given section of road, as it takes into account a wide variety of factors. Key factors considered in the establishment of a speed limit include crash profile, road function, road use, roadside development, road characteristics, traffic mix, crash history and the presence of vulnerable road users, such as pedestrians, motorcyclists and bicycle riders. Other factors may also include the number, type and frequency of driveways and intersections which indicate potential conflict points. Also there are few methodologies available for determining the optimum speed limits for each road segment. Thus further research is necessary for setting criteria for setting speed limit. The research give priority the road segments that cut across different types of road environments for defining speed limits.

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Therefore, it has a great importance to develop more detailed analytical models capable of supporting the selection process of roadside characteristics through the production of objective estimates for segment-specific speed limits. This should go beyond design aspects and should be based on quantifiable explanatory variables that translate to the level of roadside capability and use. However, if the selection of candidates for explanatory variables can be easily determined, the choice of speed limits according to roadside characteristics and the importance of each variable in that choice are not obvious; it needs experience and knowledge. Thus, it is rationale to include expert judgment analysis to measurable data to produce more appropriate speed choices for each type of road environment.

The speed-limits choice set is naturally discrete, thus, it is natural to model it through discrete choice modeling, for which the multinomial logit (MNL) is the standard option. This is a new approach on choosing legal speed limits, one that allows consideration of many different variables that characterize the road segments, thus providing a detailed understanding on their relevance in affecting speeds. This is especially useful for rural highways as its cross many different environments that may be difficult to classify in speed categories.

Statement of Problem

The Road safety situation in Bangladesh is rapidly deteriorating largely as a direct consequence of increase population, motorization and urbanization. Injury and death rates from road accidents in Bangladesh are the highest in the world. Bangladesh has around 0.7 million motorized vehicles and 1.5 million non-motorized vehicles, with the former expected to double in the next 10 years. According to police statistics, road traffic crashes cause 4,000 deaths and injure another 5000 a year, but the unofficial figures are much higher. However WHO (2009) estimates that the actual fatalities could well be 20,038 each year (Hoque, 2010). In economic terms, road accidents cost the community in order of US $ 1000 million, nearly 2% of GDP. In terms of vehicle ownership Bangladesh has one of the highest fatality rate internationally, over 100 deaths per 10000 motor vehicles (Hoque, 2010).

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The principal contributing factors of accidents in Bangladesh are adverse roadway roadside environment, poor detailed design of junctions and road sections, excessive speeding, overloading, dangerous overtaking, reckless driving, carelessness of road users, failure to obey mandatory traffic regulations, variety of vehicle characteristics and defects in vehicles and conflicting use of roads (Hoque, 2007). Over 70% of road fatalities occurred on rural sections of main highways of which 38% occurs on national highways. The common types of accident in national highways are head on and rear end collisions, right angle collision, overturn the vehicle, hit object in road and off road, hit pedestrian, side sweep (BRTA, 2011). These types account for nearly of 85 percent of the total accidents of the country. These types of accident occur due to excessive speed (driving above the speed limit) or inappropriate speed (driving too fast for the conditions, but within the limits). Speed of a vehicle depends on roadside environment. In Bangladesh nearly 30% accident occurs due to adverse road conditions or environments. Thus, it is important to manage travel speed by imposing speed limits considering the roadside characteristics.

In Bangladesh most of the national highways are undivided two-lane highways. The pavement width of the national highways is 7.3 m. These roads built passing through rural areas, small town and also commercially developed places (bazaar area). This creates safety problems caused by the constraints of entry and exit of vehicles, parking maneuvers, and pedestrian crossing. As a Bangladesh is a flood prone country many bridges and culverts had constructed along the roads alignment. The common road environmental deficiencies are listed below:

- Presences of ditches, trees, poles at roadside
- On-road parking
- Broken or no shoulder (paved or unpaved) along the road pavement
- Inadequate speed control measures like speed hump, pedestrian crossing, road marking, road signs etc.
- Absence of speed control lights at intersection
- Too many access points or no access control

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- Bus stops at roadside
- Poor sight distance
- Narrow bridges and culverts
- Presence of too many intersections
- Encroachment of roadside places

Therefore, all of these factors need to be considered to control the speed as well as setting speed limits for a section of a road.

Roads in Bangladesh have been improved through urban and rural areas without considering safety implications. Speeds have increased because of the much better pavement, and this has resulted in more accidents. Thus speed control should be a primary objective to reduce accident. For this reason speed limits would be set to alert the drivers. According to Motor Vehicle Ordinance, 1983 the speed limit for light vehicles like cars is 113 km/hr, for passenger vehicles 56 km/hr and for heavy vehicle 48 km/hr. In this Ordinance only considered vehicle types not roadside environment. Speed limits would not be the same for all types of roads as it depends on roadside environment. Again no road in Bangladesh has a combination of geometric design standard and traffic composition that should permit higher speed limit than 80 km/hr (or lower, if roadside activities or other reasons so demands) (FINNROAD, 2005). Also due to various roadside character the speed limits of a same road will be vary at different segments. In RTA Annual report 2008 it is recommended for establishing the speed limit zones for safer roads (BRTA, 2011).

Thus it is necessary to study an analytical model for setting speed limits on segmental basis in Bangladesh condition. Developing countries like Bangladesh there are scarcities of crash and other traffic relate data. That’s why it would be rationale to include expert judgments in the segmental model. Hence this study would provide a basis towards setting speed limits for the two lane highways in Bangladesh.

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OBJECTIVES

The main objective of this research is to develop an analytical model for setting speed limits for different parts of the rural undivided two-lane national highways in Bangladesh. The specific objectives of this study are as follows:

1. To review the potential roadside attributes which influence the setting of speed limits.

2. To develop an analytical model capable of supporting the selection of appropriate speed limits for the different segments of rural two-lane national highways in Bangladesh on the basis of a number of different characteristics of the road's surrounding environment.

3. To recommend suitable speed limits for various types of road segments in Bangladesh.

Scope of Study

The study was carried out on two different important national highways in Bangladesh namely N5 and N6. Due to limited time and resources, investigations will be carried out for 20 kilometers for each road and total 40 kilometers only. The studied portions represented various categories of road environments. The location of the study portion of highways is shown in the attached Bangladesh Map (figure 1). The detail location and alignment of study areas in the selected highways are described in figure 2 and 3. The important features of these two highways and selected links are mentioned in table 1 and table 2.

Link 34 of N5 (Manikganj - Aricha) has the highest fatality risk and link 49 of N6 (Natore - Rajshahi) is one of top ten highway link which has the highest fatal accident rate (BRTA, 2005). Therefore according to high fatal accident rate and fatal accident index these links were selected for study.

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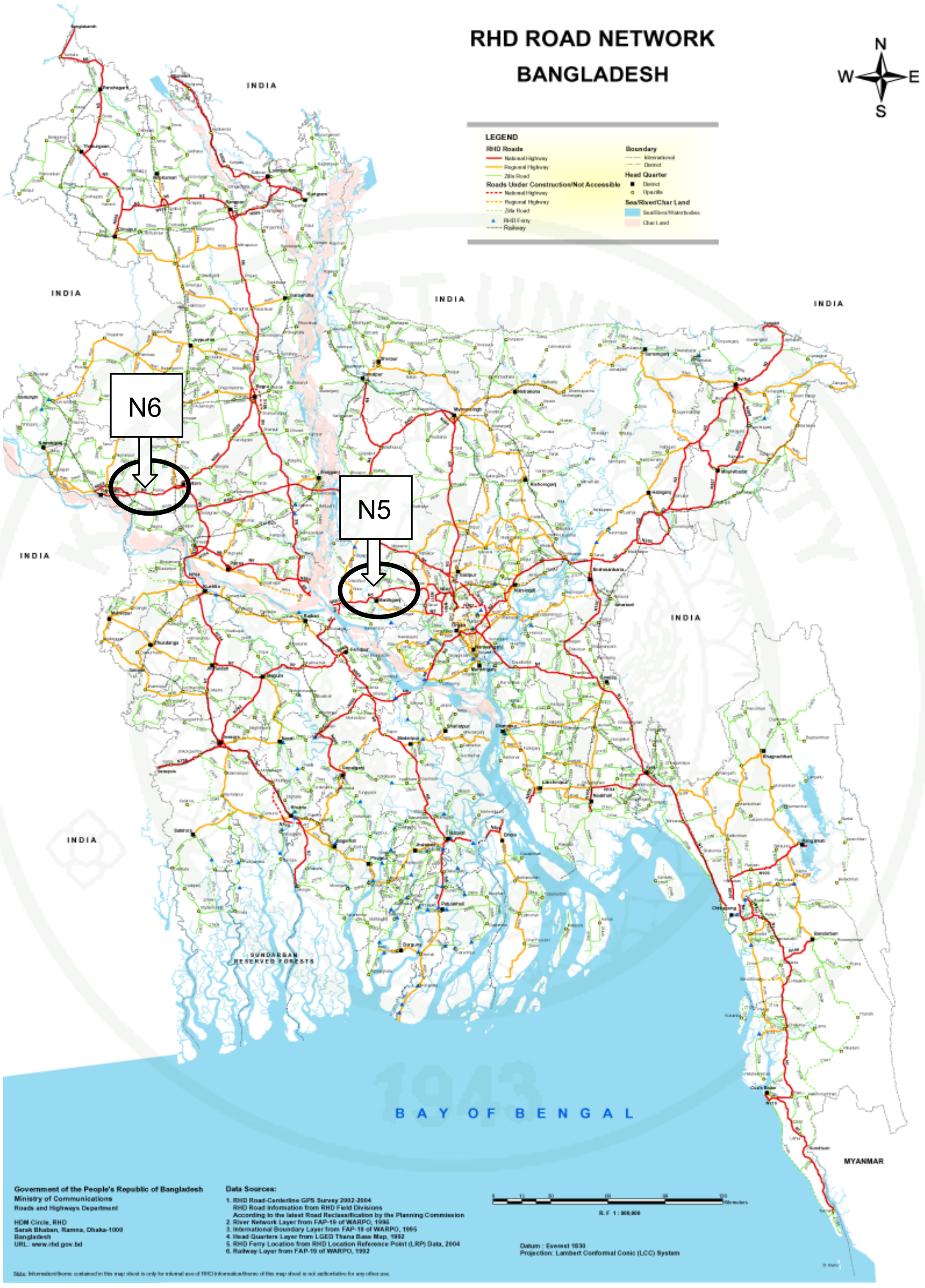

Figure 1 Study areas on Bangladesh road network map

Source: RHD (2005)

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Figure 2 The route map of the study portion at road no. N5

Source: RHD (2005)

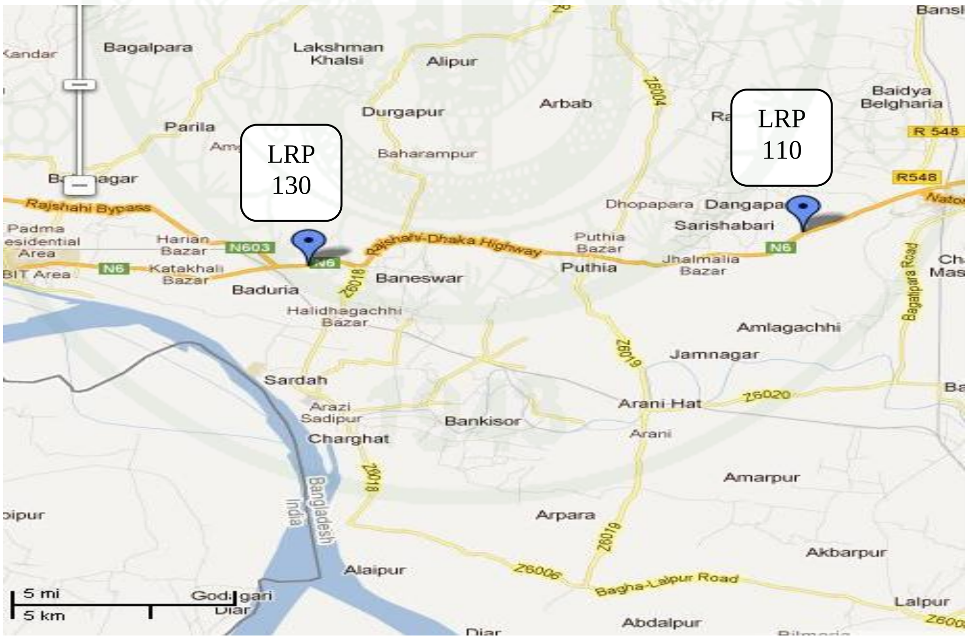

Figure 3 The route map of the study portion at road no. N6

Source: RHD (2005)

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Table 1 Features of the selected roads for study

Road No.	Road Name	Class	Length	Avg. Width	Traffic AADT	Accident Rate
N5	Dhaka (Mirpur)-Utholi-Paturia- Natakhola-Kashinathpur-Bogra-Rangpur-Beldanga-Banglabandh	National Highway	507 km	6.96 m	15016	3.42
N6	Kashinathpur -Dasuria-Natore-Rajshahi Road	National Highway	150 km	7.38 m	10912	3.75

Source: RHD (2011); BRTA (2005)

Table 2 Details of the study portions of selected roads

Road No.	Location for Study		Fatal Accident	Fatalities	Fatal Accident Rate	Fatality Index
	LRP & Chainage	Link No. & Name				
N5	LRP 043 LRP 063 Ch 42+000 Ch62+000	33 Nabinagar-Manikganj	11	16	6.1	1.5
		34 Manikganj-Aricha	3	8	6.5	2.7
N6	LRP110-LRP130 Ch111+000-Ch131+000	49 Natore-Rajshahi	13	7	20.8	0.5

Source: RHD (2011); BRTA (2005)

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Detailed investigations throughout the routes were out of scope. The study was carried out along the undivided two lane portion of the highways. The pavement width all over the studied sections is 7.3 m and remains paved shoulder on both sides of the pavement. During modeling for determining speed limits the factors of roadside environments and expert judgments were considered. Analysis the effect of the other factors such as vehicle, road user, weather, road condition and accident probability was out of scope. From each road 15 km was selected for model calibration and another 5 km for model validation.

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LITERATURE REVIEW

1. General

Speed has many positive as well as negative impacts. Speed allows a reduction in journey time and therefore enhances mobility. Otherwise, excessive and inappropriate speed is the number one road safety problem in many countries, often contributing to as much as one third of fatal accidents and an aggravating factor in all accidents (OECD, 2006).

Speed has been identified as a key risk factor in road traffic injuries. Higher speeds lead to a greater risk of a crash and a greater probability of serious injury if one occurs. This is because, as speed increases, so does the distance travelled during the driver's reaction time and the distance needed to stop. Also, at speed, the effects of failing to anticipate oncoming hazards in good time and of vehicle handling errors are magnified. In addition higher speeds can cause others to misjudge closing speed (iRAP, 2010). The figure 4 shows the stopping distance at different speeds (including reaction time of around 1second)

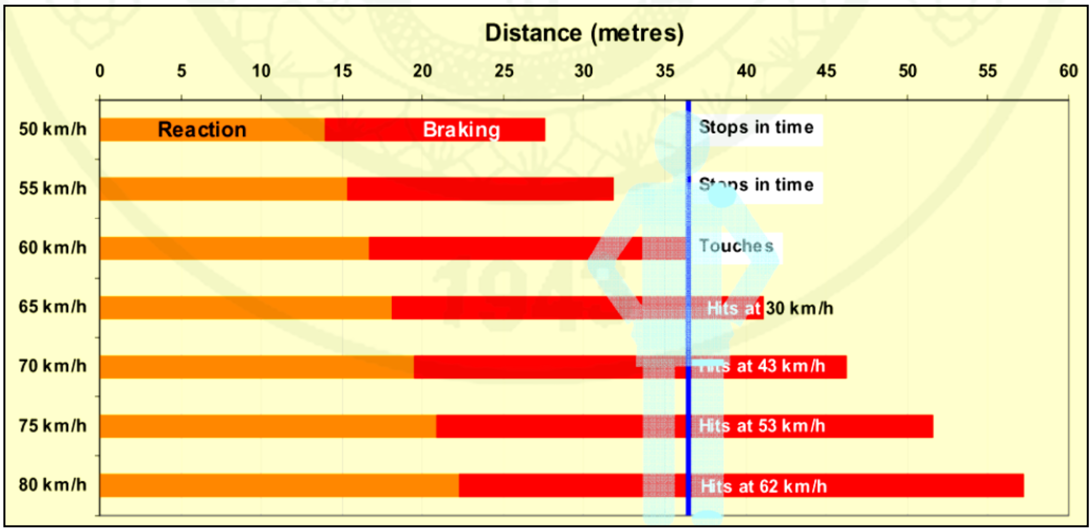

Figure 4 Stopping distance at different speeds

Source: iRAP (2010)

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Speed is one of the most significant variables in explaining both the frequency and the severity of road accidents (TRB, 1998). The relationship between travel speed and injury severity is even more strongly demonstrated by the research.

2. Travelling Speed and Crash Involvement

Most research now provides clear evidence of the relationship between higher vehicle speeds and crash involvement. Some of these studies looked at individual vehicle speeds, others at average road section speeds.

Solomon's U-shaped curve (figure 5) suggested that crash risk increased for vehicles travelling slower than average speed, as well as for vehicles travelling faster (Solomon, 1964).

Fildes *et al.* (1991) concluded that the relationship between speed and crash rate is a exponential functions for rural and urban roads as well as the higher the speed, the larger the increase of the crash rate (figure 6)

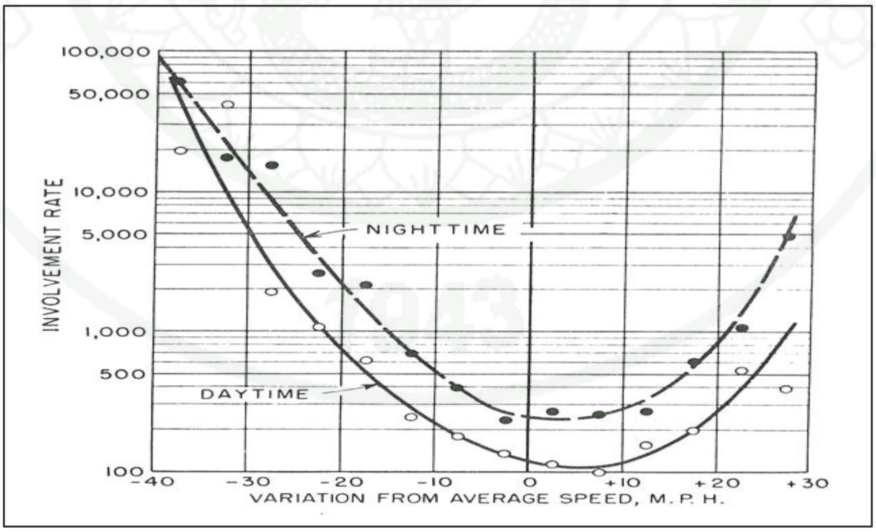

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Figure 5 Solomon's U-shaped curve shows that crash involvement rate with variation from average speed

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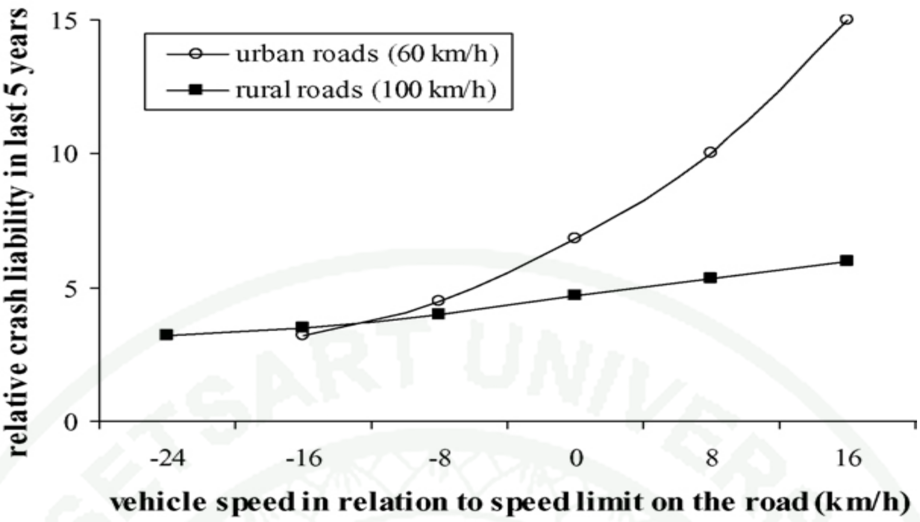

Figure 6 The relation between speed and crash rate

Source: Fildes *et al.* (1991)

Stuster *et al.* (1998) concluded that the increase in the percentage of traffic accidents with injuries doubles with the percentage increase of the speed squared and quadruples when fatal crashes are considered.

The studies of Maycock *et al.* (1998) and Quimby *et al.* (1999) in the UK had a similar design, and found a similar pattern of increase in crash liability with increasing speed.

Maycock *et al.* (1998) developed the following mathematical function which represents the crush relation with speed:

$$\boldsymbol{A_{i3} = 0.265(\frac{v}{\bar{v}})^{13.1}} \qquad \dots\dots\dots\dots (\mathbf{1})$$

Where,

A_{i3} = self reported crash liability in last 3 years

v = Individual vehicle speed

$\bar{v}$ = Average speed

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They translated this function in the rule of thumb that 1% increase in speed is related to a 13.1% increase in crash liability.

In contrast to study of Maycock *et al.*, Quimby *et al.* (1999) found the following function:

$$\boldsymbol{A_{i3} = 0.215(\frac{v}{\bar{v}})^{7.8}} \qquad \ldots\ldots\ldots\ldots\ldots(\mathbf{2})$$

They concluded from this function that a 1% increase in free speed is related to an increase of 7.8% in crash liability. The results of both studies are graphically depicted in figure 7.

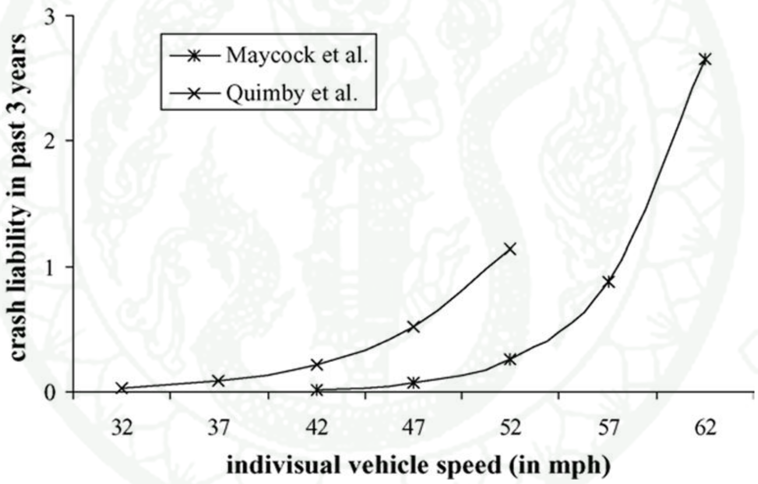

Figure 7 The relationship between individual vehicle speed and crash liability

Source: Maycock *et al.* (1998); Quimby *et al.* (1999)

Baruya (1998) performed a cross-sectional study to assess the relationship between average speed and crash frequency. Cross-sectional studies compare different characteristics of different roads, including average speed, to determine the amount of variance in crash frequency that they explain. Baruya found the following power function to describe the relationship between average speed and injury crash frequency:

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$$A_r = 5.66fl^{0.748}\ l^{0.87}e^{(0.038j-0.056w+0.023v_{limit})}$$
$$\times e^{(0.023v_{limit})}\overline{v}^{-2.492}o^{0.114}v_{limit} \qquad \dots\dots\dots\dots\dots(3)$$

Where

fl = Traffic flow (average amount of daily traffic)

l = Length of the road section (km)

j = Number of junctions per road section

w = Width of the road lanes (m)

v_{limit} = Speed limit

$o_{v\text{limit}}$ = Proportion speed limit offenders

Baruya concluded that many crashes involving slow speed were probably attributable not to speed variation but to road and traffic characteristics, including congested traffic, narrow roads or roads with a high density of intersections and vehicles that were stopping or slowing to turn or just entering the road.

More recently Aarts and Van Schagen (2006) reached the conclusion that small speed reduction (1 or 2 km/hr) produce a significant effect on road-accident probability, and this effect is a function of the reference speed.

From another perspective, the probability that a pedestrian will be killed if hit by a motor vehicle increases dramatically with speed. In figure 8 the probability of a fatal injury for a pedestrian colliding with a vehicle is illustrated (GRSP, 2008). A report from the OECD/ECMT (2006) states in its conclusions that in pedestrian crashes, pedestrians have higher chances of surviving when the vehicle is traveling less than 30 km/h (19 mi/h), decreasing drastically when the speed increases to 50 km/hr (31 mi/h).

Thus there is a direct positive relationship between travel speed and crash involvement. Therefore, it is important to manage the travel speed for reducing crash involvement.

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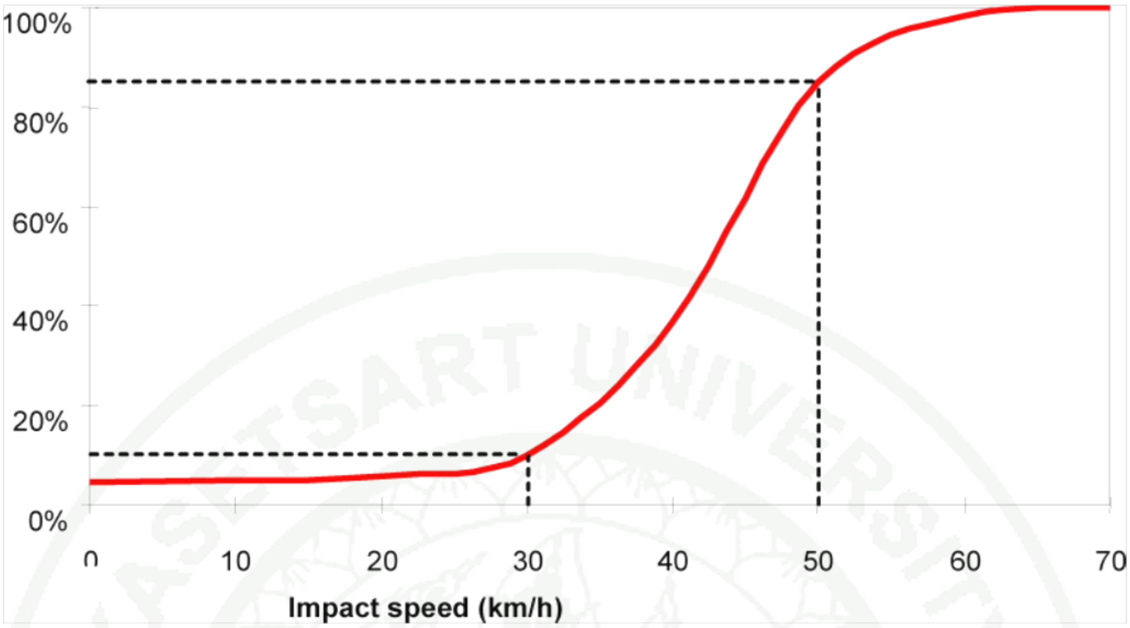

Figure 8 Probability of fatal injury for a pedestrian colliding with a vehicle

Source: GRSP (2008)

3. Speed Management

Speed management can be defined as a set of measures to limit the negative effects of excessive and inappropriate speeds in the transport system (OECD, 2006). The objectives of the speed management are as follows:

- Road safety, by reducing fatalities and injuries on the roads.
- The environment, by reducing adverse impacts, such as noise and pollution.
- Quality of life, especially for people living in urban areas, including the most vulnerable persons.

A variety of measures already exist for managing speed. These measures include:

- Infrastructure related measures such as gates, islands and refuge islands, narrowing, roundabouts, speed humps, cushions etc.

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- Speed limits
- Signs, signals and markings
- Vehicle technologies such as ISA
- Education; training and incentives; enforcement
- New technologies such as ITS

4. Importance of Speed Limits

The primary method of managing travel speed is by imposing speed limits. Therefore speed limits are most important in determining the relative crash risk that road users will be subjected to on a length of road. Speed limits enhance safety in two ways. They have a limiting function. By establishing an upper bound on speeds, the objective is to reduce both the probability and severity of crashes. Another function of speed limits, which is related to their coordinating function, is to achieve an orderly flow of traffic and improve traffic flow efficiency (TRB, 1998).

Speed limits act as a key source of information for road users. Set correctly, they help reinforce drivers' assessments of a safe speed and act as a pointer to the nature of the road and associated level of risk to both themselves and vulnerable road users. Speed limits are therefore an important part of the toolkit for achieving appropriate vehicle speeds and wider road safety benefits (OECD, 2006).

Speed limits specify the maximum safe speed of travel permitted for light vehicles on a road under ideal conditions. Speed limits are not intended, however, to be seen by drivers as setting a target speed, nor as being appropriate in all conditions. Drivers should be encouraged to adopt lower speeds when required by the prevailing conditions. Speed limits are the means by which legal sanctions can be brought to bear on those who drive faster than is appropriate on the roads (OECD, 2006).

Firth *et al*. (2005) and Oxley (2006) stated that "speed limits considered being the most powerful road feature that determines the speed at which drivers and riders choose to travel and therefore play a pivotal role in determining overall crash and

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injury risk." Thus speed limit selection is a critical indicator to road users for selecting the safe speed of a road section in ideal conditions.

5. Crash Severity and Speed Limits

Many studies world-wide have examined the effect of raising or lowering speed limits in both rural and urban environments and consistently show that crash incidence and injury severity decline whenever speed limits have been reduced.

Nilsson (1982) evaluated the safety effects on Swedish rural roads after changing speed limit from 110 to 90 km/hr and vice versa. It was found that a speed limit reduction was accompanied by a reduction in average speed as well as a reduction in the number of crashes (figure 9). Nilsson published power relationships connecting traffic speeds with road trauma. The increases in fatal crashes, serious casualty crashes (those resulting in death or serious injury) and casualty crashes (those resulting in death or any injury) are each related to the 4th, 3rd, and 2nd powers, respectively, of the increase in mean traffic speed. The functions are given below:

Fatality rate: $\boldsymbol{F_2 = F_1(\frac{v_2}{v_1})^4}$ ……….(**4**)

Serious injury rate: $\boldsymbol{I_2 = I_1(\frac{v_2}{v_1})^3}$ **……… (5)**

Injury rate: $\boldsymbol{A_2 = A_1(\frac{v_2}{v_1})^2}$ ……… (**6**)

Where,

F_1 = Number of (police reported) fatal crashes before change

F_2 = Number of (police reported) fatal crashes after change

I_1 = Number of (police reported) serious injury crashes before change

I_2 = Number of (police reported) serious injury crashes after change

A_1 = Number of (police reported) injury crashes before change

A_2 = Number of (police reported) injury crashes after change

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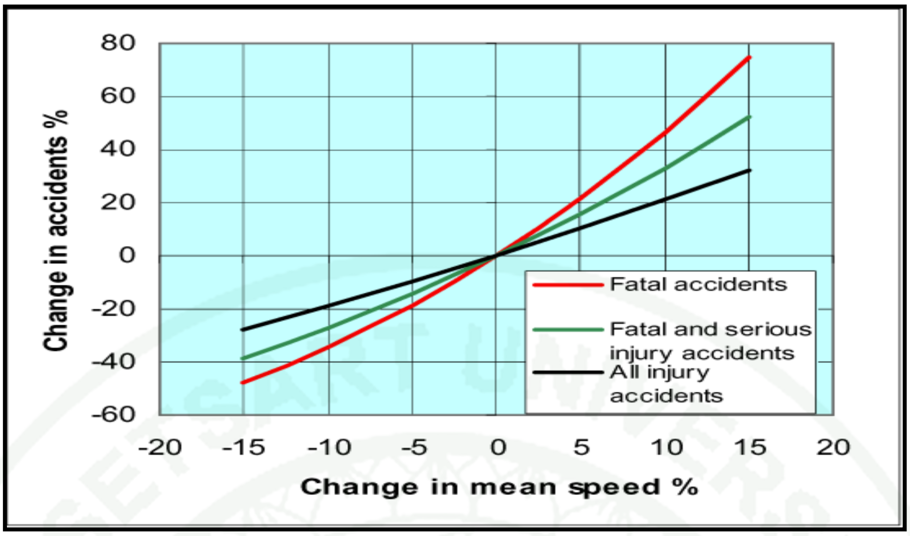

Figure 9 The power model: relationship between change in mean speed and accidents

Source: Nilsson (1982)

Finch *et al.* (1994) developed a model of the relationship between the change in mean speed and the change in crashes before and after speed limit changes on main rural roads in Finland, Denmark, Switzerland, and the United States. The results suggest that for every 1 mi/h change in speed, the number of injury crashes increases 5 percent or a 3-percent increase in injury crashes for every 1 km/hr increase in speed (figure 10)

Interstate highways in the USA have been the largest area of study of changes in speed limits. In 1974, the National Maximum Speed Limit (NMSL) for highways was introduced and set at 55 mi/h (88 km/hr). Several studies examined the effect of the new speed limit on road safety. The Transportation Research Board (TRB, 1984) reviewed these studies and found that the lower speed limit reduced both travel speeds and fatalities, but that compliance with the speed limit decreased over time.

The NMSL was raised to 65 mi/h (105 km/hr) in 1987. Following the change, 40 states raised their speed limits to the new maximum. The effect of the change was examined by a large number of studies at both the national and state level. A review

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of these studies by the TRB (1998) concluded that "raising the speed limit led to an increase in both rural interstate fatalities and fatal crashes". For example, one study conducted by Garber and Graham (1989) that controlled for many other variables that affected highway safety found that, across the 40 states that raised their speed limits, there was a 15% increase in fatalities on interstate highways.

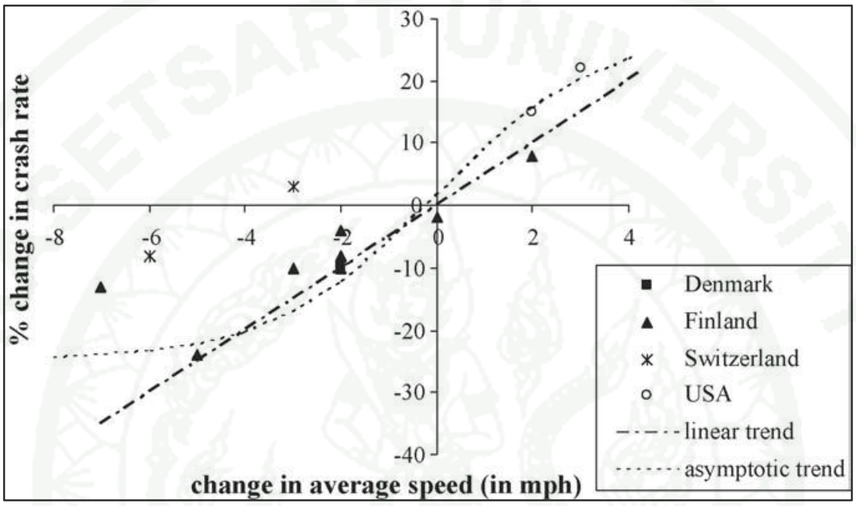

Figure 10 Relation between changes in average traffic speed and change in crash rate

Source: Finch *et al.* (1994)

In 1995, the NMSL was repealed, again allowing states to set their own speed limits. Several states raised their speed limits almost immediately. An evaluation by the National Highway Traffic Safety Administration (NHTSA, 1998) reported that "it is estimated that the 32 states that increased[interstate] speed limits experienced approximately 350 more fatalities than would have been expected based on historical trends, about nine percent above expectations"

Kloden *et al.* (1997) concluded that in a 60 km/hr speed limit area, the risk of involvement in a casualty crash doubles with each 5 km/hr increase in travelling speed above 60 km/hr (figure 11). Reanalysis of the data of the previous study

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(Kloeden *et al.,* 2002) revealed the following exponential function between speed of an individual vehicle and his risk of an injury crash on urban roads.

$$\boldsymbol{I_r = \exp(0.1133374\Delta v + 0.0028272v^2)} \qquad \textbf{……….(7)}$$

Where

I_r = Injury crush rate

$\Delta\boldsymbol{v}$ = Difference between individual vehicle speed and average traffic speed

$\boldsymbol{v}$ = Individual vehicle speed

In a similar second study, Kloeden *et al.* (2001) examined the speed–crash rate relationship on rural roads with speed limits between 80 and 120 km/hr. For these roads, they found the following exponential function

$$\boldsymbol{I_r = \exp(0.07039\Delta v + 0.0008617v^2)} \qquad \textbf{………(8)}$$

These results indicate that on urban roads the crash rate increases more with increasing speed than on rural roads.

Farmer *et al.* (1999) studied the trends in motor vehicle occupant deaths over 8 years for 24 states in USA that raised interstate speed limits and seven states that did not following the 1995 repeal of the US National Maximum Speed Limit. They found that fatalities on interstates increased 15% in the 24 states that raised speed limits. After accounting for changes in vehicle miles of travel, fatality rates were 17% higher following the speed limit increases. Similar increases were reported following the 1987 speed limit increases on rural interstates. Deaths on roads other than interstates were essentially unchanged.

One of the most recent evaluations of changes in speed limits examined the change from 100 to 110 km/hr on Melbourne's rural and outer freeway network in 1987 and the change back to 100 km/hr in 1989. Sliogeris (1992) found that, compared to a control group of all other roads in Victoria that remained at 100 km/h between 1987 and 1989, the injury crash rate per kilometer travelled increased by

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24.6% following the change from 100 to 110 km/hr, and decreased by 19.3% following the change back to 100 km/hr.

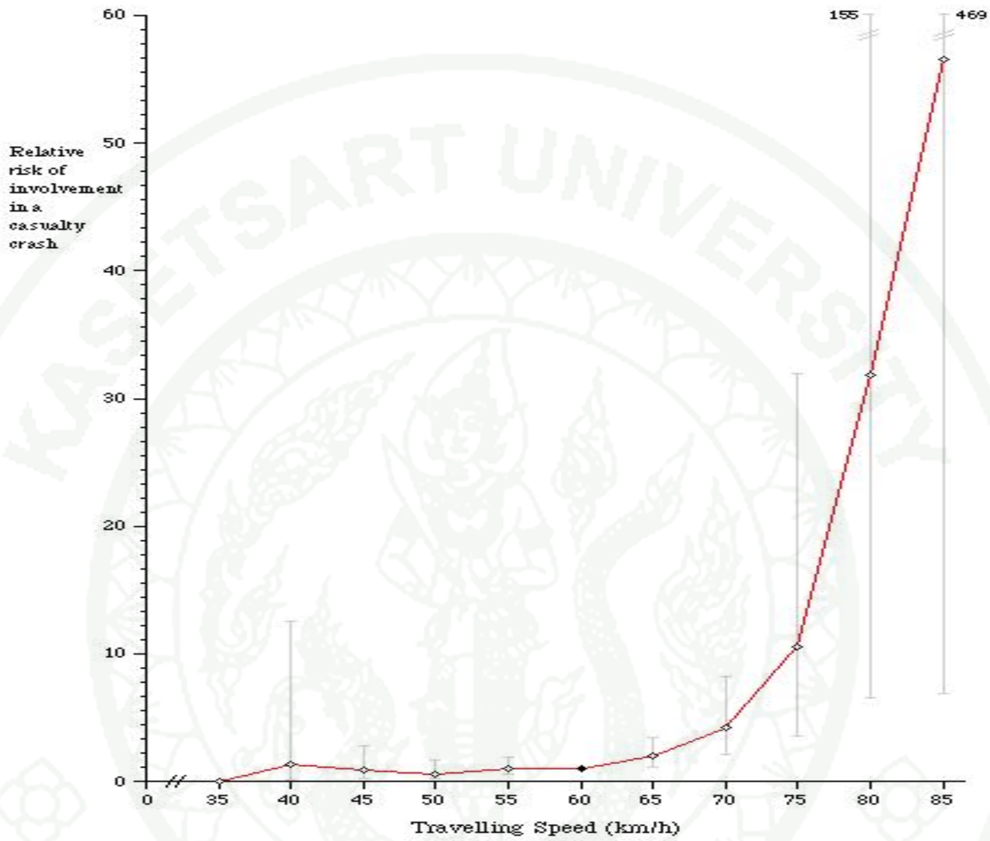

Figure 11 Travelling speed and the risk of involvement in a casualty crash relative to travelling at 60 km/hr in a 60 km/hr speed limit zone

Source: Kloden *et al.* (1997)

There is a consistent finding from the studies referred to above that shows that increasing the speed limit increases crash, injury, and fatality rates and that decreasing the speed limit can reduce these rates. This stream of research has motivated many countries to decrease the legal speed limits.

However this is not consensual. For example, Lave and Elias (1994) studied the change on the legal speed limits from 55 mi/h to 65 mi/h in the United States and

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concluded that in some cases this can actually save lives.

Malyshkina and Mannering (2008) studied the effect of the increase in legal speed limits and road crash severity and concluded that a change from 65 to 70 mi/h did not produce a significant increase in the severity indicators on interstate highways.

These different views of the problem have been strengthening the need for developing decision-support instruments for setting the most appropriate speed limits for each specific case.

6. General Speed Limits versus Speed Zones

General speed limits apply statewide or even nationwide. These are set by legislation. Typically, general or legislated limits apply to a category of highway and reflect the design characteristics of the particular road class. They also differ by area, distinguishing rural from urban or local roads.

Speed limits in speed zones apply to a particular section of road. These are established by administrative action and are intended to be determined on the basis of an engineering study. The traffic, road, and land use conditions should be considered in establishing an appropriate speed limit in a speed zone (TRB, 1998).

7. Methods of Setting Speed Limits

The following methods (TRB, 1998) are used for setting speed limits. These methods are based in different views of the problem.

7.1 Statutory Limits

In this method speed limit sets by government statute or ordinance on local roads. During setting speed limits it considers the trade-offs among safety, travel time, and other objectives that are politically determined. Statutory limits

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typically are established by road class and sometimes by location (e.g., rural). Thus legislated or statutory speed limits can be arbitrary. In USA Statutory national speed limits were imposed twice during World War II (35 mi/h) and during the energy crisis of 1973. The objective was to reduce energy costs rather than transportation costs and safety.

7.2 Optimum Speed Limits (Empirical Method)

In the early 1960s Oppenlander proposed a scientifically based procedure for regulating vehicle operating speeds to set speed limits at an optimal level from a societal perspective. Oppenlander's approach attempted to define costs per mile of travel as a function of speed for four cost categories: (*a*) vehicle operation, (*b*) travel time, (*c*) crashes, and (*d*) service (i.e., comfort and convenience). The cost curves were developed from studies of vehicular travel on various types of highways for different traffic situations, travel conditions, and types of motor vehicles. The "optimal speed" was determined by solving for the minimum point on the total cost curve, which represented the minimum social cost of highway transport for a particular set of conditions. The approach is most appropriate for establishing general speed limits for different road classes. However, it can also be used for setting speed limits in speed zones by adjusting optimal speeds to reflect the specific physical and environmental features of a given highway segment. If empirical method is implemented, it could be difficult to enforce because socially optimal speed limits are typically lower than what individual drivers would select.

7.3 Engineering Study Method

The most common method for determining speed limits in a speed zone sets the limit on the basis of an engineering study. The study requires data collection and analysis in the determination of an appropriate limit. The data include measurement of prevailing traffic speeds, crash data, and information on highway, traffic, and roadside conditions not readily apparent to drivers. Fitzpatrick *et al.* (1997) found that the 85th percentile speed is the most widely used factor for

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determining the level at which to set the limit. Setting the speed limit near the 85th percentile, that is the speed at or below which 85 percent of drivers operate their vehicles, assumes that most drivers are capable of judging the speed at which they can safely operate (Krammes *et al.*, 1996)The 85th percentile speed is determined through spot speed studies of free flowing traffic (i.e., traffic unimpeded by other vehicles), which yield a distribution of speeds from which the 85th percentile is calculated (Krammes *et al.*, 1996) (figure 12).The implication for enforcement is that no more than 15 percent of motorists will be out of compliance. The 85th percentile speed was mostly accepted because traffic engineers often found that this was the upper limit of the 10 mi/h (16 km/hr) pace. Setting the speed limit near this point would encourage most drivers to travel at more uniform speeds, thus minimizing opportunities for vehicle conflict. In addition, experience indicated that the 85th percentile speed appeared to be reasonable from a law enforcement standpoint.

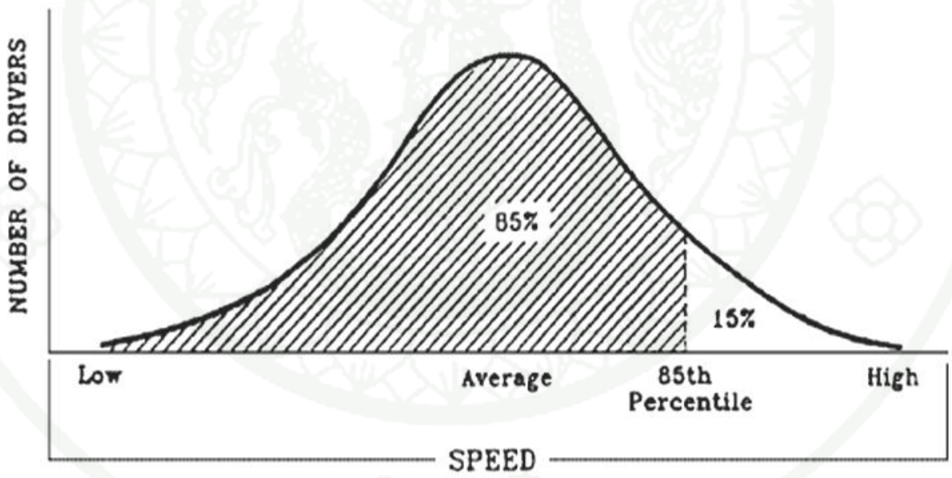

Figure 12 Speed distribution showing the 85th percentile speed

Source: Krammes *et al.* (1996)

A final concern with setting the speed limit at the 85th percentile speed is that it may not be appropriate for all classes of roads. For example, property access, community concerns, and pedestrian safety are important factors in setting appropriate speed limits on many urban roads, particularly residential streets. Thus, basing speed limits on the 85th percentile speed—a measure of unconstrained free

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flowing travel speed—will not be as appropriate on these streets as on major arterial highways where travel efficiency is the primary road function.

7.4 Expert System–Based Approach

The decisions and judgments required to establish speed limits were thought to be particularly amenable to an expert system approach. Expert systems are computer programs that mimic an expert's thought processes to solve complex problems in a given field. The problem must have a well-defined knowledge base, "experts" must be able to verbalize their knowledge and experience in the form of tasks to be undertaken and decisions to be made, and outcomes must be limited in number and clearly defined. Some of examples of computer based program for determining speed limits are VLIMITS, NLIMITS, QLIMITS, and USLIMITS.

Victoria expert system VLIMITS was developed by the Australian Road Research Board (ARRB) at 1987. Experts reviewed the field data for determining appropriate speed limits for various road classes and traffic conditions. This "expert judgment" was reduced to a personal computer program, which leads the user through a series of question-answer menus that ultimately results in a recommended speed limit for a particular road section. VLIMITS was revised and updated in 1992. At the same time, development of related versions of the program—NLIMITS and QLIMITS—was begun for use in New South Wales and Queensland, respectively. The system takes the user through a five-step process which includes (*a*) environmental characterization of the area (e.g. urban, rural), (*b*) roadway and roadside factors (e.g. divided highway, number of lanes), (*c*) a first approximation of a speed limit based on a and b, (*d*) special activities(e.g. school zone) or other factors that might modify the final zoning (e.g. zone length, adjacent zone speed limits), and (*e*) 85th percentile speed. The output of this process is a recommended speed zone value; specific factors may also be flagged for further consideration.

USLIMITS was developed for setting speed limits for various states of USA. The input of this program is (a) density of surrounding development (e.g. high

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density, low density), (b) frequency of roadside access (e.g. number of residential driveways, commercial, industrial, shopping, and special activity properties, and the number and type of intersecting roads), (c) road function (e.g. traffic movement vs. access to abutting properties), (d) road characteristics (e.g. Paved width, divided or undivided, lane width and number of lanes, sight restrictions), (e) freeway conditions and important high speed road characteristics (e.g. interchange spacing, AADT, shoulders), (f) existing vehicle operating speeds, (g) adjoining speed limits, (h) any special conditions that may exist on the road section (e.g. adverse alignment, pedestrian and roadside activities, high crash rates etc). The output of this program is a recommended speed.

7.5 Other Methods for Setting Speed Limits

7.5.1 Basic Law Limits

Another approach to setting speed limits is to leave it up to the driver to determine a reasonable and prudent travel speed. In this method vehicles shall be driven in a careful and prudent manner, depending on the conditions at the time and place of operation.

7.5.2 Variable Speed Limits

Drivers are expected to adjust their speeds on the basis of actual conditions. Variable speed limits offer drivers guidance on appropriate maximum and minimum speed limits on the basis of real-time monitoring of prevailing traffic and roadway conditions, using dynamic information displays to inform motorists of the appropriate limits. Variable message signs, which provide information to motorists about speeds for specific conditions (fog, high crosswinds, work zones), have been in use for some time. Development of a new generation of technologies as part of the Intelligent Transportation Systems program has given new impetus to implementation of variable speed limit systems.

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Therefore, different countries have different ways of defining appropriate speed (and hence speed limits) on their road networks. Whatever the method chosen, it is preferable to use a “rounded” number for the speed limit, such as 40, 50, 60 km/hr. Some countries use “odd” limits (30, 50, 70 km/hr, etc.). Given the large variety of road networks, it would be advisable to use the full range of speed limits (30, 40, 50, 60 km/hr, etc.) to more closely align speeds with road safety.

8. Minimum Distance for Setting Speed Limits

Most countries set a minimum distance over which local speed limits are applied – for instance not less than 600 meters and encourage reasonable consistency of limits over a length of a route (OECD, 2006).

The minimum length of a speed limit should generally be not less than 600 meters to avoid too many changes of speed limit along the route. In exceptional circumstances this can be reduced to 400 meters for lower speed limits, or even 300 meters on roads with a purely local access function. Anything shorter is not recommended (DFT, 2006).

For consistency it is important that, within routes, separate assessments should be made for each length of road of 600 meters or more for which a different speed limit might be considered appropriate. When this is completed, the final choice of appropriate speed limit for individual sections might need to be adjusted to provide reasonable consistency over the route as a whole.

9. Factors Considered for Setting Speed Limits

The relationship among speed limits, driver speed choice, and safety on a given road is complex. Setting appropriate speed limits and related enforcement strategies is the first step in a chain of events that may affect crash probability and crash severity (figure 13) (TRB, 1998).

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The appropriate speed for a section of road is set taking into account safety, mobility and environmental considerations and the impact of the chosen speed on the quality of life for the people living alongside the road. Appropriate speed differs from one type of road to another and recognizes the different weight to be given to the various elements on the different parts of the road network.

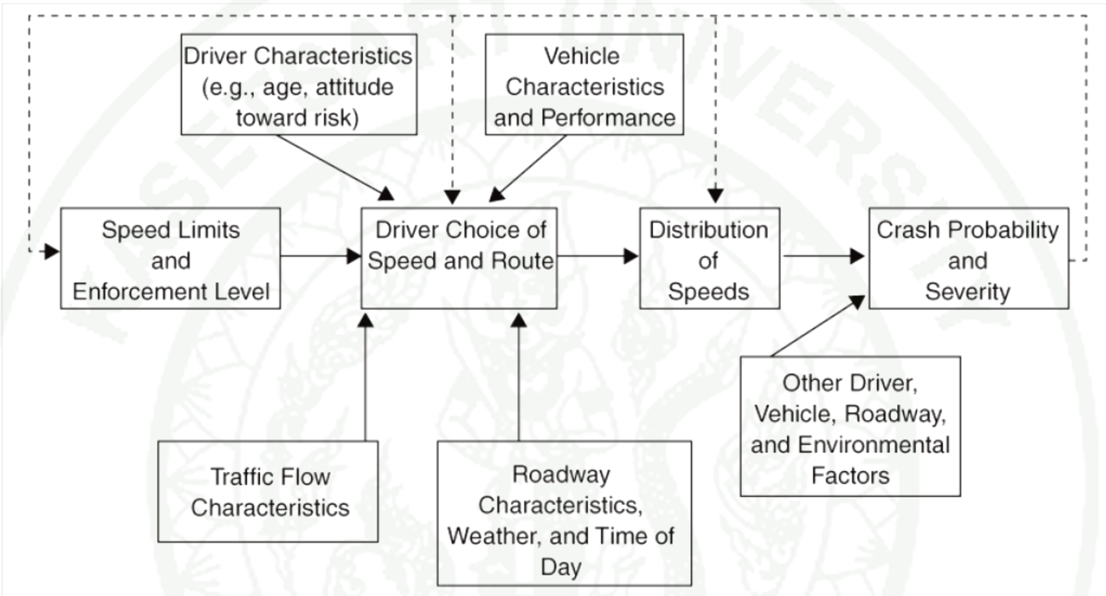

Figure 13 Systems view of relationships among speed limits, enforcement levels, and safety

Source: TRB (1998)

Appropriate speed limits should also take into consideration noise levels generated by traffic for people living in the surroundings. A number of criteria are normally used in the different countries for defining general speed limits. Some of these criteria are listed (OECD, 2006):

- Type of road/street/environment
- Type of vehicle or type of loads (specific speed limits for heavy vehicles, public transport vehicles, farm vehicles, transport of dangerous goods, etc.)
- Type of tires

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- Type of drivers (specific speed limits for young or novice drivers)
- Weather conditions (specific speed limits in case of rain, fog, etc.)

Therefore, principal aim in determining appropriate speed limits should therefore be to provide a consistent message between the road geometry and environment and for changes in speed limit to reflect changes in the road layout and characteristics. The following will be important factors for setting an appropriate speed limit (TRB, 1998; Stuster *et al*., 1998):

- Driver attitude and behavior
- Road function (strategic, through traffic, local access etc.)
- Road geometry (width, sightlines, bends, junctions and accesses etc.)
- Road environment (rural, residential, shop frontages, schools etc.)
- Level of adjacent development
- Traffic composition
- Traffic Density
- Vehicle Characteristics
- Environmental Condition
- Weather Condition

10. Roadway Characteristics and Speed Limits

Road characteristics greatly influence what seems to be an appropriate speed to a driver/rider: for example, roadside development tends to slow traffic down, so drivers will travel faster on open rural roads and slower on built-up urban roads. However many roads may give incorrect messages to drivers and riders: while appearing safe for high-speed travel, they may contain vulnerable road users, concealed tight curves etc. In addition, road features play a vital role in determining the severity of injuries in the event of a crash (Oxley, 2006).

The following roadside features can influence the driver behavior to select speed (Correia and Silva, 2011; Fildes *et al*., 2005; Stuster *et al*., 1998):

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- Presence of roadside hazards such as trees, vegetations, ditches, poles etc.
- Buildup areas or commercial development near the road way such as school, filling station, factory, market etc.
- Number of intersections and their design
- Design speeds of the road way
- Road surface conditions
- Road geometry such as curvature, grade, length of grade, number of lanes, sight distance, lateral clearance, road width etc.
- Number of access points
- Presence of bus stops, parking places
- Speed control measures such as speed hump, speed control traffic lights, pedestrian crossing etc.

11. Effectiveness of Speed Limits

The effectiveness of setting speed limits justified when they reflect implicit trade-offs among road user safety, travel efficiency, and practicality of enforcement. The trade-offs vary by roadway functional class and environment, reflecting in part different levels of risk associated with driving on different roadway types.

On rural roads there is often a difference of opinion as to what constitutes a reasonable balance between risk of an accident, travel efficiency and environmental impact. Higher speed is often perceived to bring benefits in terms of shorter travel times for people and goods. However, evidence suggests that when traffic is travelling at constant speeds, even at a lower level, it may result in shorter and more reliable overall journey times. With inappropriate speed for the conditions also come costs, the greatest of which is death and injury to people, increased community severance, and environmental impacts. The objective should be to seek an acceptable balance between costs and benefits, so that speed-management policies take account of environmental, economic and social effects as well as the reduction in casualties they may achieve (DFT, 2006).

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Up until the mid-1980s, the approach used for road management tended to put the emphasis on standardized geometric solutions. This led to the adoption of operational principles with the emphasis put on design speeds and quality of service, which was mostly associated with high average speeds, not really adapted to its surrounding environment. In many countries limits were set largely to reflect driver behavior, and it was common practice to establish the speed limit near the 85th percentile speed. Some European countries are using the mean speed of traffic as the basis for the local speed limits (TRB, 1998; Fildes *et al.*, 2005; GRSP, 2008; OECD, 2006). These approaches are increasingly considered as no longer appropriate for today's road environment now that the substantial increases in risk associated with small increments in travel speeds by a majority of road users are better understood. Emerging approaches to speed limit setting include assessing the combined risk of the interaction of the infrastructure, the travel speeds and the volume and mix of traffic and pedestrians. It is recommended that local speed limits be set based on achieving lower than average accident risk (OECD, 2006). Therefore by that time, in many countries in Europe but also in the United States, Canada, and Australia, the emphasis started to shift toward traffic safety and progressively increased its focus on environmental and quality of- life-related issues, particularly in small urban (OECD, 2006).

The balance between safety and level of service is a difficult one to reach: on the one hand, speed limits should be kept to a minimum to reduce the probability of an accident; but on the other hand, this reduces the level of service for people traveling by car, which has motivated a shift in the United States allowing states to raise their speed limits on interstates in rural areas to as high as 75 mi/h (120 km/hr), in some cases causing an increase in accident rates . Moreover, speed limits that differ greatly from drivers’ expectations may introduce a general disregard for posted speed limits, producing contradictory reactions (Correia and Silva, 2011).

Therefore presently integrated approach is used for setting speed limit in which the interests and needs of all the stockholders are considered as a coherent perspective. There is the need to define coherent speed-management strategies that

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can be applied to different traffic environments, serving as reference matrices for the geometric and operational design of road solutions that, while being context-sensitive in each and every segment, will also present adequate consistency and homogeneity throughout the length of each route.

The computer applications NLIMITS, QLIMITS, VLIMITS and USLIMITS are some examples of instruments to support an appropriate legal speed limit in a comprehensive and systematic way. However, these systems were developed based on local specifications; therefore, their scope is limited to Australia and the United States, respectively. On the other hand, the use of these models requires the availability of a wide range of information that is not always available namely in Bangladesh, such as the distribution of actual speeds observed in several sections of the roads and accident data. Moreover, they are limited by the need for a description of different road environments, demanding an a priori classification of each segment, which may be difficult to provide in many cases.

In this context, it is especially important to continue developing more realistic mathematical models that are to support in a logical and scientific perspective the choice of legal speed limit to apply in each context.

12. Setting Speed Limits by Discrete Choice Model

In the above perspective Correia and Silva (2011) proposed a multinomial logit (MNL) discrete choice model for selecting speed limits as an exploratory method for relating measurable roadside characteristics and speed limits over the full length of rural two-lane highways. The model was developed using as a case study 34 km of rural roads in the region of Coimbra (Portugal). The choice of four traffic safety experts was recorded for each 200 m segment, in both directions, permitting the estimation of the MNL. Only straight and nearly straight roadway segments were considered, and speed limitations resulting from restrictive geometric properties of the segments were disregarded in this study. The explanatory variables were collected to describe the built-up characteristics of the different segments of the road and its

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surrounding environment. The model adjusted well to the data; and an external data set was shown to be consistent with the expert judgment. Variables that were added to translate lateral roadside constraints were those with a higher significance in explaining the choice of lower limits.

They also mentioned that this type of analysis should also be useful for other countries, even for those that use more realistic methods for choosing speed limits, for example, the 85th percentile speed (United States) that adjusts better to the drivers' expectations. These methods tend to leave aside the lateral environment and its safety issues, which are considered in the model.

It concluded by the authors, "There is still a need for further development and validation of this model. Specifically, one should aim for identifying other variables that might have the potential to help in determining these appropriate speed limits."

Therefore this model is suitable in developing countries like Bangladesh due to scarcities of data as well as the choice of speed limits is naturally discrete.

13. Multinomial Logit (MNL) Discrete Choice Model

13.1 General

Discrete choice models describe decision makers' choices among a set of alternatives. In order for alternatives to be included in a choice set they must be mutually exclusive, whereby choosing one alternative necessarily implies not choosing any of the other alternatives; the alternatives must be exhaustive where all possible alternatives are considered; the choice set must be finite, in that the alternatives have a maximum number.

Discrete choice models are usually derived based on the theory of stochastic utility whereby a choice is made by a decision maker to maximize the utility function and therefore use random utility theory. In random utility theory it is

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assumed that an individual will derive utility from alternatives. The utility that one derives from alternatives has the highest utility among the alternatives.

The random utility framework starts with a structural model,

U(choice 1) = f_1 (attributes of choice 1, characteristics of the consumer, ε_1),

....

U(choice J) = f_J (attributes of choice J, characteristics of the consumer, ε_J),

Where $\varepsilon_1,...,\varepsilon_J$ denote the random elements of the random utility functions .

As stated in the equation below, the individual will only choose alternative *i*, if and only if the utility he/she derives from this alternative is greater than all the other alternatives in the choice set.

$$U_{in} > U_{ij} \ \forall \ j \neq i \qquad \text{...... (9)}$$

Utility is assumed to be composed of a deterministic component *V*i and a random component ε_i. The deterministic component can be measured, as this component is related to the alternatives in the choice set. The random section cannot be measured, and the most appropriate way to model this component is to assign a distribution to the random element and estimate the probabilities of choice. Therefore, in random utility models the utility expression is outlined in the equation below:

$$U_i = V_i + \varepsilon_i \qquad \text{.......... (10)}$$

As the random component cannot be measured, it is assumed to be set to a probability distribution defined by the model used to analyze the data. As the random component cannot be modeled, the probability that individual *n* will choose alternative *i* can be expressed as in the equation below:

$$P_i = \mathrm{Prob}(U_i > U_j) \ \forall \ j \neq i \qquad \text{........(11)}$$

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Therefore, the probability that the respondent will choose alternative *i* is the probability that the utility of that alternative is greater than any of the other alternatives in the choice set (Ben-Akiva and Lerman, 1985).

The multinomial logit model (MNL) is one of the most widely used discrete choice models. The model is derived under the premise that the error term is identically and independently distributed or Gumbel distributed (Ben-Akiva and Lerman, 1985). This results in the probability of choosing an alternative as expressed in the equation below.

$$\boldsymbol{P_{\mathrm{i}}} = \frac{\boldsymbol{e^{V_i}}}{\sum_{j=1}^{J} \boldsymbol{e^{V_j}}} \qquad \dots\dots\dots\dots(\mathbf{12})$$

Where P_i is the probability that the individual will choose alternative *i*, V_i is the deterministic element of utility for alternative *i* and *J* is the number of alternatives in the choice set.

The estimation of such model is best done by maximum likelihood, using the likelihood function. Assuming the order of observations follow the following sequence, where n_1 individuals (among q individuals) choose alternative 1, and n_2 individuals choose alternative 2 and so on , the likelihood function may be written as in the equation below.

$$\boldsymbol{L} = \prod_{q=1}^{n_1} \boldsymbol{P_{1q}} \prod_{q=n_1+1}^{n_1+n_2} \boldsymbol{P_{2q}}\,, \dots\dots, \quad \prod_{q=Q-n_j+1}^{Q} \boldsymbol{P_{jq}} \quad \dots\dots\dots\dots.(\mathbf{13})$$

The expression above can be simplified by introducing a dummy variable f_{jq}, which is equal to 1 if *j* is chosen and 0 otherwise. Resulting in the simplification of the previous equation to the expression found in the equation below.

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$$\boldsymbol{L} = \prod_{q=1}^{Q} \prod_{j=1}^{J} \boldsymbol{P}_{jq}^{f_{jq}} \qquad \ldots\ldots\ldots\ldots\ldots(\mathbf{14})$$

Given the previous two expressions the log likelihood function may be written as in the equation below.

$$\boldsymbol{L}^{*} = \sum_{q=1}^{Q} \sum_{j=1}^{J} \boldsymbol{f}_{jq \ln P_{jq}} \qquad \ldots\ldots\ldots\ldots(\mathbf{15})$$

In the equation above, the $L*$ is maximized within the utility expression producing utility estimates for the alternatives being examined.

13.2 Correlation among Variables

In statistics, dependence refers to any statistical relationship between two random variables or two sets of data. Correlation refers to any of a broad class of statistical relationships involving dependence. Correlations are useful because they can indicate a predictive relationship that can be exploited in practice. There are several correlation coefficients. The most common of these is the Pearson correlation coefficient, which is sensitive only to a linear relationship between two variables. If we have a series of n measurements of X and Y written as x_i and y_i where i = 1, 2, ..., n, then the sample correlation coefficient can be used to estimate the population Pearson correlation r between X and Y. The sample correlation coefficient is written

$$r_{xy} = \frac{\sum_{i=1}^{n} (x_i - \bar{x})(y_i - \bar{y})}{(n-1)s_x s_y} \qquad \textbf{…………… (16)}$$

where x and y are the sample means of *X* and *Y*, and s_x and s_y are the sample standard deviations of *X* and *Y*.

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The Pearson correlation is +1 in the case of a perfect positive (increasing) linear relationship (correlation), −1 in the case of a perfect decreasing (negative) linear relationship (anti correlation), and some value between −1 and 1 in all other cases, indicating the degree of linear dependence between the variables. As it approaches zero there is less of a relationship (closer to uncorrelated). The closer the coefficient is to either −1 or 1, the stronger the correlation between the variables.

When variables are highly correlated [usually a cutoff 0.8 correlation in absolute value is used as a limit (Hensher, 1994), it is not possible to measure the true effect of each variable on the choice set of multinomial discrete choice model.

13.3 Statistical Significance of the Coefficients

An important element in assessing the performance of an individual coefficient is that the estimated coefficient can be said to be statistically different from zero. Discrete choice models use the t-ratio to determine if the statistic produced is statistically different from zero.

Standard t-tests provide a significance level of rejecting the null hypothesis. The null hypotheses being that coefficients estimated are statistically different from zero. The t-values are placed in brackets next to each estimated coefficient in this thesis. A t-value of < ±2.56 rejects the null hypothesis at the 99% confidence level and value of between ±2.56 and 1.96 is significant at the 95% confidence level.

While values of between ± 1.96 and 1.50 are significant at the 85% confidence level, they are not considered in this thesis, and t-values 1.9 are considered not to be significant. To accept a coefficient with a lower significance can be said to be stretching the usefulness of the estimate.

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13.4 Pseudo-R2 Values

The overall model fit to the data can be measured using the pseudo-R2. It is given by the following expression:

$$\boldsymbol{pseudo\ R^2 = 1 - \frac{L(*)}{L(c)}} \qquad \dots\dots\dots.(\mathbf{17})$$

where L(*) = log likelihood of the estimated model and L(c) = log likelihood of a model with only the alternative specific constants (this is a standard output of any discrete choice model estimation software package). The literature on discrete choice models indicates that a good pseudo-R2 value should be between 0.2 and 0.4 (Louviere *et al*., 2000).

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MATERIALS AND METHODS

Equipment

PC-Computer with CPU speed 2.0 GHz and 1.99 GB of RAMS

Methods

1. Literature Review

Journals and articles on speed, speed management and setting on speed limits have been reviewed to familiarize with the theoretical part. In addition; books and guidelines of different countries were studied. The purpose of literature review was to gain firsthand knowledge on the methods of studies adopted, which could be used as a guideline for this study. The review of past studies would also provide some idea of the techniques of modeling on setting speed limits.

2. Methodology

The methodology of the study described in figure 14. The research study was conducted in following five parts:

1. Reviewing the potential roadside attributes influencing setting speed limits.

2. Collecting roadside characteristics data along the roads under study.

3. Establishing an analytical model for setting appropriate speed limits for the different segments of rural two-lane highways on the basis roadside characteristics.

4. Verifying the validation of the model with external data set.

5. Evaluating/determining the suitable speed limits for road segments.

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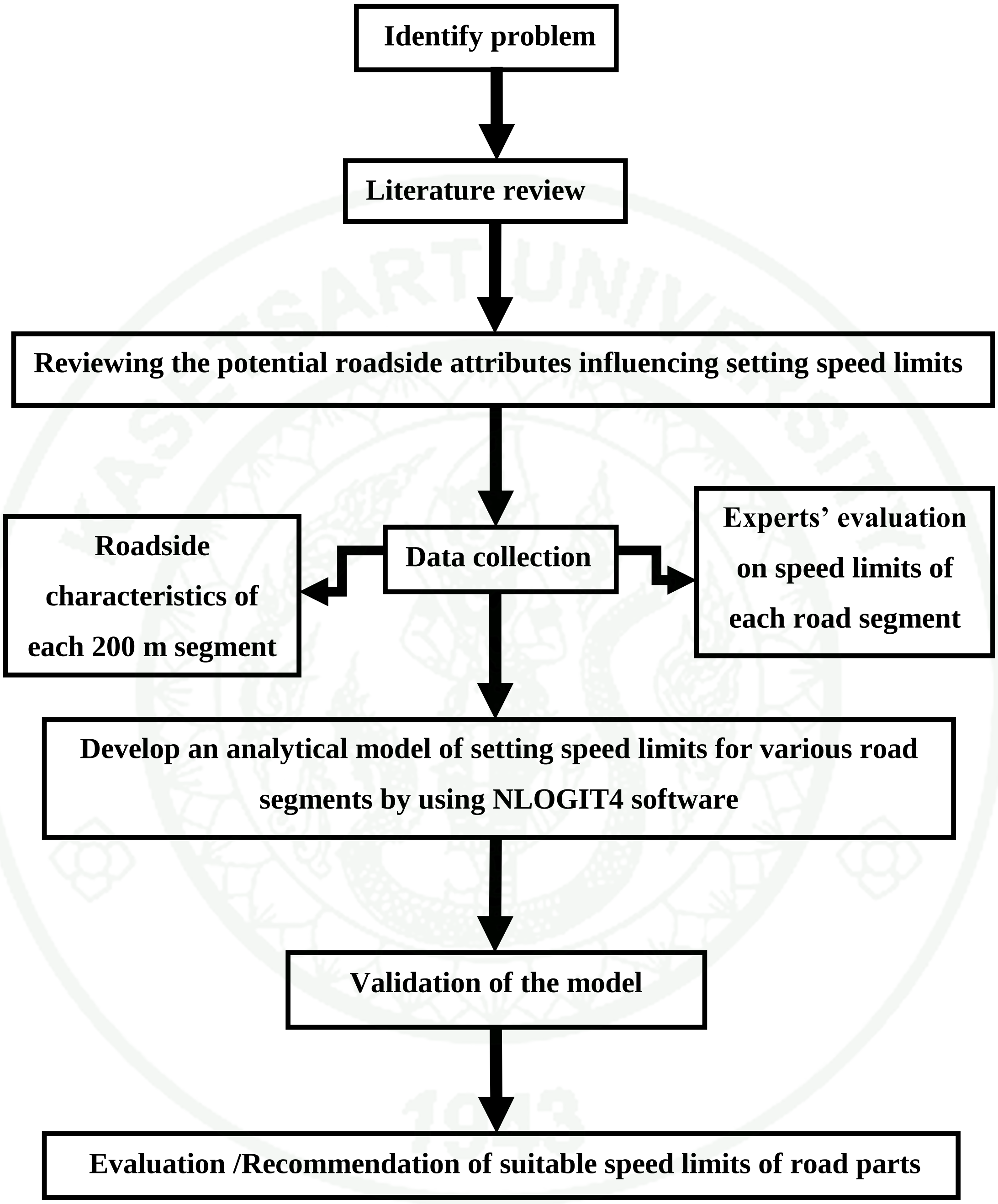

Figure 14 Flow chart of research approach

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3. Potential Roadside Attributes

From literature review it has been familiarized that many attributes characterizing the road and its environment have significant influence on setting speed limits. In this regard, the most suitable variables for determining speed limits on the study area were identified by field survey. The potential attributes are described below.

3.1 Side Roads

Both the study roads have side roads with a very short distance (less than 200 m). These roads are shown either one side or both sides of the pavement. Traffics enter from these roads to main highways laterally. Thus side roads have a negative impact on setting speed limits. In figure 15 pictures of side roads are given.

Figure 15 Side roads in the study areas

3.2 Commercially Developed Areas

In Bangladesh most of markets or bazaars (highway hazards) are situated very near or along the highways. Several commercially developed areas such as markets, buildings, bazaar areas along the road sides were identified in the study areas. These areas are distinguished as two types namely, highly commercially

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development area and medium commercially development area. Highly commercially development or lateral restriction area (HLA) is situated right next to the highway and the obstacles of this area are closely spaced. Medium commercially development or lateral restriction area (MLA) has a reserve space separating the obstacles from the roadway and they are not so closely spaced. In figure 16 scenarios of commercially development areas are shown

Medium Commercially Development Area **Highly Commercially Development Area**

Figure 16 Commercially developed areas in the study area N6

3.3 Build up Areas

Buildup area means the presence of school, college, factory, worship place, shops etc. at the roadside. Almost all the roads in Bangladesh have such types of structures. In figure 17, an industry in the study area of road no.N5 is shown.

Figure 17 Picture of a roadside industry, trees, electric poles in the study area N6

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3.4 Tall Objects at Roadsides

Injury crashes happen if vehicle struck with roadside tall objects such as electric poles, trees. All of these objects mainly trees are common along the road sides in Bangladesh. In figure 17 electric poles and trees are shown at roadside.

3.5 Bridges and Culverts

Particularly narrow bridges and culverts appear to pose a significant safety problem on rural roads. Bangladesh is a low lying and a flood prone country. Thus many bridge and culverts are remained along the roads. A bridge picture on the study area N5 is given in figure 18.

Figure 18 A bridge on the national highway N6

3.6 Bus Stops

Bus stops along the roadsides have a negative effect on speeding. Most of the bus stoppages are shown either very nearer to the pavement or along the road edge. Due to passengers safety it is necessary to down the speed near the bus stops. A roadside bus stop in the study area is shown in figure 19.

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Figure 19 A roadside bus stops at road no.N5

3.7 Curvature

The literature identified vertical curvature (raised section) and horizontal curvature (bends and curves) as a risk factor for crashes on rural roads. The roads of Bangladesh often pass through these types of curvature. The curvature associate problems with sight distance. Sharp curves on the study roads are shown in figure 20.

Figure 20 Sharp curves on the study roads

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3.8 Speed Reducing Structures

Speed reducing structures such as speed humps and rumble strips are observed on the study roads. These structures are found near bazaar area, buildup area and intersection. Pictures of the speed reducing structures on the study road N5 are given in figure 21.

Figure 21 Speed reducing structures on N5

3.9 Roadside Ditches

Injury crashes occur when a vehicle runs into a ditch. As Bangladesh is a flood prone country most of the roads are build on artificial embankment. Thus ditches are present at frequently along the roadside. Two types of ditches are found namely, shallow ditches and deep ditches. In this study the depth of ditches up to 1.5 m considered as shallow ditches otherwise as deep ditches. Roadside ditches in the study areas are shown in figure 22.

3.10 Access Paths

It is common at roadside in Bangladesh the presence of access paths. There are two types access paths are found such as pedestrian access path and access path to nearby buildings. For ensure safety to the pedestrian it is justify reducing speed near the access paths. The access paths are shown in figure 23.

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Figure 22 Roadside ditches in the study area

Figure 23 Access paths in the study section N5

3.11 Intersections

Rural intersections are dangerous locations, particularly at-grade intersections. As at these locations, conflicts occur at high impact angles, often at high speeds and result in high injury severity. Roundabout and t-junction intersections are found in the study area. A t-junction intersection on N5 is shown in figure 24.

3.12 Parking Spaces

Two types of parking spaces are found in the study area such as on road parking spaces and off road parking spaces. In the study area most of the vehicles are

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Figure 24 An intersection on N5

found parking on the on road parking spaces. Thus parking spaces have negative impact on speed as they create traffic jams. A picture of parking space is given in figure 25.

Figure 25 On road parking spaces along the study portion of N5

3.13 Filling Stations

Filling stations are found on roadsides. As vehicles enter and exit from the filling stations, it is justify reducing vehicle speed near filling stations. In figure 26 a roadside filling station in the study area N5 is shown.

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Figure 26 A roadside filling station in the study area N6

3.14 Earthen Shoulder

Paved shoulder is found all along the study area. But proper earthen shoulder is not recognized along the study roads. Adequate designed earthen shoulder is very much essential for setting speed limits. In figure 27 the inadequate earthen shoulder is shown at pavement side.

Figure 27 Inadequate earthen shoulder in the study portion of N5

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3.15 Non-motorized Lanes

Non-motorized lanes at some portions of the study road have been shown. These lanes are provided both sides of the pavement, mainly at highly commercially development areas. It has positive impact on choosing speed. A non motorized lane in the study section on N6 is shown in figure 28.

Figure 28 Non motorized lanes at study road N6

4. Data Collection

A Multinomial discrete choice model was applied to a sample of data collected in along 40 km of two different national two-way highways (20 km from each road). These routes were divided into a number of segments of equal length of 200 meter. It was considered that 200 m would be an adequate length for the segments, since it is long enough to present intrinsic and observable characteristics and short enough for those characteristics to be relatively homogeneous. Note that the 200 m constitutes the interval for collecting data, not posting speed limits.

For each segment, a detail physical evaluation of the roadside environment was done. The attributes values were collected through direct observation from inside a slow-moving vehicle. This task involved two operators, one for driving the vehicle

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and the other for registering the data associated with each variable. In the situations in which this method could not be applied, the alternative was to walk and examine in detail all the elements that might or might not match the chosen variables.

Further an evaluation for each segment was done by 10 (ten) traffic or transportation experts (professional experts from Bangladesh, having ten to thirty years experience on road design and safety, **Appendix G**) on the correspondingly appropriate speed limits from a choice of three options: **40, 60, and 80** km/hr. According to traffic experts in Bangladesh, the lowest speed (40 km/hr) is the typical speed for highly hazardous locations such as bazaar area. The highest speed limit for two-lane highways is 80 km/hr (FINNROAD, 2005). Thus 40 km/hr is the lowest and 80 km/hr is the highest speed limits in two-lane highways for Bangladesh. The aims of selecting intermediate speed limit (60 km/hr) was to establish more realistic speed limit at which drivers feel they can safely drive in each road segment. The questionnaire or evaluation sheet for the experts is attached in **Appendix A**. In this evaluation sheet there are total 200 nos. segments and the obstacles or road side characteristics of each 200 meter segment are listed. The experts' chose most suitable speed limit from the three choices that might be applied in each segment by examining the listed road side characteristics.

5. Variables for Model

From previous literatures, attributes characterize the road side environments and also influence speeds were identified. In the literature review chapter the list are given. The potential roadsides attributes of the study area are described earlier. The attributes recognized from literature were compared with the study area. Thus 31 variables were considered most important for determining speed limits in the study roads. Table 3 shows the final list of variables used for the model specification. In this table also the model name, data type of the variables also described. These 31 variables were independent variables in the model. The dependent variable was CHOICE. The values of choice variable are 0, 1 and 2. 0 value for 80 km/hr as it is highest and reference speed limit and 1 and 2 for 60 km /hr and 40 km/hr respectively.

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Table 3 Variables names, types and model name

No.	Name of Variables	Model Name	Data Type
1	Side roads (Both sides)	SRB	Discrete (Value between 0 and 2)
2	Side roads (One side)	SRS	Discrete (Value between 0 and 2)
3	Medium commercially development area	MLA	Binary (1 if present; 0 otherwise)
4	Highly commercially development area	HLA	Binary (1 if present; 0 otherwise)
5	Build up area	BUILDAR	Binary (1 if present; 0 otherwise)
6	Trees at roadsides	TREE	Binary (1 if present; 0 otherwise)
7	Presence of bridges	BRIDG	Discrete (Value between 0 and 200m)
8	Presence of culverts	CULVER	Discrete (Value between 0 and 2)
9	Bus stops (Both sides)	BUSB	Binary (1 if present; 0 otherwise)
10	Bus stops (one side)	BUSS	Binary (1 if present; 0 otherwise)
11	Grade at road alignment	GRADE	Binary (1 if present; 0 otherwise)
12	Curvature at road alignment	CURVE	Binary (1 if present; 0 otherwise)
13	Speed humps	HUMP	Discrete (Value between 0 and 2)

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Table 3 (Continued)

No.	Name of Variables	Model Name	Data Type
14	Rumble strips	RUMBLE	Binary (1 if present; 0 otherwise)
15	Roadside shallow ditches (Both sides)	SDITCHB	Binary (1 if present; 0 otherwise)
16	Roadside shallow ditches (One side)	SDITCHS	Binary (1 if present; 0 otherwise)
17	Roadside deep ditches (Both sides)	DDITCHB	Binary (1 if present; 0 otherwise)
18	Roadside deep ditches (Both sides)	DDITCHS	Binary (1 if present; 0 otherwise)
19	Access path to nearby buildings (Both sides)	PATHBB	Binary (1 if present; 0 otherwise)
20	Access path to nearby buildings (one side)	PATHBS	Binary (1 if present; 0 otherwise)
21	Intersection	INTER	Binary (1 if present; 0 otherwise)
22	Pedestrian access path	PATHP	Discrete (Value between 0 and 2)
23	On road parking spaces (Both sides)	ONPARKB	Binary (1 if present; 0 otherwise)
24	On road parking spaces (One side)	ONPARKS	Binary (1 if present; 0 otherwise)
25	Off road parking spaces (Both sides)	OFPARKB	Binary (1 if present; 0 otherwise)
26	Off road parking spaces (One side)	OFPARKS	Binary (1 if present; 0 otherwise)

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Table 3 (Continued)

No.	Name of Variables	Model Name	Data Type
27	Filling station (Both sides)	FSB	Discrete (Value between 0 and 2)
28	Filling station (One side)	FSS	Discrete (Value between 0 and 2)
29	Inadequate earthen shoulder (Both sides)	EARTSB	Binary (1 if present; 0 otherwise)
30	Inadequate earthen shoulder (one side)	EARTHS	Binary (1 if present; 0 otherwise)
31	Presence of non motorized lane	NONML	Binary (1 if present; 0 otherwise)

6. Nlogit4 Software

Figure 29 Starting picture of NLOGIT 4 program

NLOGIT4 is a major suite of programs for the estimation of discrete choice models. A major feature of NLOGIT4 is the simulation package. With this program, one can use any model that one have estimated to do ‘what if’ sorts of simulations to examine the effects on predicted behavior of changes in the attributes of choices in his

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model. NLOGIT Version 4.0 is the result of an ongoing (since 1985) collaboration of William Greene (Econometric Software, Inc.) and David Hensher (Econometric Software, Inc., Australia). With Nlogit4 one can analyze the models such as binary choice models, ordered choice models, multinomial logit choice models, conditional logit models, nested logit models, probit models etc. Figure 29 and 30 shows the picture and screenshot of Nlogit4 software respectively.

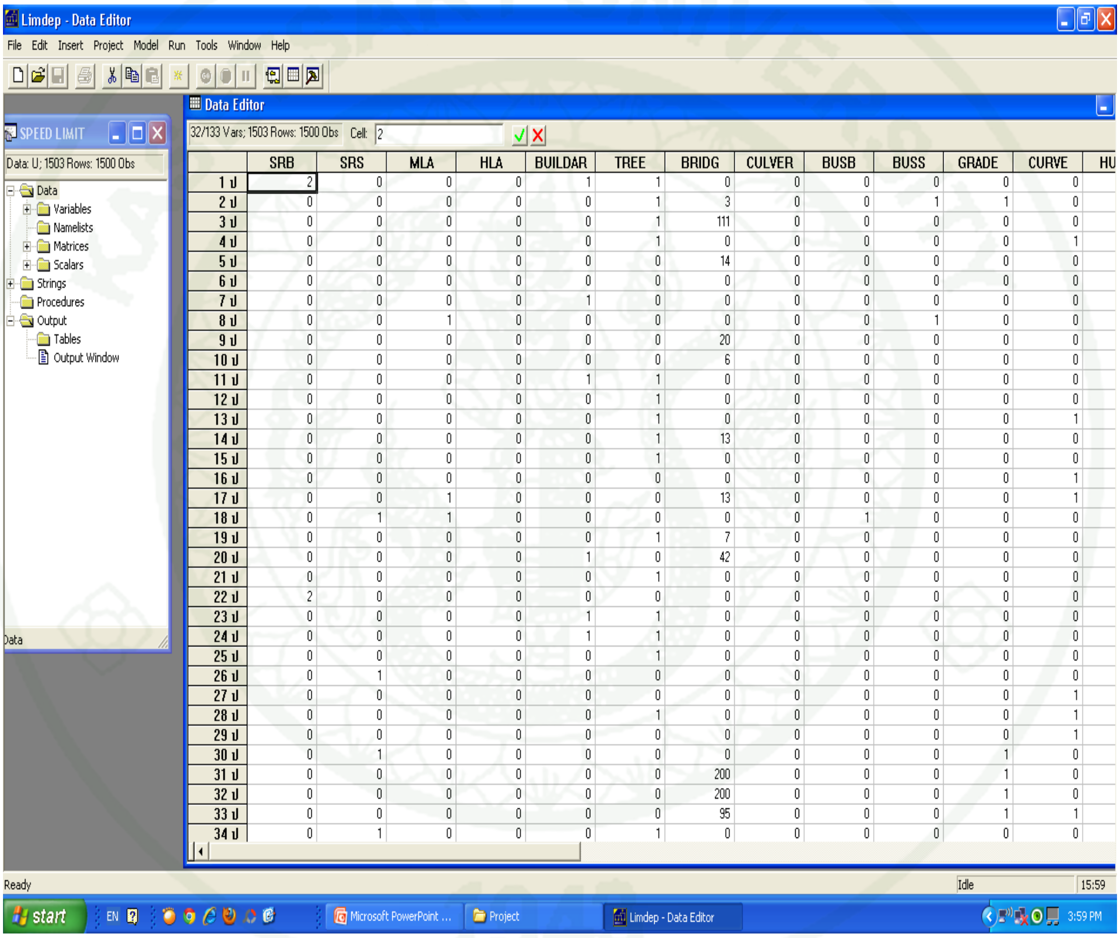

Figure 30 Screenshot of NLOGIT 4 program

7. Model Buildup

In literature review it is mentioned that discrete choice models describe decision makers' choices among a set of alternatives. Discrete choice models are usually derived under the premise of a utility maximizing consumer and therefore use

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random utility theory. In random utility theory it is assumed that an individual will derive utility from alternatives. The decision maker chooses the alternative with the highest utility (equation 9). Utility is assumed to be composed of a deterministic component *Vi* and a random component ε_i (equation 10). The random component is assumed to be set to a probability distribution defined by the model used to analyze the data (equation 11). The choice probability depends only on the difference in utility and not its absolute level. The fact that only differences in utility matter has implications for the identification of discrete choice models. If a constant is added to the utility of all alternatives, then the alternative with the highest utility does not change. Thus a constant is added to the deterministic part of utility.

$$\boldsymbol{V_i = \beta_i + \sum_{k=1}^{j} \beta_{k_i} x_k} \qquad \ldots\ldots(\mathbf{18})$$

Where β_i is a constant specific to alternative *i*, x_k is a explanatory variable, β_{ki} is a coefficient of the explanatory variable x_k for the alternative i and j is the number of explanatory variables.

This constant captures the average effect on utility of all factors that are not included in the model. When alternative-specific constants (ASC) are included in the model, ε_i has zero mean by construction. However, since only differences in utility matter, only differences in alternative-specific constants matter (Ben-Akiva and Lerman, 1985).

In this study, speed limit was determined by multinomial logit (MNL) discrete choice model. The model is derived under the premise that the error term is logistically distributed. The probability of choosing an alternative in the MNL discrete choice model is described in equation 12.

In this model all variables do not vary between alternatives. Only differences in utility matter influence the choice. Thus a reference alternative (utility = 0) has to be defined, with which the other alternatives are compared. In this study, the reference

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alternative was chosen to be 80 km/h because it is the maximum appropriate speed limits for a rural two-lane highway in Bangladesh. Hence, the coefficients of attributes would aim to indicate why in some segments the maximum speed limit cannot be applied, trying to identify highly significant factors that necessitate reduction.

The systematic or deterministic part of the utility expressions for the MNL discrete choice model in this study is thus defined as follows:

$$\boldsymbol{V\left(40\frac{km}{h}\right) = \beta_{40\frac{km}{h}} + \sum_{k=1}^{k_{40\frac{km}{h}}} \beta_{k_{40\frac{km}{h}}} x_k} \quad \ldots \ldots (\mathbf{19})$$

$$\boldsymbol{V\left(60\frac{km}{h}\right) = \beta_{60\frac{km}{h}} + \sum_{k=1}^{k_{60\frac{km}{h}}} \beta_{k_{60\frac{km}{h}}} x_k} \quad \ldots \ldots \ldots (\mathbf{20})$$

$$\boldsymbol{V(80\ km/h) = 0} \qquad \textbf{(Reference alternative) … (21)}$$

where

k = number of significant variables in each utility function

$\boldsymbol{\beta_{k_{40\frac{km}{h}}}}$= Independent coefficient of each variable (x_k) for the utility 40 km/hr

$\boldsymbol{\beta_{k_{60\frac{km}{h}}}}$= Independent coefficient of each variable (x_k) for the utility 60 km/hr

$\boldsymbol{\beta_{40\frac{km}{h}}}$ = Alternative specific constant (ASC) for the utility 40 km/hr

$\boldsymbol{\beta_{60\frac{km}{h}}}$ = Alternative specific constant (ASC) for the utility 60 km/hr

8. Model Calibration

One important analysis, which should always be part of the estimation of discrete choice models, is an analysis of the correlation (equation 16) among the variables. When they are highly correlated [usually a cutoff 0.8 correlation in absolute value is used as a limit (Hensher, 1994)], one cannot measure the true effect of each variable on the choice that is being studied. Thus, it is not possible to measure their importance in the model. The correlations were computed for all variables using Nlogit4 software (Econometric Software Inc.).

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The MNL model was calibrated through maximum likelihood estimation (equation 15) using the software Nlogit4. From each road 15 km was selected for Model calibration. The locations of roads for model calibration are given in table 4.

Table 4 Location of roads segments for model calibration

Road No.	**Location**	**Length km**	**No. of Segments**
N5	Chainage 42+000 to Chainage 55+000	13	65
N5	Chainage 60+000 to Chainage 62+000	2	10
N6	Chainage 111+000 to Chainage 126+000	15	75
Total		**30**	**150**

The utility expressions of the model are described in equation 19, 20 and 21. An independent coefficient (β_k) was calibrated for each variable (x_k) in the two utility specifications (40 km/hr and 60 km/hr), as also an alternative specific constant (ASC) was calibrated for each alternative to capture the weight of other factors not translated in the attributes ($\beta_{40km/h}$ *and* $\beta_{60km/h}$).

Thus the number of statistical cases corresponds to 150 segments ×10 experts=1500 cases. According to correlation analysis the suitable variables were selected for model. Also the variables with significance lower than a 5% level were gradually taken out of the model to increase its robustness. First, the variable with most lowest significant would be discard from the model and so on. The overall model fit to the data was measured using the pseudo-R^2 (equation 17). Thus the process of include or exclude the variables in the model would continue until all the variables are found statistically significant and also the value of pseudo-R^2 of the model remain within the range 0.2 to 0.4.

Therefore the final output of the model shows the significant variables that would remain in the final specification with their corresponding coefficients, values and significances for the utility functions of 40 km/hr and 60 km/hr speed limits.

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9. Model Validation

Another 5 Km of each road was selected to verify the model validation. The locations of roads for model validation are given in table 5.

Table 5 Location of roads segments for model validation

Road No.	Location	Length km	No. of Segments
N5	Chainage 55+000 to Chainage 60+000	5	25
N6	Chainage 126+000 to Chainage 131+000	5	25
Total		**10**	**50**

For each 200 m segment, the choices of the same experts on the appropriate speed limits were compared with the model results. This comparison was not be a straightforward one, given that the model produces probabilities of choosing a certain speed limit, and the empirical data available is a speed limit selected by each expert for each 200 m segment. The way of comparing the results were chosen from the model the speed limit with the highest probability of being the predicted one and then to compare this speed limit with the frequency of answers of the experts for this specific predicted speed limit (0% indicates that no expert selected this speed limit and 100% means all ten experts chose that). Finally the average of the frequency would be determined. If this value will more than 50 than it would be called that the model is quite good (Correia and Silva, 2011).

10. Determination and Evaluation of Speed Limits

If the model found statistically significant, important conclusions would be made based on the model output. Also the speed limits of various types of road attributes were determined from the model result.

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Putting the coefficient values (β) of the significant variables found from the model in the utility expression (equation 19, 20, 21), the utility of choices (40, 60, 80 km/hr speed limit) of each 200 m segment was determined. The probability of the choices was determined using the equation no. 12. The choice with the highest probability is the selected speed limit of that segment.

From this model the probability of speed limit of the 200 meter road segment is found. But practically it is not justified for setting speed limit for 200 meter length. These are usually set for at least 600 m length (DFT, 2006). Also speed limits are usually set for a suitable length of nearly same roadside characteristics. Thus a suitable length of nearly same roadside characteristics was identified for setting speed limits. For this purpose the probability of speed limits of all three choices of each segment were determined by using the model. Then probability of speed limits *i* for a road length has been determined by the following equation (Ben- Akiva and Larman, 1985).

$$\boldsymbol{P_l(i) = 1/N \sum_{1}^{N} \left(P_n(i)\right)} \qquad \ldots\ldots\ldots\ldots(\mathbf{22})$$

Where, N = no. of 200 m road segments within the road length l

$P_l(i)$ = probability of speed limit i for the road length l

$P_n(i)$ = probability of speed limit i for the n^{th} segment

Using the above equation the probability of each choice of speed limit was calculated. Thus the choice with highest average probability would be selected speed limits of that road length.

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RESULTS AND DISCUSSION

1. Correlation among Variables

The correlation matrix of the listed variables is attached in **Appendix B**. The correlations have shown consistently low values in absolute value. The highest correlation is equal to 0.67281 between non motorized lane (NONML) and highly commercially development area (HLA). This is realistic because all non motorized lanes are present in the highly commercial development areas. The lowest correlation (0.00111) has found between speed hump (HUMP) and bridge (BRIDG).Thus the absolute values of correlations are less than 0.8. Given this result, it was decided not to exclude any of the variables based on their correlations from the model.

2. Calibration of the Coefficients

It has been mentioned that the total statistical cases were 1500 and there were selected variables 31 for model calibration. The model was calibrated by multinomial logit (MNL) discrete choice model using Nlogit4 (Econometric Software Inc.) software. First all 31 independent variables were used for model calibration. From first step it was shown that the ASC and some variables were not statistically significant. Thus the variables with significance lower than a 5% level were gradually (step by step) taken out of the model to increase its robustness. The final model was set after 17 steps. In **Appendix C** the result of all steps of model calibration is attached. Finally in the model 16 and 17 variables are remained for the utility of 60km/hr and 40 km/hr respectively. The variables that remained in the final specification can be seen in table 6 and table 7 with their corresponding coefficients, values and significances.

The overall model fit to the data can be measured using the pseudo-R^2 (equation 17). This index reached the value of 0.32179. The literature on discrete

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choice models indicates that a good pseudo-R^2.should be between 0.2 and 0.4 (Louviere *et al.*, 2000). Therefore the index value is fairly good.

Table 6 Calibrated coefficients of 60 km/hr utility for the MNL model

Variable	**Coefficient, β**	**Error**	**b/St.Er.**	**P[∣Z∣ >z]**
ASC	-1.29070623	0 .14765655	-8.741	0.0000
SRB	1.34112189	0.35640833	3.763	0.0002
SRS	1.69576038	0.22615938	7.498	0.0000
MLA	3.11368390	0.83323600	3.737	0.0002
HLA	Non Significant thus not consider			
BUILDAR	2.11979479	0.33264085	6.373	0.0000
BRIDG	0.01681031	0.00397105	4.233	0.0000
BUSB	2.10468300	1.07173219	1.964	0.0496
CURVE	2.17629549	0.22929986	9.491	0.0000
HUMP	2.30341840	0.79493480	2.898	0.0038
RUMBLE	2.05102099	0.53037377	3.867	0.0001
SDITCHB	1.21813057	0.22924842	5.314	0.0000
SDITCHS	0.68565600	0.32095919	2.136	0.0327
DDITCHB	2.42113342	0.62242713	3.890	0.0001
DDITCHS	1.22271730	0.32770521	3.731	0.0002
PATHBB	1.19022710	0.48161075	2.471	0.0135
PATHP	1.16814609	0.34182304	3.417	0.0006
ONPARKS	Non Significant thus non consider			
FSS	2.56006724	0.59171317	4.327	0.0000

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Table 7 Calibrated coefficients of 40 km/hr utility for the MNL model

Variable	Coefficient, β	Error	b/St.Er.	P[∣Z∣ >z]
ASC	-2.58445014	0.19039169	-13.574	0.0000
SRB	1.47324300	0.36979128	3.984	0.0001
SRS	2.19205079	0.24824610	8.830	0.0000
MLA	4.48014065	0.83468627	5.367	0.0000
HLA	5.52119132	1.37590957	4.013	0.0001
BUILDAR	2.52551552	0.35529609	7.108	0.0000
BRIDG	0.02021913	0.00417421	4.844	0.0000
BUSB	3.13055392	1.07049534	2.924	0.0035
CURVE	2.58171009	0.25227924	10.234	0.0000
HUMP	5.29341065	0.76552923	6.915	0.0000
RUMBLE	3.04056178	0.53767449	5.655	0.0000
SDITCHB	1.36597912	0.28383438	4.813	0.0000
SDITCHS		Non Significant thus not consider		
DDITCHB	2.56231134	0.66309180	3.864	0.0001
DDITCHS	1.11940969	0.36446052	3.071	0.0021
PATHBB	1.53339054	0.50972473	3.008	0.0026
PATHP	1.58569690	0.36170732	4.384	0.0000
ONPARKS	3.89085339	1.88870695	2.060	0.0394
FSS	2.65681371	.62203183	4.271	0.0000

It is expected from the model that the coefficients of the variables of the utility of 40 km/hr have higher value than that of the 60 km/hr. These results are caused by the decision to use 80 km/hr as the reference; it is predictable that the increase of the explanatory variables is translated to higher differences between the lowest speed-limit alternative (40 km/hr) and the reference speed limit.

This effect is immediately noticeable in the values of the alternative specific constants (ASC in Table 6 and 7). The values of the two coefficients of the alternative

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specific constants are negative, with ASC of 40 km/hr having a very high negative impact because 80 km/hr is the maximum allowable speed on rural two lane highways. For example, the presence of side road at one side or both sides (SRS and SRB) increases the utility of choosing lower limits compared with the 80 km/hr maximum speed limit on rural two-lane highways. Also comparing coefficients for the same variables in both utility functions, it is observed that they are higher for the 40 km/hr speed limit, an outcome that agrees with expectations. This tendency happens in general for all variables represented in both functions.

3. Model Validation Result

The calculation of the model validation with external data set of 50 segments is shown in **Appendix D**. If the model was perfect, for every predicted speed limit one would get 100% of the experts choosing that option and the average of this frequency over all the 200 m segments would be 100%.

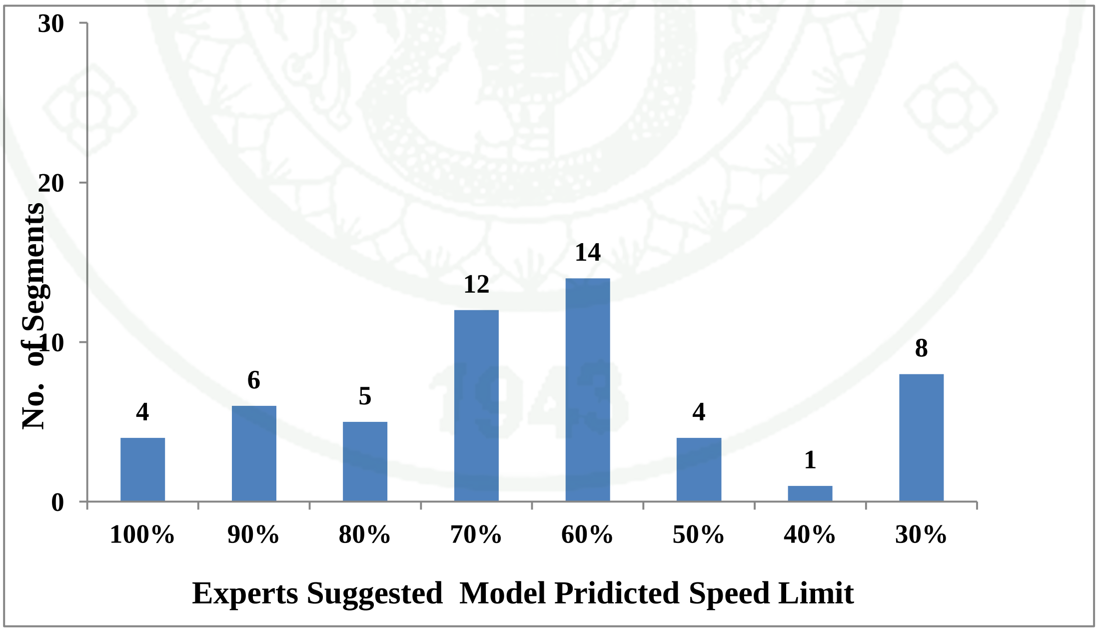

Figure 31 Percentage of segments that suggested by experts same as model predicted Speed Limit

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Using the available data 4 of the 50 segments registered a 100% value, meaning that the ten experts suggested speed limits exactly the same as predicted by the model; 6 registered a 90% value; 5 segments corresponded to 80%; 12 segments corresponded to 70%; 14 segments registered to 60%; 4 segments to 50%; 1 segments corresponded to 40%; and 4 to 30%. Figure 31 shows the number of segments that suggested by experts corresponding to the model predicted speed limit.

The average of this frequency is 67.6%, say 68%. As the value of the average frequency is more than 50%, it is concluded that there is a fairly good consistency and accuracy of the model in predicting the expert judgment.

4. Discussion on Model Outcome

As the model is found statistically significant, the outcome of it supports some important conclusions regarding the variables. The following conclusions are made if each variable is present alone in the roadside. The detail calculations for effective coefficient values of significant variables are attached in **Appendix E**. The effective value of coefficients was found by adding the variable's corresponding coefficient with alternate specific constant (ASC) of the utilities. The effective coefficient for the variables of the utility 80 km/hr is zero as it is a reference alternative.

The presence of one side road (SRS); buildup area (BUILDAR); curvature (CURVE); and deep ditches at both sides of road (DDITCHB) has positive coefficients for 60 km/hr. It indicates when they present speed reduced is justified.

Similarly presence of highly commercially developed area (HLA); and on road parking spaces (ONPARKS) has highly positive coefficients for 40 km/hr. It indicates if they present lowest speed limit is reasonable.

Also it is distinguished that the presence of double side roads (SRB & SRS); bus stops at both sides (BUSB); rumble strips (RUMBLE); double pedestrian access

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path (PATHP); and filling station (FSS) has positive coefficients for both the utilities (40km/hr and 60 km/hr). But these variables are more significant for 60 km/hr.

Again the existence of medium commercially developed area (MLA); and speed hump (HUMP) has positive coefficient for both utilities but they are more highly significant for 40 km/hr.

In addition the Bridge (BRIDG) length less than 77 m, there is no positive coefficient for the both choices of 60 km/hr and 40 km/hr. But the length more than 128 m has positive coefficient for both the utilities. But the bridge length up to 200m has more positive value for 60 km/hr.

Table 8 Suitable speed limits for significant variables

Variable	**Speed Limit (km/hr)**	**Variable**	**Speed Limit (km/hr)**
SRS	60	HLA	40
SRB	60	MLA	40
BUILDAR	60	HUMP	40
CURVE	60	ONPARKS	40
DDITCHB	60	BRIDG<77m	80
BUSB	60	DDITCHS	80
RUMBLE	60	SDITCHB	80
PATHP(Double))	60	SDITCHS	80
FSS	60	PATHP(Single)	80
BRIDG(77-200 m)	60	PATHBB	80

Moreover there are no positive coefficient for the utilities of deep ditches at one side (DDITCHS); shallow ditches (SDITCHB &SDITCHS); access path to nearby buildings (PATHBB); and single pedestrian access path (PATHP). It indicates

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when these variables present alone there is no need to decrease speed. But where the variables are shown with other utilities may need to decrease speed.

From above discussion the suitable speed limits for the variables are given in table 8. The detail calculation of speed limit of the significant variables is shown in **Appendix E**. The mentioned speed limits in the table are applicable only if the variables are present alone. If two or more variables are present in a segments than the speed limit of that segment may be different.

5. Determination and Discussion on Speed Limits

Using equation no. 19, 20 and 21 as well as the values of the coefficient of the significant variables of table 6 and 7 the utility of three choices each 200 m segment was determined. Also the probability of three choices (80, 60, 40 km/hr) of each segment was determined by using equation no 12. The utility with highest probability is the preferred speed limit of that segment. The speed limits at suitable length (at least 600 meter) of nearly same road sites characteristics have been determined using equation no. 22. Thus in **Appendix F** the speed limit of each 200 m segment and the corresponding posted speed limit are mentioned.

Table 9 shows the summary of the chosen speed limits of road segments. The percentage of segments with respect to chosen speed limits is depicted in figure 32. From this figure the following observations are made.

Table 9 Summary of road segments with respect to selected speed limits

Speed Limits	Nos. of 200 m segments for selected speed limits		
	N5	N6	Total
40 km/hr	34	28	62
60 km/hr	50	45	95
80 km/hr	16	27	43

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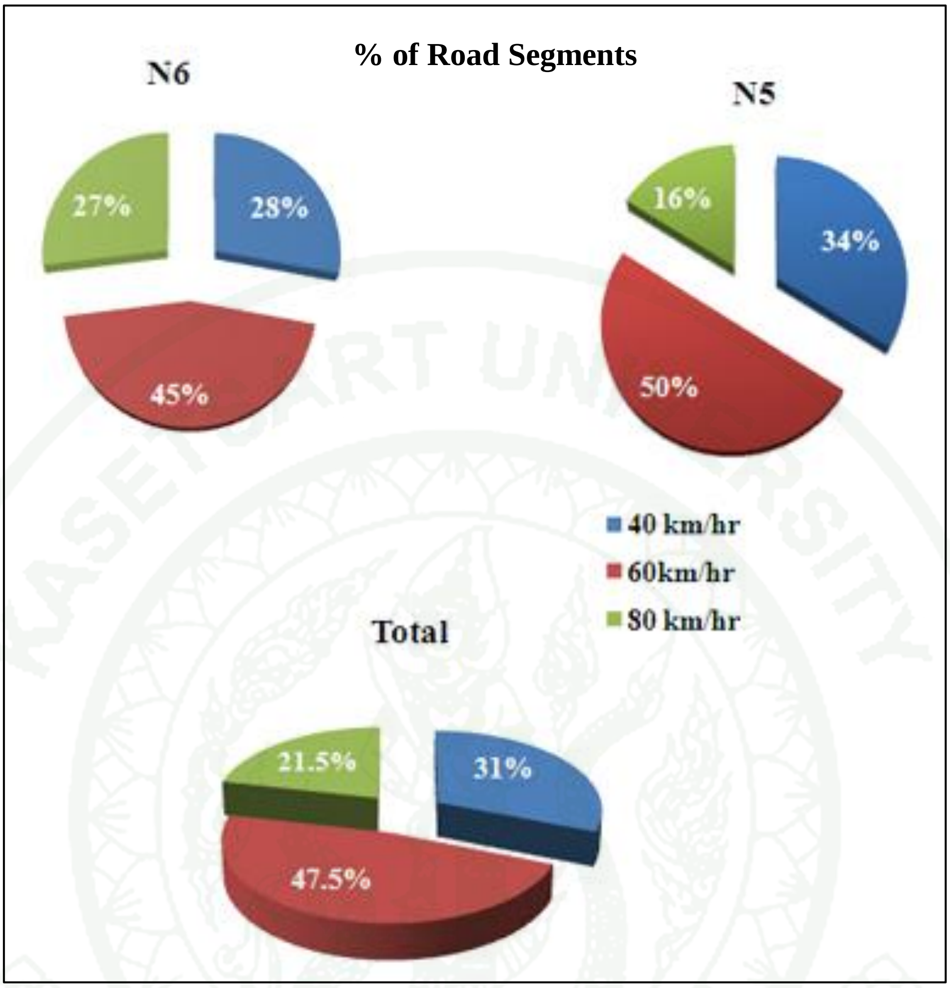

Figure 32 Percentage of 200 m road segments with respect to chosen speed limits

In the study area of N5, 34%, 50% and 16% road segments are appropriate for setting speed limit 40, 60 and 80 km/hr respectively. Whereas in N6, 28%, 45% and 27% segments are suitable for speed limit 40, 60 and 80 km/hr respectively. Thus in average 31%, 47.5% and 21.5% segments are appropriate for setting speed limit 40, 60 and 80 km/hr respectively. Therefore, 84% and 73% segments of road no. N5 and N6 respectively are not suitable for applying maximum speed limit of 80 km/hr. In average 78.5% road segments are not appropriate for setting highest speed limit.

The detail locations of posted speed limits (as described in **Appendix F**) for the studied sections of both roads are mentioned in table 10 and 11.

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Table 10 Detail location of posted speed limits at road no. N5

Chainage	Length (m)	Speed Limit (km/hr)	Chainage	Length	Speed Limit (Km/hr)
42+000 - 42+600	600	40	52+200 - 54+200	2000	60
42+600 - 43+400	800	60	54+200 - 55+000	800	40
43+400 – 44+200	800	40	55+000- 56+800	1800	60
44+200 - 45+000	800	80	56+800 - 57+400	600	80
45+000- 46+000	1000	40	57+400- 58+600	1200	60
46+000 - 48+400	2400	60	58+600 - 59+200	600	40
48+400 - 49+400	1000	40	59+200 - 61+200	2000	60
49+400 - 50+000	600	60	61+200 - 62+000	800	40
50+000 - 52+200	2200	40			

Table 11 Detail location of posted speed limits at road no. N6

Chainage	Length (m)	Speed Limit (km/hr)	Chainage	Length	Speed Limit (Km/hr)
111+000 - 111+800	800	40	120+800 -122+000	1200	60
111+800 - 112+800	1000	80	122+00 - 123+600	1600	80
112+800 - 114+000	1200	40	123+600 -124+200	600	40
114+000 - 114+600	600	80	124+200 -126+400	2200	60
114+600 - 116+600	2000	60	126+400 -127+000	600	40
116+600 - 117+600	1000	40	127+000 -128+200	1200	60
117+600 - 118+400	800	60	128+200 -129+400	1200	40
118+400 - 120+000	1600	40	129+400 -131+000	1600	60
120+000 - 120+800	800	80			

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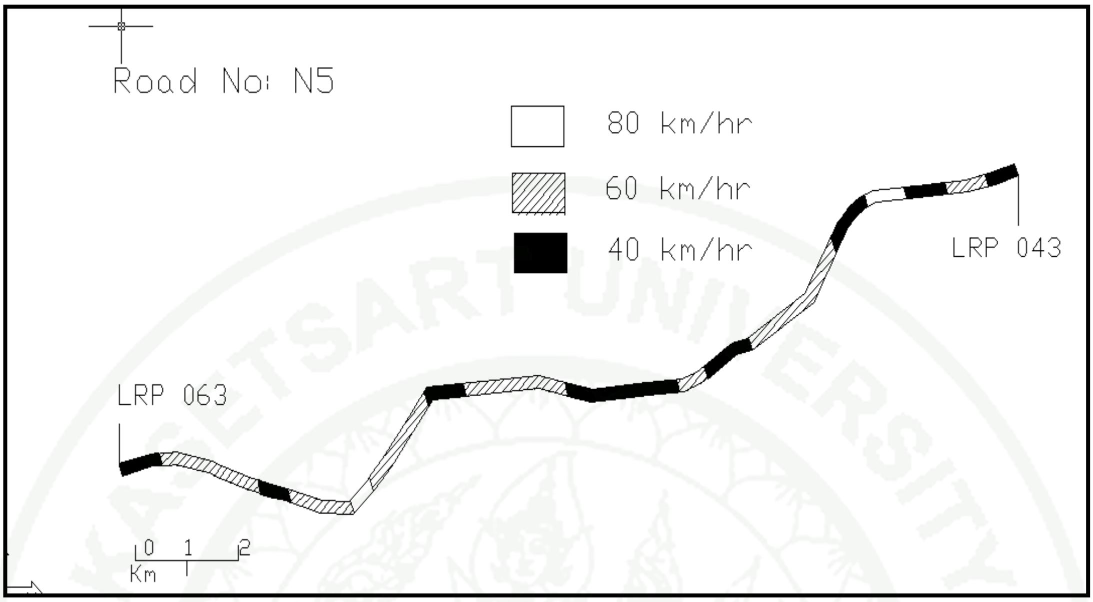

Figure 33 Layout showing posted speed limits on road no. n5

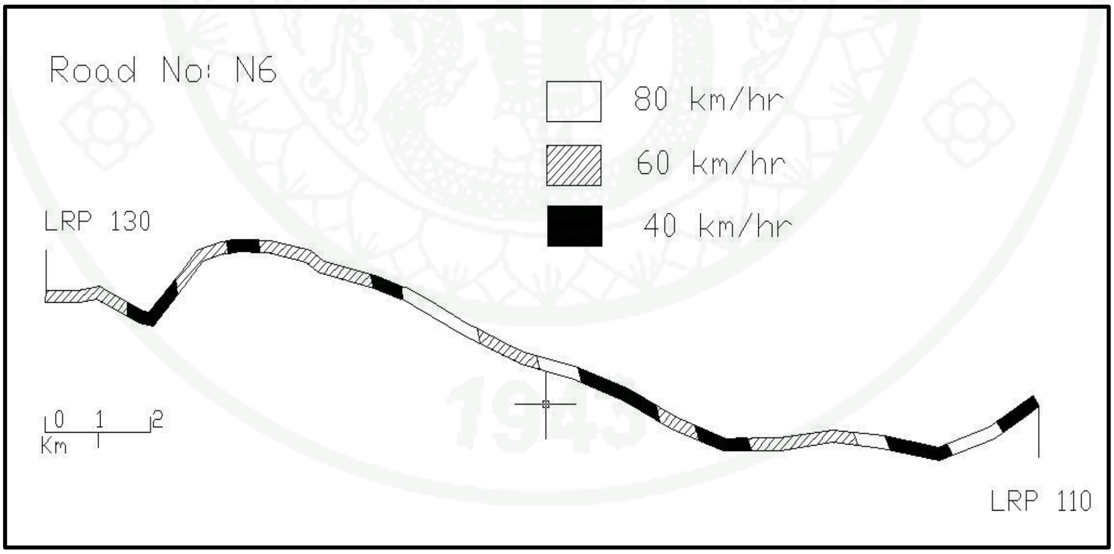

Figure 34 Layout showing posted speed limits on road no. n6

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Also the layouts of posted speed limits (in the road alignment map) for road N5 and N6 are depicted in figure 33 and 34 respectively. In table 12 the road lengths of posted speed limits are summing up. The percentage of road lengths of posted speed limits is shown in figure 35. From this figure the following remarks are made.

Table 12 Summary of road lengths with respect to posted speed limits

Speed Limits	Road length, Km		
	N5	**N6**	**Total**
40 km/hr	7.8	7.0	14.8
60 km/hr	10.8	9.0	19.8
80 Km/hr	1.4	4.0	5.4

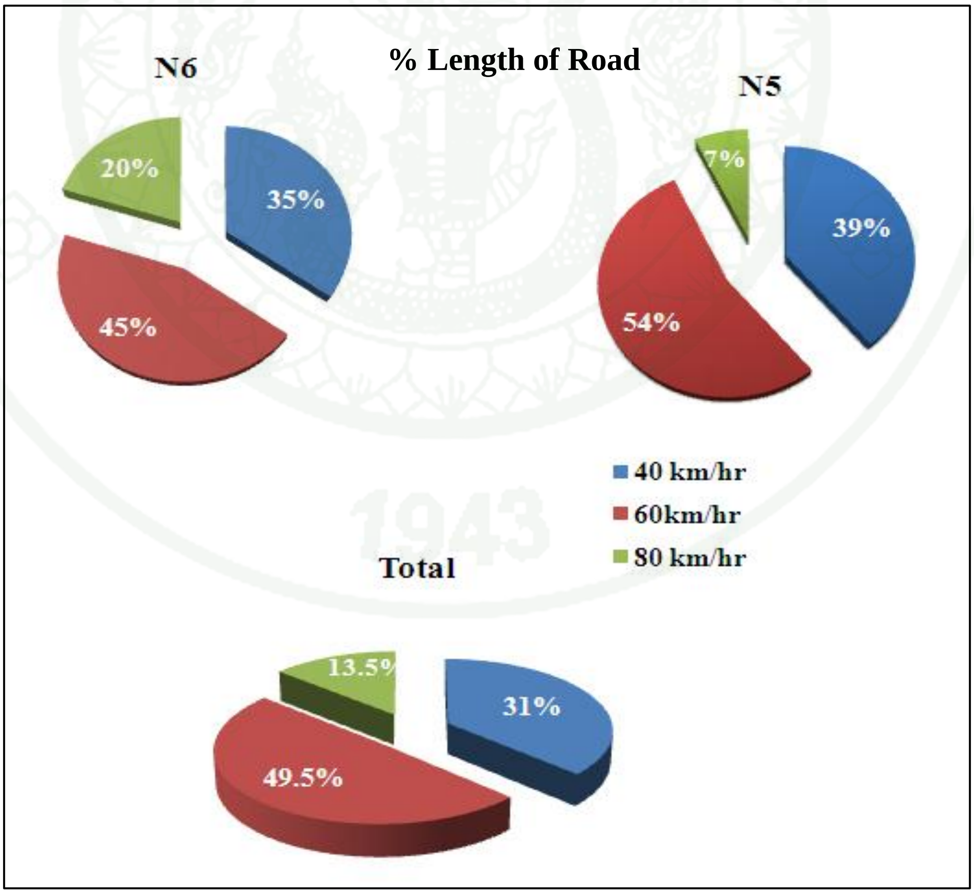

Figure 35 Percentage of road lengths with respect to posted speed limits

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In N5 39%, 54% and 7% lengths of road are appropriate for applying speed limit 40, 60 and 80 km/hr respectively. Whereas in N6, 35%, 45% and 20% lengths are suitable for speed limit 40, 60 and 80 km/hr respectively. Thus in average 37%, 49.5% and 13.5% studied road lengths are appropriate for setting speed limit 40, 60 and 80 km/hr respectively. Therefore, 93% and 80% lengths of road no.N5 and N6 are not suitable for applying maximum speed limit of 80 km/hr respectively. In average 86.5% road lengths are not appropriate for setting highest speed limit.

It is also noted from figure 14 that 16% and 27% road segments of N5 and N6 are suitable for applying maximum speed limit respectively. Also from figure 16 it has been noted 7% and 20% length of road sections of N5 and N6 are appropriate for setting maximum speed limit respectively. Thus N5 has more obstacles for applying maximum speed limit than N6. This outcome agrees with the real situation of the studied roads. Practically there are more obstacles in N5. Also it is noted that the speed limit 60 km/hr is appropriate most parts of the studied roads (54% and 45%).

It has been mentioned that setting speed limit for a length of 200 m is not realistic. In this study at least 600 m road length was considered for setting speed limit. Thus 3 or more road segments were selected for posting speed limit. From appendix table F it has been observed that within the length of posted speed limit the most segments have lower or equal speed limit to the posted speed limit. But few segments (one or two) need lower speed limits than the posted limit. As these segments are scattered it is not justified to reduce the speed limit for that whole section considering travel efficiency. Thus it is better to convey the information (warning signs) about the significant roadside variables to the road users' along with setting speed limits.

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CONCLUSION AND RECOMMENDATION

Conclusion

The presented MNL discrete choice model is suitable for selecting practical speed limits on segmental basis without considering speed related traffic and geometric characteristics along rural highways. This method allows a cautious and expert-opinion-based choice of legal speed limits, balancing safety and people's expectations, improving driving and risk perception related with the different road environments.

The developed model is able to constitute an interesting decision support method for helping in the definition of legal speed limits for various type of road environment, having as its basis a set of measurable descriptive variables. Using expert choice from a set of three speed limits (40, 60, and 80 km/h), this study identified the legal speed limits that experts consider appropriate for each segment.

.

The analysis shows that only 13.5% of road length under study is appropriate for setting highest speed limit (80 km/hr); whereas 49.5% is suitable for 60 km/hr and 37% is to 40 km/hr. Again the percentages of posted speed limits are nearly same for both of the study roads (N5 and N6). It is also revealed from the experiment that 40 km/hr speed limit is most appropriate for hazardous area such as bazaar or on road parking area. Whereas at curvature; side roads; access path; educational institutions; industry; deep ditches at roadsides need to decrease speed and thus in these cases suitable speed limit is 60 km/hr. When these attributes present along with others the limit should be less than 60 km/hr.

Therefore it is concluded that it is not possible to attain highest speed limit (80 km/hr) at the most parts of the studied roads. This is the reason for the presence a lot of obstacles along the roadside. The scenario is same for other national highways in Bangladesh. Hence this outcome concurs with the opinion of the experts that no roads in Bangladesh are suitable for attain maximum speed more than 80 km/hr.

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Recommendation

It is obvious that there is still a need for further development and validation of this model. Particularly, one should intend to recognize other variables and also include road user, such as drivers' and pedestrian judgment that might have the potential to help in determining appropriate speed limits for the highways.

The variables such as pavement condition (roughness data), traffic volume (AADT), traffic composition, weather condition, and accident probability need to incorporate for more result. The view of safety the opinion of road users has a great impact for selecting speed limits. Thus in further studies it is rational to utilize drivers' and pedestrian opinions. This type of work should also perform on other types of highways such as four lane highways, regional highways, feeder roads etc.

Future work should also focus on further model validation. For this purpose it would be very important to evaluate the influence that the mismatch between the model speed limit and the expert chosen speed limit. Thus it would need to further examine the feasibility of reducing the number of explanatory variables from the model.

This type of analysis should also be useful for other countries even for those that use more realistic methods for choosing speed limits, for example, the 85th percentile speed that adjusts better to the drivers' expectations. These methods tend to leave aside the lateral environment and its safety issues, which are considered in the model.

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APPENDICES

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Appendix A
Questionnaire

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Dear Sir
I am doing Master's Degree in Kasetsart University at Bangkok, Thailand. The Topics of my thesis is "Determining Speed Limits on Rural Two-lane Highways in Bangladesh". The main objective of the thesis is developing an analytical model for setting speed limits of different segments of road by multinomial discrete choice model using NLOGIT4 Software. The study is limited to two different national highways namely N5 and N6. The choice of speed on a road segment depends on many variables that characterize the road segment. Thus the study is based on roadsides characteristics data. The factors such as vehicle, road user, weather, accident data etc. are out of scope of this study.

Detail roadsides characteristics data which may affect the choice of speed limit for every **200 meter** segment of each road has been collected. Both of the roads are two way national highways having **pavement width 7.3 meters** and also **remain paved shoulder** on both sides of the pavement. In the questionnaire tables, the detail road side characteristics of each segment are listed. There are 200 segments. For each segment there are three options **(40 *km/hr, 60 km/hr and 80 km/hr)*** for choosing speed limit. ***Allowing the listed obstacles, you have to select one option which you consider the most suitable speed of that segment.***

Your cooperation will encourage me for the fulfillment of my study. After completing the questionnaire please send it by e-mail.

Thank you for your great cooperation.

Md. Mohibul Haque
Sub-Divisional Engineer
Roads and Highways Department
Email: mohib_rhd@yahoo.com

<u>Thesis Committee</u>

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Questionnaire

Name:
Designation : Organization:

Please select the appropriate speed limit of each segment according to its roadsides characteristics.

Road No: N5 **Segment Length: 200 meter**

Segm-ent No.	Location (Chainage)	Attributes/ Roadsides Characteristics/obstacles	Circle/put the appropriate speed limit
1	42+ 000-42+200	• Side Roads (Both sides) - 2 nos. • Presence of Few Shops • Presence of Trees at roadsides	40 60 80
2	42+ 200-42+400	• Presence of Bridge - 01 no. (03 m) • Bus stops (Left side) • Presence of Grade at road alignment • Speed Hump (Breaker) - 01 no. • Presence of Trees at roadsides	40 60 80
3	42+ 400-42+600	• Presence of Bridge – 01 no. (111m) • Presence of Rumble strips • Presence of Trees at roadsides	40 60 80
4	42+ 600-42+800	• Presence of Curvature at road alignment • Presence of roadside Shallow Ditches (Both sides) • Presence of Trees at roadsides	40 60 80
5	42+ 800-43+000	• Presence of Bridge -01 no. (14 m)	40 60 80
6	43+ 000-43+200	• Presence of Industry at roadside • Access Path to nearby buildings (Left side)	40 60 80
7	43+200-43+400	• Access Path to nearby buildings (Left side) • Presence of roadside Shallow Ditches (Both sides)	40 60 80

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Segm-ent No.	Location (Chainage)	Attributes/ Roadsides Characteristics/obstacles	Circle/put the appropriate speed limit
8	43+ 400-43+600	• Presence Medium Commercially Development Area such as Bazaar area, Market, Buildings etc. • Speed Hump (Breaker) - 01 no. • Bus Stops (Right side)	40 60 80
9	43+ 600-43+800	• Presence of Bridge -01 no. (20 m) • Speed Hump (Breaker) – 01 no.	40 60 80
10	43+ 800-44+000	• Presence of Bridge - 01 no. (06 m) • Access Path to nearby buildings (Left side) • Presence of roadside Shallow Ditches (Both sides)	40 60 80
11	44+ 000-44+200	• Presence of Few Houses • Presence of Trees at roadsides • Pedestrian Access Path-01 no.	40 60 80
12	44+ 200-44+400	• Pedestrian Access Path-01 no. • Presence of Trees at roadsides	40 60 80
13	44+ 400-44+600	• Presence of Curvature at road alignment • Presence of Trees at roadsides	40 60 80
14	44+ 600-44+800	• Presence of Bridge -01 no. (13 m) • Presence of Trees at roadsides	40 60 80
15	44+ 800-45+000	• Presence of roadside Shallow Ditches (Both sides) • Presence of Trees at roadsides	40 60 80
16	45+ 000-45+200	• Presence of Curvature at road alignment	40 60 80
17	45+ 200-45+400	• Presence of Bridge - 01 no. (13 m) • Presence of Medium Commercially Development Area such as Bazaar area, Market, Building etc. • Presence of Curvature at road alignment	40 60 80

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Segm-ent No.	Location (Chainage)	Attributes/ Roadsides Characteristics/obstacles	Circle/put the appropriate speed limit
18	45+ 400-45+600	• Presence Medium Commercially Development Area such as Bazaar area, Market, Building etc. • Presence of Rumble strips • Side Road (Right side) - 01 no. • Presence of On road parking spaces (Right side) • Bus Stops (Both sides)	40 60 80
19	45+ 600-45+800	• Presence of Bridge -01 no. (7m) • Presence of Trees at roadsides	40 60 80
20	45+ 800-46+000	• Presence of Bridge - 01 no. (42 m) • Pedestrian Access Path - 02 nos. • Presence Of Industry (Right side) • Access Path to nearby buildings (Right side)	40 60 80
21	46+ 000-46+200	• Filling Station (Right side) - 01 no. • Presence of roadside Shallow Ditches (Both sides) • Presence of Trees at roadsides	40 60 80
22	46+ 200-46+400	• Side Roads (Both sides) - 02 no. • Presence of Rumble strips	40 60 80
23	46+ 400-46+600	• Presence of Industry (Left side) • Presence of roadside Deep Ditches (Right side) • Presence of Trees at roadsides	40 60 80
24	46+ 600-46+800	• Presence of Industry (Left side) • Roadside Deep Ditches (Right side) • Presence of Trees at roadsides	40 60 80
25	46+ 800-47+000	• Presence of Trees at roadsides	40 60 80

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Segm-ent No.	Location (Chainage)	Attributes/ Roadsides Characteristics/obstacles	Circle/put the appropriate speed limit
26	47+ 000-47+200	• Side Road (Right side) – 01 no.	40 60 80
27	47+ 200-47+400	• Presence of Rumble strips • Presence of Curvature at road alignment	40 60 80
28	47+ 400-47+600	• Presence of Curvature at road alignment • Presence of Trees at roadsides	40 60 80
29	47+ 600-47+800	• Presence of Curvature at road alignment • Roadside Shallow Ditches (Both sides)	40 60 80
30	47+ 800-48+000	• Side Road (Left side) - 01 no. • Speed Hump (Breaker) - 01 no. • Presence of Grade	40 60 80
31	48+ 000-48+200	• Presence of Bridge - 01 no. (part) (200 m) • Presence of Grade	40 60 80
32	48+ 200-48+400	• Presence of Bridge - 01 no. (part) (200 m) • Presence of Grade	40 60 80
33	48+ 400-48+600	• Presence of Bridge - 01 no. (part) (95 m) • Presence of Grade • Presence of Curvature at road alignment • Speed Hump (Breaker) - 01 no.	40 60 80
34	48+ 600-48+800	• Side Road (Left side) - 01 no. • Presence of roadside Shallow Ditches (Both sides) • Presence of Trees at roadsides	40 60 80
35	48+ 800-49+000	• Presence of Bridge - 01 no. (19m) • Side Roads (Left side) - 01 no. • Speed Hump (Speed Breaker) - 01 no. • Presence of Few Shops	40 60 80
36	49+ 000-49+200	• Speed Hump (Breaker) - 01 no. • Presence of Few Shops • Roadside Deep Ditches (Right side)	40 60 80

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Segm-ent No.	Location (Chainage)	Attributes/ Roadsides Characteristics/obstacles	Circle/put the appropriate speed limit
37	49+ 200-49+400	• Side Roads (Left side) - 01 no. • Presence of Rumble strips	40 60 80
38	49+ 400-49+600	• Side Road (Left side) - 01 no. • Presence of Trees at roadsides	40 60 80
39	49+ 600-49+800	• Bridge - 01 no. (15 m) • Presence of Few Shops • Presence of Trees at roadsides	40 60 80
40	49+ 800-50+000	• Presence of Curvature at road alignment • Presence of roadside Shallow Ditches (Both sides) • Presence of Trees at roadsides	40 60 80
41	50+ 000-50+200	• Roadside Deep Ditches (Right side) • Side Road (Left side) - 01 no. • Presence of Rumble strips	40 60 80
42	50+ 200-50+400	• Side Road (Right side) - 01 no. • Filling Station (Left side) with access paths – 01 no. • On road parking spaces (Right side) • Off road parking spaces (Right side)	40 60 80
43	50+ 400-50+600	• On road parking Spaces (Right side) • Presence of Few Shops	40 60 80
44	50+ 600-50+800	• Presence of Bridge - 01 no. (49m) • Side Road (Left side) - 01 no. • Roadside Deep Ditches (Right side) • Presence of Trees at roadsides	40 60 80
45	50+ 800-51+000	• Presence of Medium Commercially Development Area such as Bazaar area, Market, Building etc. • On road parking spaces (Both sides)	40 60 80

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Segm-ent No.	Location (Chainage)	Attributes/ Roadsides Characteristics/obstacles	Circle/put the appropriate speed limit
46	51+ 000-51+200	• Presence of Highly Commercially Development Area such as Bazaar area, Market, Building etc • Filling Stations (Both sides) with access paths - 02 nos. • On road parking spaces (Both sides) • Off road parking spaces (Right side) • Bus Stops (left side) - 01 no.	40 60 80
47	51+ 200-51+400	• Presence of Highly Commercially Development Area such as Bazaar area, Market, Building etc. • Presence of Intersection • Side Roads (Both sides) - 02 nos. • Filling Station (left side) with access path-01 no.	40 60 80
48	51+ 400-51+600	• Presence of Highly Commercially Development Area such as Bazaar area, Market, Building etc • Side Road (Right side) - 01 no. • Bus Stops (Right side) • Presence of On road parking spaces (Both sides) • Presence of Off road parking spaces (Both sides) • Road side Deep Ditches (Both sides)	40 60 80
49	51+ 600-51+800	• Presence of Bridge -01 no (29 m) • Presence of Grade • Side Road (Left side) - 01 no. • Roadside Deep Ditches (Both sides)	40 60 80

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Segm-ent No.	Location (Chainage)	Attributes/ Roadsides Characteristics/obstacles	Circle/put the appropriate speed limit
50	51+ 800-52+000	• Presence of Curvature • Roadside Deep Ditches (Right side) • Side Roads (Left side) - 02 nos. • Presence of Trees at roadsides	40 60 80
51	52+ 000-52+200	• Presence of Rumble strips • Access path to nearby buildings (Both sides)	40 60 80
52	52+ 200-52+400	• Filling Station (Left side) with access path - 01 no. • Presence of roadside Deep Ditches (Right side)	40 60 80
53	52+ 400-52+600	• Side Road (Left side) - 01 no. • Presence of Trees at roadsides	40 60 80
54	52+ 600-52+800	• Side Road (Left Side)-01 no. • Presence of Roadside Deep Ditches (Right side) • Filling station (Left side) with access paths - 01 no.	40 60 80
55	52+ 800-53+000	• Presence of Culvert - 02 nos. • Roadside Deep Ditches (Right side)	40 60 80
56	53+ 000-53+200	• Filling Station (Left side) with access path - 01 no. • Presence of Trees at roadsides	40 60 80
57	53+ 200-53+400	• Presence of Curvature at road alignment • Roadside Shallow Ditches (Both sides) • Presence of Trees at roadsides	40 60 80
58	53+ 400-53+600	• Side Road (Right side) - 01 no. • Roadside Shallow Ditches (Both sides) • Presence of Trees at roadsides	40 60 80

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Segm-ent No.	Location (Chainage)	Attributes/ Roadsides Characteristics/obstacles	Circle/put the appropriate speed limit
59	53+ 600-53+800	• Presence of roadside Shallow Ditches (Both sides) • Presence of Trees at roadsides	40 60 80
60	53+ 800-54+000	• Presence of roadside Shallow Ditches (Both sides) • Presence of Trees at roadsides	40 60 80
61	54+ 000-54+200	• Presence of Rumble strips • Presence of Trees at roadsides	40 60 80
62	54+ 200-54+400	• Presence of Curvature at road alignment • Side Road (Right side) - 01 no. • Speed Hump (Breaker) - 01 no.	40 60 80
63	54+ 400-54+600	• Presence of Bridge - 01 no. (12m) • Speed Hump (Breaker) - 01 no.	40 60 80
64	54+ 600-54+800	• Presence of Curvature at road alignment • Side Road (Right side) - 01 no. • Roadside Deep Ditches (Right side) • Presence of Trees at roadsides	40 60 80
65	54+ 800-55+000	• Presence of Curvature at road alignment • Presence of roadside Deep Ditches (Right side) • Speed Hump (Breaker) - 01 no.	40 60 80
66	55+ 000-55+200	• Side Road (Right side) - 01 no. • Presence of large Office Building at roadside (Palli Bidyut) • Presence of Trees at roadsides	40 60 80
67	55+ 200-55+400	• Presence of roadside Deep Ditches (Both sides) • Side Road (Left side) - 01 no. • Presence of Trees at roadsides	40 60 80

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Segm-ent No.	Location (Chainage)	Attributes/ Roadsides Characteristics/obstacles	Circle/put the appropriate speed limit
68	55+ 400-55+600	• Presence of Bridge - 01 no. (13 m) • Roadside Deep Ditches (Both sides) • Side Road (Right side) - 01 no. • Presence of Trees at roadsides	40 60 80
69	55+ 600-55+800	• Bus Stops (Right side) -01 no. • Presence of roadside Deep Ditches (Both sides) • Presence of Trees at roadsides	40 60 80
70	55+ 800-56+000	• Presence of Grade • Presence of Bridge - 01 no (Part) (134 m)	40 60 80
71	56+ 000-56+200	• Presence of Bridge - 01 no. (Part) (200 m) • Presence of Grade	40 60 80
72	56+ 200-56+400	• Presence of Bridge - 01 no. (Part) (200m) • Presence of Grade	40 60 80
73	56+ 400-56+600	• Presence of Bridge - 01 no. (Part) (114 m) • Presence of Grade • Presence of Curvature at road alignment	40 60 80
74	56+ 600-56+800	• On road parking spaces (Left side) • Presence of Rumble strips	40 60 80
75	56+ 800-57+000	• Presence of Bridge - 01 no. (19 m) • Presence of Trees at roadsides	40 60 80
76	57+ 000-57+200	• Presence of Trees at roadsides	40 60 80
77	57+ 200-57+400	• Presence of Trees at roadsides	40 60 80
78	57+ 400-57+600	• Side Road (Left side) - 01 no. • Presence of Curvature at road alignment • Bridge - 01 no. (29 m) • Presence of Trees at roadsides	40 60 80
79	57+ 600-57+800	• Presence of Curvature at road alignment • Pedestrian Access Path - 01 no.	40 60 80

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Segm-ent No.	Location (Chainage)	Attributes/ Roadsides Characteristics/obstacles	Circle/put the appropriate speed limit
80	57+ 800-58+000	• Presence of Curvature at road alignment • Presence of Rumble strips • Roadside Deep Ditches (Both sides) • Presence of Trees at roadsides	40 60 80
81	58+ 000-58+200	• Presence of Bridge - 01 no. (12m) • Presence of Trees at roadsides	40 60 80
82	58+ 200-58+400	• Presence of Curvature at road alignment • Access Path to nearby Building (Left side) • Roadside Deep Ditches (Both sides) • Presence of Trees at roadsides	40 60 80
83	58+ 400-58+600	• Presence of Curvature at road alignment • Roadside Deep Ditches (Both sides) • Side Road (Left side) - 01 no.	40 60 80
84	58+ 600-58+800	• Presence of Curvature at road alignment • Roadside Deep Ditches (Right side) • Presence of Medium Commercially Development Area such as Bazaar area, Market, Building etc. • Presence of Bridge - 01 no. (12 m) • Speed Hump (Breaker) - 01 no. • On road parking spaces (Both sides)	40 60 80
85	58+ 800-59+000	• Presence of Medium Commercially Development Area such as Bazaar area, Market, Buildings etc. • Side Roads (Both sides) - 02 nos. • Speed Hump (Breaker) - 01 no. • Bus Stops (Both sides) - 01 no.	40 60 80
86	59+ 000-59+200	• Presence of Rumble strips • Presence of Trees at roadsides	40 60 80

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Segm-ent No.	Location (Chainage)	Attributes/ Roadsides Characteristics/obstacles	Circle/put the appropriate speed limit
87	59+ 200-59+400	• Bridge - 01 no. (13 m) • Presence of Culvert - 01 no. • Roadside Deep Ditches (Both sides) • Presence of Trees at roadsides • Inadequate Earthen Shoulder (Both sides)	40 60 80
88	59+ 400-59+600	• Presence of Culvert - 01 no. • Presence of roadside Deep Ditches (Both sides) • Presence of Trees at roadsides • Inadequate Earthen Shoulder (Both sides)	40 60 80
89	59+ 600-59+800	• Presence of roadside Deep Ditches (Right side) • Side Road (Left side) - 01 no. • Presence of Rumble strips • Inadequate Earthen Shoulder (Both sides)	40 60 80
90	59+ 800-60+000	• Presence of Curvature at road alignment • Pedestrian Access Paths (Both sides) - 02 nos. • Presence of roadside Deep Ditches (Right side)	40 60 80
91	60+ 000-60+200	• Presence of roadside Deep Ditches (Right side) • Presence of Trees at roadsides	40 60 80
92	60+ 200-60+400	• Presence of Bridge - 01 no. (13 m) • Roadside Deep Ditches (Right side) • Pedestrian Access Path (Left side) - 01 no. • Presence of Curvature at road alignment • Presence of Trees at roadsides • Inadequate Earthen Shoulder (Both sides)	40 60 80

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Segm-ent No.	Location (Chainage)	Attributes/ Roadsides Characteristics/obstacles	Circle/put the appropriate speed limit
93	60+ 400-60+600	• Presence of Curvature at road alignment • Roadside Deep Ditches (Right sides) • Side Road (Left side) - 01 no. • Presence of Rumble strips • Inadequate Earthen Shoulder (Both sides)	40 60 80
94	60+ 600-60+800	• Presence of Curvature • Roadside Deep Ditches (Both sides) • Presence of Trees at roadsides • Inadequate Earthen Shoulder (Both sides)	40 60 80
95	60+ 800-61+000	• Presence of Bridge - 01 no. (12 m) • Roadside Deep Ditches (Both sides) • Presence of Trees at roadsides • Inadequate Earthen Shoulder (Both sides)	40 60 80
96	61+ 000-61+200	• Roadside Deep Ditches (Both sides) • Presence of Rumble strips • Presence of Trees at roadsides • Inadequate Earthen Shoulder (Both sides)	40 60 80
97	61+ 200-61+400	• Presence of Bridge - 01 no. (13 m) • Presence of Curvature at road alignment • Presence of Rumble strips	40 60 80
98	61+ 400-61+600	• Presence of Medium Commercially Development Area such as Bazaar area, Market, Buildings etc. • Side Road (Left side) - 01 no. • Roadside Deep Ditches (Right side) • Speed Hump (Breaker)-01 no. • Access Path to nearby buildings (Left Side) • Bus Stops - 01 no.	40 60 80

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Segm-ent No.	Location (Chainage)	Attributes/ Roadsides Characteristics/obstacles	Circle/put the appropriate speed limit
99	61+ 600-61+800	• Speed Hump (Breaker) – 01 no. • Presence of roadside Deep Ditches (Right side)	40 60 80
100	61+ 800-62+000	• Roadside Deep Ditches (Right side) • Presence of Trees at roadsides • Inadequate Earthen Shoulder (Right side)	40 60 80

Road No: N6 **Segment Length: 200 meter**

Segm-ent No.	Location (Chainage)	Attributes/ Roadsides Characteristics/Obstacles	Circle the appropriate speed limit
101	111+ 000-111+200	• Speed Hump (Breaker) - 02 nos. • Presence of Few Shops at roadsides • Bus Stops (Both sides)	40 60 80
102	111+ 200-111+400	• Presence of Culvert- 01 no. • Side Road (Left side) – 01 no.	40 60 80
103	111+ 400-111+600	None	40 60 80
104	111+ 600-111+800	• Side Road (Left side) – 01 no. • Presence of Trees at roadsides	40 60 80
105	111+ 800-112+000	• Presence of Trees at roadsides	40 60 80
106	112+ 000-112+200	• Side Road (Right side) – 01 no.	40 60 80
107	112+ 200-112+400	• Presence of Trees at roadsides	40 60 80
108	112+ 400-112+600	• Presence of Culvert- o1 no. • Access Path to nearby buildings (Both sides)	40 60 80
109	112+ 600-112+800	None	40 60 80

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Segm-ent No.	Location (Chainage)	Attributes/ Roadsides Characteristics/Obstacles	Circle the appropriate speed limit
110	112+ 800-113+000	• Presence of Curvature • Side Road (Left side) – 01 no. • Presence of Mosque at roadside • Presence of Few Shops at roadsides • Access Path to nearby buildings (Both sides) • Bus Stops (Both sides)	40 60 80
111	113+ 000-113+200	• Side Road (Right side) – 01 no.	40 60 80
112	113+ 200-113+400	• Presence of Trees at roadsides	40 60 80
113	113+ 400-113+600	• Side Road (Left side) – 01 no. • Presence of Trees at roadsides	40 60 80
114	113+ 600-113+800	• Side Roads (Both Sides) – 02 nos. • Speed Humps (Breaker) – 02 nos. • Bus Stops (Both sides) • Presence of Few Shops at roadsides	40 60 80
115	113+ 800-114+000	• Presence of School at roadside	40 60 80
116	114+ 000-114+200	• Presence of roadside Shallow Ditches (Both sides)	40 60 80
117	114+ 200-114+400	None	40 60 80
118	114+ 400-114+600	• Presence of Trees at roadsides	40 60 80
119	114+ 600-114+800	• Presence of Curvature • Side Roads (Both sides) – 02 nos. • Presence of Trees at roadsides	40 60 80
120	114+ 800-115+000	• Side Road (Right side) – 01 no. • Bus Stops (Both sides) • Access Path to nearby buildings (Right side) • Presence of Trees at roadsides	40 60 80
121	115+ 000-115+200	• Presence of Few Shops at roadsides • Presence of Trees at roadsides	40 60 80

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Segm-ent No.	Location (Chainage)	Attributes/ Roadsides Characteristics/Obstacles	Circle the appropriate speed limit
122	115+ 200-115+400	• Side Road (Left side) – 01 no. • Presence of Trees at roadsides	40 60 80
123	115+ 400-115+600	• Presence of Curvature • Presence of Trees at roadsides	40 60 80
124	115+ 600-115+800	None	40 60 80
125	115+ 800-116+000	• Presence of Trees at roadsides	40 60 80
126	116+ 000-116+200	• Presence of Curvature at road alignment • Presence of Trees at roadsides	40 60 80
127	116+ 200-116+400	• Pedestrian Access Paths – 02 nos. • Presence of Trees at roadsides	40 60 80
128	116+ 400-116+600	• Curvature at road alignment • Few shops, buildings at roadsides • Presence of Trees at roadsides	40 60 80
129	116+ 600-116+800	• Filling Station (Right side) – 01 no. • Presence of Shops at roadsides • Roadside Shallow Ditches (Right side) • On road parking spaces (Both sides)	40 60 80
130	116+ 800-117+000	• Presence of Highly Commercially Development Area such as Bazaar area, Market, Buildings etc • Bus Stops (Both sides) • Presence Non Motorized Lane along the Road (Both sides)	40 60 80
131	117+ 000-117+200	• Presence of Bridge - 01 no. (38 m) • Presence of Highly Commercially Development Area such as Bazaar area, Market, Buildings etc • Side Road (Left) - 01 no. • Non Motorized Lane (Both sides)	40 60 80

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Segm-ent No.	Location (Chainage)	Attributes/ Roadsides Characteristics/Obstacles	Circle the appropriate speed limit
132	117+ 200-117+400	• Presence Medium Commercially Development Area such as Bazaar area, Market, Buildings etc • Side Road (Left side) - 01 no.	40 60 80
133	117+ 400-117+600	• Presence of Curvature at road alignment • Presence of Industry at roadside (left side) • Side Road (Right side) - 01 no.	40 60 80
134	117+ 600-117+800	• Presence of Curvature at road alignment • Access Path to nearby buildings (Both sides) • Presence of Trees at roadsides	40 60 80
135	117+ 800-118+000	• Presence of Curvature • Access Path to nearby buildings (Both sides) • Presence of Trees at roadsides	40 60 80
136	118+ 000-118+200	• Presence of Curvature	40 60 80
137	118+ 200-118+400	• Presence of Fire Station (Right side) • Presence of Curvature at road alignment • Access Path to nearby buildings (Both sides)	40 60 80
138	118+ 400-118+600	• Access Path to nearby buildings (Both sides) • Bus Stops (Both sides) • Presence of Trees at roadsides	40 60 80
139	118+ 600-118+800	• Side Road (Right side) – 01 no. • Filling Station (Right side) with access path – 01 no. • Presence of Trees at roadsides • Presence of Few Shops at roadsides	40 60 80

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Segm-ent No.	Location (Chainage)	Attributes/ Roadsides Characteristics/Obstacles	Circle the appropriate speed limit
140	118+ 800-119+000	• Presence of School, Buildings, Shops • Access Path to nearby buildings (Right side) • Presence of On road parking spaces	40 60 80
141	119+ 000-119+200	• Presence Highly Commercially Development Area such as Bazaar area, Market, buildings etc • Presence Non Motorized Lane along the Road (Both sides) • Side Road (Right side) – 01 no. • Speed Hump (Breaker) – 01 No. • Bus Stops (Both sides)	40 60 80
142	119+ 200-119+400	• Presence Highly Commercially Development Area such as Bazaar area, Market, Building etc. • Presence Non Motorized Lane along the Road (Both sides) • Side Roads (Both sides) - 02 nos. • Bus Stops (Both sides)	40 60 80
143	119+ 400-119+600	• Presence Highly Commercially Development Area such as Bazaar area, Market, Buildings etc. • Presence Non Motorized Lane along the Road (Both sides) • Speed Hump (Breaker) – 01 no.	40 60 80
144	119+ 600-119+800	• Presence of Medium Commercially Development Area such as Bazaar area, Market, Building etc. • Presence Non Motorized Lane along the Road (Both sides)	40 60 80

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Segm-ent No.	Location (Chainage)	Attributes/ Roadsides Characteristics/Obstacles	Circle the appropriate speed limit
145	119+ 800-120+000	• Side Road (Left side) - 01 no. • Presence of Trees at roadsides • Access Path to nearby buildings (Right side) • Presence of On road parking spaces	40 60 80
146	120+ 000-120+200	• Presence of Trees at roadsides	40 60 80
147	120+ 200-120+400	• Presence of Trees at roadsides	40 60 80
148	120+ 400-120+600	• Access Path to nearby buildings (Both sides) • Side Road (Left side) - 01 no. • Filling Station (Right side) with access path - 01 no.	40 60 80
149	120+ 600-120+800	None	40 60 80
150	120+ 800-121+000	• Side Road (Left side) - 01 no. • Presence of Trees at roadsides	40 60 80
151	121+ 000-121+200	• Presence of Curvature at road alignment	40 60 80
152	121+ 200-121+400	• Presence of Culvert-01 no. • Roadside Shallow Ditches (Both sides)	40 60 80
153	121+ 400-121+600	• Side Roads (Both sides) – 02 nos. • Presence of Trees at roadsides	40 60 80
154	121+ 600-121+800	• Presence of Trees at roadsides	40 60 80
155	121+ 800-122+000	• Speed Humps (Breaker) – 02 nos. • Presence of Trees at roadsides • Presence of roadside Deep Ditches (Right side) • Access Path to nearby buildings (Both sides) • Bus Stops (Both sides)	40 60 80
156	122+ 000-122+200	• Presence of Culvert - 01 no. • Road side Ditches (Both sides)	40 60 80

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Segm-ent No.	Location (Chainage)	Attributes/ Roadsides Characteristics/Obstacles	Circle the appropriate speed limit
157	122+ 200-122+400	• Side Road (Right side) - 01 no. • Roadside Shallow Ditches (Left side)	40 60 80
158	122+ 400-122+600	• Presence of road side Shallow Ditches (Left side) • Presence of Trees at roadsides	40 60 80
159	122+ 600-122+800	• Roadside Shallow Ditches (Left side) • Presence of Trees at roadsides	40 60 80
160	122+ 800-123+000	• Presence of Culvert - 01 no. • Roadside Shallow Ditches (Both sides)	40 60 80
161	123+ 000-123+200	• Roadside Shallow Ditches (Left side) • Presence of Trees at roadsides	40 60 80
162	123+ 200-123+400	• Road side Shallow Ditches (Both sides) • Presence of Trees at roadsides	40 60 80
163	123+ 400-123+600	• Presence of Bridge - 01 no. (60 m) • Roadside Shallow Ditches (Both sides)	40 60 80
164	123+ 600-123+800	• Presence of Curvature at road alignment • Roadside Shallow Ditches (Left side) • Presence of Trees at roadsides	40 60 80
165	123+ 800-124+000	• Presence of Highly Commercially Development Area such as Bazaar area, Market, Building etc. • Presence of Curvature at road alignment • Roadside Shallow Ditches (Left side) • Presence of Trees at roadsides • Bus Stops (Both sides)	40 60 80
166	124+ 000-124+200	• Speed Humps (Breaker) - 2 nos. • Side Roads (Both sides) – 02 nos. • Presence of Medium Commercially Development Area such as Bazaar area, Market, Buildings etc.	40 60 80

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Segm-ent No.	Location (Chainage)	Attributes/ Roadsides Characteristics/Obstacles	Circle the appropriate speed limit
167	124+ 200-124+400	• Presence of Trees at roadsides • Access Path to nearby buildings (Left side)	40 60 80
168	124+ 400-124+600	• Presence of Trees at roadsides • Presence of curvature at roadsides • Roadside Shallow Ditches (Left side)	40 60 80
169	124+ 600-124+800	• Presence of Medium Commercially Development Area such as Bazaar area, Market, Building etc. • Side Road (Right side) – 01 no. • Speed Hump (Breaker) – 01 no. • Presence of Holy Mazaar/shrine • Bus Stops (Both sides)	40 60 80
170	124+ 800-125+000	• Access Path to nearby buildings (Right) • Side Road (Right side) – 01 no. • Presence of Curvature at road alignment	40 60 80
171	125+ 000-125+200	None	40 60 80
172	125+ 200-125+400	• Presence of Culvert - 01 no. • Presence of Curvature at road alignment	40 60 80
173	125+ 400-125+600	• Presence of Curvature at road alignment • Presence of Trees at roadsides	40 60 80
174	125+ 600-125+800	• Presence of Curvature at road alignment	40 60 80
175	125+ 800-126+000	• Side Roads (Both sides) – 02 nos. • Presence of Curvature at road alignment • Industry at roadside (Left side) • Presence of Trees at road sides	40 60 80
176	126+ 000-126+200	• Presence of Culvert - 01 no. • Presence of Curvature at road alignment • Access Path to nearby buildings (Right) • Presence of Trees at roadsides	40 60 80

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Segm-ent No.	Location (Chainage)	Attributes/ Roadsides Characteristics/Obstacles	Circle the appropriate speed limit
177	126+ 200-126+400	• Presence of Trees at roadsides	40 60 80
178	126+ 400-126+600	• Medium Commercially Development Area such as Bazaar area, Market, Building etc. • Side Road (Left side) – 01 no. • Bus Stops (Both sides) • Speed Hump (Breaker) – 01 no. • On road parking spaces (Both sides)	40 60 80
179	126+ 600-126+800	• Presence of Medium Commercially Development Area such as Bazaar area, Market, Building etc. • Presence of Intersection • Presence of Curvature • Speed Hump (Breaker) – 01 no. • Presence of Culvert - 01 no. • Side Road (Left side) - 01 no.	40 60 80
180	126+ 800-127+000	• Roadside Deep Ditches (Right side) • Presence of Trees at roadsides	40 60 80
181	127+ 000-127+200	• Side Road (Right side) – 01 no. • Roadside Shallow Ditches (Right side)	40 60 80
182	127+ 200-127+400	• Presence of Culvert - 01 no. • Presence of Trees at roadsides	40 60 80
183	127+ 400-127+600	• Presence of Curvature at road alignment • Presence of Trees at roadsides	40 60 80
184	127+ 600-127+800	• Side Roads (Right side) – 02 nos. • Presence of Curvature at road alignment • Presence of Trees at roadsides	40 60 80
185	127+ 800-128+000	• Presence of Curvature at road alignment • Presence of roadside Shallow Ditches (Both sides)	40 60 80

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Segm-ent No.	Location (Chainage)	Attributes/ Roadsides Characteristics/Obstacles	Circle the appropriate speed limit
186	128+ 000-128+200	• Presence of Curvature at road alignment • Presence of Mosque • Access Path to nearby buildings (Right)	40 60 80
187	128+ 200-128+400	• Presence of Filling Stations with access paths (Both sides) - 02 nos. • Presence of Curvature at road alignment • Side roads (Left side) - 01no. • Bus Stops (Both Sides) • Access Path to nearby buildings (Both sides) • On road parking spaces (Right side)	40 60 80
188	128+ 400-128+600	• Presence of Medium Commercially Development Area such as Bazaar area, Market, Buildings etc. • Side Roads (Both sides) - 02 nos. • Presence of Curvature at road alignment • On road parking spaces (Both sides)	40 60 80
189	128+ 600-128+800	• Highly Commercially Development Area such as Bazaar, Market, Buildings etc. • Side Road (Left side) - 01no. • Presence of Curvature at road alignment • On road parking spaces (Both sides)	40 60 80
190	128+ 800-129+000	• Highly Commercially Development Area such as Bazaar, Market, Building etc. • Side road (Left side) - 01no. • Presence of Curvature at road alignment • Speed Hump (Breaker) – 01 no. • Bus Stops (Both sides)	40 60 80

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Segm-ent No.	Location (Chainage)	Attributes/ Roadsides Characteristics/Obstacles	Circle the appropriate speed limit
191	129+ 000-129+200	• Presence of Highly Commercially Development Area such as Bazaar area, Market, Buildings etc. • Presence of Intersection • Speed Hump (Breaker) – 01 no. • Side Roads (Both sides) - 02 nos. • Access Path to nearby buildings (Both sides)	40 60 80
192	129+ 200-129+400	• Presence of Medium Commercially Development Area such as Bazaar area, Market, Buildings etc. • Presence of Curvature at road alignment • Pedestrian Access Path (Left side) - 01 no. • On road parking spaces (Both sides)	40 60 80
193	129+ 400-129+600	• Presence of curvature at road alignment • Presence of Office building • Access path nearby buildings (Both sides)	40 60 80
194	129+ 600-129+800	• Presence of Curvature • Roadside Shallow Ditches (Right side) • Access path to nearby buildings (Left side)	40 60 80
195	129+ 800-130+000	• Presence of Curvature • Presence of Culvert-01 no. • Presence of road side Shallow Ditches (Right side) • Presence of Trees at roadsides • Access path to nearby buildings (Left side)	40 60 80

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Segm-ent No.	Location (Chainage)	Attributes/ Roadsides Characteristics/Obstacles	Circle the appropriate speed limit
196	130+ 000-130+200	• Presence of Curvature • Side Roads (Right side) - 01 no. • Roadside Shallow Ditches (Right side) • Presence of Trees at roadsides • Access Path to nearby buildings (Left side)	40 60 80
197	130+ 200-130+400	• Presence of Culvert - 01 no.	40 60 80
198	130+ 400-130+600	• Presence of Curvature • Roadside Ditches (Left side) • Presence of Trees at roadsides	40 60 80
199	130+ 600-130+800	• Roadside shallow Ditches (Both sides) • Presence of Trees at roadsides • Side Roads (Right side) - 01 no.	40 60 80
200	130+ 800-131+000	• Presence of Curvature • Roadside Shallow Ditches (Right side) • Presence of Trees at roadsides	40 60 80

Thank you for cooperation

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Appendix B
Correlation matrix

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Correlation Matrix for Listed Variables

	SRB	SRS	MLA	HLA	BUILDAR	TREE	BRIDG	CULVER
SRB	-	-.14975	.03507	.17040	.12265	-.00374	-.06273	-.04368
SRS	-.14975	-	.12330	.03725	-.04909	-.12942	-.06933	-.06003
MLA	.03507	.12330	-	-.06383	-.02946	-.23951	-.04797	-.05390
HLA	.17040	.03725	-.06383	-	-.10697	-.18345	-.02168	-.05390
BUILDAR	.12265	-.04909	-.02946	-.10697	-	-.06682	-.05089	-.09033
TREE	-.00374	-.12942	-.23951	-.18345	-.06682	-	-.12008	-.18096
BRIDG	-.06273	-.06933	-.04797	-.02168	-.05089	-.12008	-	-.05205
CULVER	-.04368	-.06003	-.05390	-.05390	-.09033	-.18096	-.05205	-

	SRB	SRS	MLA	HLA	BUILDAR	TREE	BRIDG	CULVER
BUSB	.12579	.11140	.14842	.34211	.14029	-.09602	-.07324	-.06405
BUSS	-.04573	.03187	.23185	.26441	-.07531	-.09140	-.03905	-.03795
GRADE	-.05248	.02265	- .05157	-.05157	-.07703	-.12557	.62422	-.04355
CURVE	-.01059	-.07170	-.07913	-.07913	-.03240	.07064	-.06166	-.05994
HUMP	.14297	.02326	.23745	.04067	.14940	-.24632	**-.00111**	-.07644
RUMBLE	.03815	.05015	.00701	-.06967	-.11675	-.10555	.05356	-.05883
SDITCHB	-.09283	-.11890	-.09122	-.08243	-.14135	.06621	-.04111	.13169
SDITCHS	-.05654	-.06567	-.06153	.04835	-.03106	.12814	-.05943	-.02877

	BUSB	BUSS	GRADE	CURVE	HUMP	RUMBLE	SDITCHB	SDITCHS
BUSB	-	-.05339	-.06128	-.05342	.35630	-.00720	-.10081	.02165
BUSS	-.05339	-	.16101	-.10160	.18022	-.04905	-.06422	-.04332
GRADE	-.06128	.16101	-	-.03760	.16535	-.05629	-.07370	-.04972
CURVE	-.05342	-.10160	-.03760	-	-.08891	.01766	-.01240	.06959
HUMP	.35630	.18022	.16535	-.08891	-	-.09880	-.12936	-.08726
RUMBLE	-.00720	-.04905	-.05629	.01766	-.09880	-	-.09957	-.06716
SDITCHB	-.10081	-.06422	-.07370	-.01240	-.12936	-.09957	-	-.08794
SDITCHS	.02165	-.04332	-.04972	.06959	-.08726	-.06716	-.08794	-

	SRB	SRS	MLA	HLA	BUILDR	TREE	BRIDG	CULVER
DDITCHB	-.03529	.04171	-.04929	.10007	-.08260	.03467	.00688	.02933
DDITCHS	-.08634	.13081	-.00691	-.09330	.01360	.01459	-.04245	.06073
PATHBB	-.06419	-.02117	-.06307	-.06307	.04314	-.01003	-.06091	.06022
PATHBS	-.03920	.07240	.04771	-.06643	.10574	-.08144	-.01541	-.04526
INTER	.32236	-.04772	-.02070	.32426	-.03469	-.07767	-.01999	-.01748
PATHP	-.04546	-.08147	-.04467	-.04467	.12857	.09723	.04609	-.03772
ONPARKB	-.03453	.00112	.11259	.28476	.05321	-.14259	-.04090	-.03577
ONPARKS	-.03763	.12500	.10160	-.02866	.11688	-.10684	-.04340	-.03795

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Correlation Matrix for Listed Variables (Continue)

	BUSB	BUSS	GRADE	CURVE	HUMP	RUMBLE	SDITCHB	SDITCHS
DDITCHB	-.04569	.15046	.14119	-.02907	-.06990	.08462	-.07044	-.04752
DDITCHS	-.00656	.01761	-.07538	.02725	.15531	.05828	-.13333	-.08994
PATHBB	.23411	-.04440	-.05096	.10771	.04313	.04186	-.09014	-.06080
PATHBS	.01950	.06329	-.05367	-.08725	-.03087	-.07251	.05781	-.05225
INTER	-.02459	-.01457	-.01672	-.04679	-.02935	-.02259	-.02958	-.01995
PATHP	-.05308	-.03145	-.03609	-.03257	-.06335	-.04876	-.06384	-.04307
ONPARKB	-.03548	.39704	-.03422	-.09575	-.06006	-.04623	-.04773	.11922
ONPARKS	.07298	-.00921	-.03631	-.10160	-.06373	.04148	-.06422	-.04332

	DDITCHB	DDITCHS	PATHBB	PATHBS	INTER	PATHP	ONPARKB	ONPARKS
DDITCHB	-	-.07204	-.04870	-.05130	-.01598	-.03450	.16309	-.01413
DDITCHS	-.07204	-	-.00489	-.00534	-.03025	.02539	-.06190	-.06568
PATHBB	-.04870	-.00489	-	-.06564	-.02045	-.04414	-.04185	-.04440
PATHBS	-.05130	-.00534	-.06564	-	-.02154	.17319	.00580	.20479
INTER	-.01598	-.03025	-.02045	-.02154	-	-.01449	-.01373	-.01457
PATHP	-.03450	.02539	-.04414	.17319	-.01449	-	-.02964	-.03145
ONPARKB	.16309	-.06190	-.04185	.00580	-.01373	-.02964	-	-.02982
ONPARKS	-.01413	-.06568	-.04440	.20479	-.01457	-.03145	-.02982	-

	SRB	SRS	MLA	HLA	BUILDAR	TREE	BRIDG	CULVER
OFPARKB	-.02210	.10392	.01119	.30730	-.03639	-.08148	-.02097	-.01834
OFPARKS	-.03064	.07969	-.00621	.20882	-.05045	-.11297	-.02907	-.02542
FSB	-.01883	-.04265	-.01850	.28983	-.03100	-.06942	-.01787	-.01562
FSS	.05173	.09658	-.06421	.06515	.03892	-.07360	-.06201	-.05422
EARTSB	.03345	.03058	.04788	.04788	.07017	-.11149	.01211	.04043
EARTHS	.02210	.03295	.02172	.02172	.03639	-.09018	.02097	.01834
NONML	.08855	.02789	.09011	**.67281**	-.08717	-.19519	-.00219	-.04393
CHOICE	.14559	.18795	.20313	.26620	.15581	-.23677	.06513	-.06889

	BUSB	BUSS	GRADE	CURVE	HUMP	RUMBLE	SDITCHB	SDITCHS
OFPARKB	.00257	.39259	-.01754	-.04909	-.03079	-.02370	-.03103	-.02093
OFPARKS	-.01517	.30791	-.02432	-.06806	-.04269	-.01072	-.04302	-.02902
FSB	-.02198	.41168	-.01495	-.04183	-.02624	-.02019	-.02644	-.01783
FSS	-.06615	-.02900	-.05188	-.14516	-.09105	-.05918	-.00433	.04742
EARTSB	.03042	.03371	.03868	-.14561	.05087	-.24638	.06842	.04616
EARTHS	.02580	.01529	.01754	.04909	.03079	.02370	.03103	.02093
NONML	.30590	-.01704	-.04203	-.11760	.08397	-.05677	-.07434	-.05015
CHOICE	.28793	.18502	.10268	.12788	.36652	.11706	-.11665	-.05450

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Correlation Matrix for Listed Variables (Continue)

	DDITCHB	DDITCHS	PATHBB	PATHBS	INTER	PATHP	ONPARKB	ONPARKS
OFPARKB	.35741	-.03174	-.02146	-.02260	-.00704	-.01520	.46480	-.01529
OFPARKS	.00694	-.04400	-.02975	-.03133	-.00976	-.02107	.29322	.34082
FSB	-.01429	-.02704	-.01828	-.01925	-.00600	-.01295	.43681	-.01302
FSS	-.04958	.07803	.05539	-.06682	.32236	-.04493	.12867	.11677
EARTSB	-.54475	-.15431	.03180	.04983	.01552	-.10074	.03177	.03371
EARTHS	.01677	-.20871	.02146	.02260	.00704	.01520	.01441	.01529
NONML	-.04017	-.07603	-.05140	-.05414	-.01687	-.03640	-.01381	-.03662
CHOICE	.05478	.10443	.08284	.10236	.08993	.01885	.13538	.07772

	OFPARKB	OFPARKS	FSB	FSS	EARTSB	EARTHS	NONML	CHOICE
OFPARKB	-	-.01024	-.00629	-.02184	.01629	.00739	.02186	.09435
OFPARKS	-.01024	-	.61452	.23118	.02258	.01024	-.02453	.07831
FSB	-.00629	.61452	-	-.01861	.01388	.00629	-.01508	.08038
FSS	-.02184	.23118	-.01861	-	.04816	.02184	-.05232	.06492
EARTSB	.01629	.02258	.01388	.04816	-	-.01629	.03902	-.06354
EARTHS	.00739	.01024	.00629	.02184	-.01629	-	.01770	.02956
NONML	.02186	-.02453	-.01508	-.05232	.03902	.01770	-	.18140
CHOICE	.09435	.07831	.08038	.06492	-.06354	.02956	.18140	-

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Appendix C
Program output

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Step 1

```
+----------------------------------------------+
| Generalized Maximum Entropy (Logit)          |
| Maximum Likelihood Estimates                 |
| Model estimated: Jan 24, 2012 at 00:27:17PM.|
| Dependent variable              CHOICE       |
| Weighting variable                None       |
| Number of observations            1500       |
| Iterations completed                11       |
| Log likelihood function      -6036.607       |
| Number of parameters                62       |
| Info. Criterion: AIC =         8.13148       |
|   Finite Sample: AIC =         8.13510       |
| Info. Criterion: BIC =         8.35109       |
| Info. Criterion:HQIC =         8.21329       |
| Number of support points =           3       |
| Weights in support scaled to 1/sqr(N)        |
+----------------------------------------------+
+--------+--------------+----------------+--------+--------+----------+
|Variable| Coefficient  | Standard Error |b/St.Er.|P[|Z|>z]| Mean of X|
+--------+--------------+----------------+--------+--------+----------+
---------+Characteristics in numerator of Prob[Y = 1]
 Constant|    1.59823425      1.47096739     1.087   .2772
 SRB     |    1.35137012       .35940233     3.760   .0002    .12266667
 SRS     |    1.77446333       .22707987     7.814   .0000    .26600000
 MLA     |    3.40210079      1.15909230     2.935   .0033    .06000000
 HLA     |     .61854848      2.20361236      .281   .7789    .06000000
 BUILDAR |    2.33252472       .34004802     6.859   .0000    .15333333
 TREE    |     .22574494       .18946956     1.191   .2335    .47466667
 BRIDG   |     .01875393       .00423171     4.432   .0000   6.51333333
 CULVER  |     .96819946       .29656481     3.265   .0011    .05333333
 BUSB    |    2.50283587      1.10942828     2.256   .0241    .08266667
 BUSS    |    1.18927279      2.36997341      .502   .6158    .03066667
 CURVE   |    2.24450797       .23322973     9.624   .0000    .24600000
 HUMP    |    2.37675186       .82736290     2.873   .0041    .15333333
 RUMBLE  |    2.21712437       .53404912     4.152   .0000    .07066667
 SDITCHB |    1.14407139       .23392601     4.891   .0000    .11533333
 SDITCHS |     .73382742       .32777570     2.239   .0252    .05600000
 DDITCHB |    1.23578342       .80318561     1.539   .1239    .03666667
 DDITCHS |     .64373884       .37069476     1.737   .0825    .12000000
 PATHBB  |     .81392090       .47904411     1.699   .0893    .05866667
 PATHBS  |     .01385984       .04826513      .287   .7740   -.60133333
 INTER   |    -.00554418       .01969225     -.282   .7783   -.65933333
 PATHP   |    1.16717479       .34616172     3.372   .0007    .04800000
 ONPARKB |    -.00281965       .03283699     -.086   .9316   -.63866667
 ONPARKS |    3.69482315      2.05069625     1.802   .0716    .03066667
 OFPARKB |    -.00454942       .02028655     -.224   .8226   -.65866667
 OFPARKS |   -1.70587744      4.25308703     -.401   .6884    .01400000
 FSB     |     .07123790      6.28953356      .011   .9910    .01066667
 FSS     |    2.86376004       .60578178     4.727   .0000    .06066667
 EARTSB  |   -1.84228446      1.19670680    -1.539   .1237    .96533333
 EARTHS  |   -1.30281926       .79464150    -1.640   .1011    .99266667
 NONML   |     .06202283      1.55528538      .040   .9682    .04066667
---------+Characteristics in numerator of Prob[Y = 2]
 Constant|    1.07122865      1.62672991      .659   .5102
 SRB     |    1.51105927       .37283340     4.053   .0001    .12266667
 SRS     |    2.26670317       .25016267     9.061   .0000    .26600000
 MLA     |    4.78937522      1.15532581     4.145   .0000    .06000000
```

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```
 HLA      |    4.42346382      2.16519551      2.043   .0411     .06000000
 BUILDAR |    2.69352588       .36412416      7.397   .0000     .15333333
 TREE     |     .03314447       .21812608       .152   .8792     .47466667
 BRIDG    |     .02173336       .00441956      4.918   .0000    6.51333333
 CULVER   |     .76882081       .37707815      2.039   .0415     .05333333
 BUSB     |    3.58885520      1.10571266      3.246   .0012     .08266667
 BUSS     |    1.71983624      2.27639627       .756   .4499     .03066667
 CURVE    |    2.62780479       .25841806     10.169   .0000     .24600000
 HUMP     |    5.18649144       .79966745      6.486   .0000     .15333333
 RUMBLE   |    3.07380101       .54541246      5.636   .0000     .07066667
 SDITCHB |    1.28407315       .28684610      4.477   .0000     .11533333
 SDITCHS |     .78176240       .40175612      1.946   .0517     .05600000
 DDITCHB |    1.18203458       .85784993      1.378   .1682     .03666667
 DDITCHS |     .50136296       .40535987      1.237   .2161     .12000000
 PATHBB   |    1.14061094       .50704438      2.250   .0245     .05866667
 PATHBS   |     .02506352       .05243568       .478   .6327   -.60133333
 INTER    |     .00165254       .03645868       .045   .9638   -.65933333
 PATHP    |    1.55851393       .36960519      4.217   .0000     .04800000
 ONPARKB |     .01489796       .04805496       .310   .7565   -.63866667
 ONPARKS |    4.07880398      2.05785958      1.982   .0475     .03066667
 OFPARKB |     .00337969       .04005904       .084   .9328   -.65866667
 OFPARKS |   -2.30447575      4.25697424      -.541   .5883     .01400000
 FSB      |    2.48529008      4.05308388       .613   .5398     .01066667
 FSS      |    2.96621167       .64012509      4.634   .0000     .06066667
 EARTSB   |   -2.15828976      1.22926325     -1.756   .0791     .96533333
 EARTHS   |   -1.59276874      1.00255845     -1.589   .1121     .99266667
 NONML    |    -.82830279      1.57510330      -.526   .5990     .04066667

+----------------------------------------------------------------------+
| Information Statistics for Discrete Choice Model.                    |
|                            M=Model MC=Constants Only   M0=No Model |
| Criterion F (log L)     -6036.60735      -6541.65965   -6591.67373 |
| LR Statistic vs. MC      1010.10461           .00000        .00000 |
| Degrees of Freedom         60.00000           .00000        .00000 |
| Prob. Value for LR           .00000           .00000        .00000 |
| Entropy for probs.       1103.65835       1598.13875    1647.91843 |
| Normalized Entropy           .66973           .96979       1.00000 |
| Entropy Ratio Stat.      1088.52017         99.55937        .00000 |
| Bayes Info Criterion        8.34134          9.01474       9.08143 |
| BIC(no model) - BIC          .74009           .06669        .00000 |
| Pseudo R-squared             .33027           .00000        .00000 |
| Pct. Correct Pred.         66.20000         39.86667      33.33333 |
| Means:       y=0    y=1    y=2    y=3    y=4    y=5     y=6   y>=7 |
| Outcome     .2160  .3987  .3853  .0000  .0000  .0000  .0000  .0000 |
| Pred.Pr     .2178  .3978  .3844  .0000  .0000  .0000  .0000  .0000 |
| Notes: Entropy computed as Sum(i)Sum(j)Pfit(i,j)*logPfit(i,j).       |
|        Normalized entropy is computed against M0.                    |
|        Entropy ratio statistic is computed against M0.               |
|        BIC = 2*criterion - log(N)*degrees of freedom.                |
|        If the model has only constants or if it has no constants,    |
|        the statistics reported here are not useable.                 |
+----------------------------------------------------------------------+
Frequencies of actual & predicted outcomes
Predicted outcome has maximum probability.

            Predicted
------  ---------------  +  -----
Actual      0    1    2  |  Total
```

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0	211	111	2	324
1	79	442	77	598
2	21	217	340	578
Total	311	770	419	1500

Step-2

```
+---------------------------------------------+
| Generalized Maximum Entropy (Logit)         |
| Maximum Likelihood Estimates                |
| Model estimated: Jan 24, 2012 at 00:28:28PM.|
| Dependent variable               CHOICE     |
| Weighting variable                 None     |
| Number of observations             1500     |
| Iterations completed                 10     |
| Log likelihood function       -6037.397     |
| Number of parameters                 60     |
| Info. Criterion: AIC =          8.12986     |
|   Finite Sample: AIC =          8.13325     |
| Info. Criterion: BIC =          8.34239     |
| Info. Criterion:HQIC =          8.20904     |
| Number of support points =            3     |
| Weights in support scaled to 1/sqr(N)       |
+---------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
Characteristics in numerator of Prob[Y = 1]					
Constant	1.60179959	1.47097214	1.089	.2762	
SRB	1.35068855	.35943114	3.758	.0002	.12266667
SRS	1.77778901	.22698990	7.832	.0000	.26600000
MLA	3.40159706	1.15879760	2.935	.0033	.06000000
HLA	.62226774	2.20387290	.282	.7777	.06000000
BUILDAR	2.33710485	.33985679	6.877	.0000	.15333333
TREE	.22427619	.18944367	1.184	.2365	.47466667
BRIDG	.01875403	.00423175	4.432	.0000	6.51333333
CULVER	.96844470	.29657468	3.265	.0011	.05333333
BUSB	2.49963619	1.10945066	2.253	.0243	.08266667
BUSS	1.19487661	2.37017968	.504	.6142	.03066667
CURVE	2.24727510	.23315933	9.638	.0000	.24600000
HUMP	2.37238054	.82737126	2.867	.0041	.15333333
RUMBLE	2.21617787	.53404974	4.150	.0000	.07066667
SDITCHB	1.14381545	.23394138	4.889	.0000	.11533333
SDITCHS	.73204229	.32789333	2.233	.0256	.05600000
DDITCHB	1.23522167	.80311437	1.538	.1240	.03666667
DDITCHS	.64162465	.37075008	1.731	.0835	.12000000
PATHBB	.81150302	.47907826	1.694	.0903	.05866667
PATHBS	.01365061	.04821377	.283	.7771	-.60133333
INTER	-.00553995	.01967612	-.282	.7783	-.65933333
PATHP	1.16601360	.34624529	3.368	.0008	.04800000
ONPARKS	3.69181430	2.05063569	1.800	.0718	.03066667
OFPARKB	-.00455182	.02029832	-.224	.8226	-.65866667
OFPARKS	-1.70523875	4.25270522	-.401	.6884	.01400000
FSB	.06491253	6.28930903	.010	.9918	.01066667
FSS	2.86264310	.60582488	4.725	.0000	.06066667
EARTSB	-1.84286281	1.19669131	-1.540	.1236	.96533333

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```
 EARTHS  |   -1.30593692      .79469126    -1.643   .1003    .99266667
 NONML   |     .06215759     1.55522924      .040   .9681    .04066667
---------+Characteristics in numerator of Prob[Y = 2]
 Constant|    1.06147117     1.62652380      .653   .5140
 SRB     |    1.51221002      .37277678     4.057   .0000    .12266667
 SRS     |    2.25839224      .24998603     9.034   .0000    .26600000
 MLA     |    4.79789250     1.15504775     4.154   .0000    .06000000
 HLA     |    4.43582214     2.16538861     2.049   .0405    .06000000
 BUILDAR |    2.68203475      .36389985     7.370   .0000    .15333333
 TREE    |     .03686991      .21812237      .169   .8658    .47466667
 BRIDG   |     .02172572      .00441937     4.916   .0000   6.51333333
 CULVER  |     .76847448      .37693339     2.039   .0415    .05333333
 BUSB    |    3.58732955     1.10552524     3.245   .0012    .08266667
 BUSS    |    1.71939056     2.27661781      .755   .4501    .03066667
 CURVE   |    2.62027736      .25826957    10.146   .0000    .24600000
 HUMP    |    5.18548565      .79962837     6.485   .0000    .15333333
 RUMBLE  |    3.07382852      .54531698     5.637   .0000    .07066667
 SDITCHB |    1.28418497      .28679702     4.478   .0000    .11533333
 SDITCHS |     .78740059      .40136068     1.962   .0498    .05600000
 DDITCHB |    1.18355695      .85788346     1.380   .1677    .03666667
 DDITCHS |     .50718933      .40525100     1.252   .2107    .12000000
 PATHBB  |    1.14473057      .50689796     2.258   .0239    .05866667
 PATHBS  |     .02532749      .05254058      .482   .6298   -.60133333
 INTER   |     .00163763      .03638872      .045   .9641   -.65933333
 PATHP   |    1.55980640      .36939233     4.223   .0000    .04800000
 ONPARKS |    4.08543336     2.05780677     1.985   .0471    .03066667
 OFPARKB |     .00338788      .04009914      .084   .9327   -.65866667
 OFPARKS |   -2.30764442     4.25658012     -.542   .5877    .01400000
 FSB     |    2.48758181     4.05283848      .614   .5394    .01066667
 FSS     |    2.96962189      .63990617     4.641   .0000    .06066667
 EARTSB  |   -2.15592078     1.22919428    -1.754   .0794    .96533333
 EARTHS  |   -1.58380972     1.00222463    -1.580   .1140    .99266667
 NONML   |    -.83667409     1.57496087     -.531   .5953    .04066667

+----------------------------------------------------------------------+
| Information Statistics for Discrete Choice Model.                    |
|                           M=Model MC=Constants Only   M0=No Model |
| Criterion F (log L)    -6037.39709     -6541.65965   -6591.67373 |
| LR Statistic vs. MC     1008.52512          .00000        .00000 |
| Degrees of Freedom        58.00000          .00000        .00000 |
| Prob. Value for LR          .00000          .00000        .00000 |
| Entropy for probs.      1104.41909      1598.13875    1647.91843 |
| Normalized Entropy          .67019          .96979       1.00000 |
| Entropy Ratio Stat.     1086.99869        99.55937        .00000 |
| Bayes Info Criterion       8.33264         9.00499       9.07168 |
| BIC(no model) - BIC         .73904          .06669        .00000 |
| Pseudo R-squared            .32981          .00000        .00000 |
| Pct. Correct Pred.        66.13333        39.86667      33.33333 |
| Means:        y=0    y=1    y=2    y=3    y=4    y=5    y=6   y>=7 |
| Outcome      .2160  .3987  .3853  .0000  .0000  .0000  .0000  .0000 |
| Pred.Pr      .2178  .3978  .3844  .0000  .0000  .0000  .0000  .0000 |
| Notes: Entropy computed as Sum(i)Sum(j)Pfit(i,j)*logPfit(i,j).       |
|        Normalized entropy is computed against M0.                    |
|        Entropy ratio statistic is computed against M0.               |
|        BIC = 2*criterion - log(N)*degrees of freedom.                |
|        If the model has only constants or if it has no constants,    |
|        the statistics reported here are not useable.                 |
+----------------------------------------------------------------------+
```

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```
Frequencies of actual & predicted outcomes
Predicted outcome has maximum probability.

             Predicted
------  ---------------  +  -----
Actual       0    1    2  |  Total
------  ---------------  +  -----
  0        211  111    2  |    324
  1         79  441   78  |    598
  2         21  217  340  |    578
------  ---------------  +  -----
Total      311  769  420  |   1500
-->
```

Step- 3

```
+----------------------------------------------+
| Generalized Maximum Entropy (Logit)          |
| Maximum Likelihood Estimates                 |
| Model estimated: Jan 24, 2012 at 00:33:26PM.|
| Dependent variable               CHOICE     |
| Weighting variable                 None     |
| Number of observations             1500     |
| Iterations completed                 10     |
| Log likelihood function       -6037.927     |
| Number of parameters                 58     |
| Info. Criterion: AIC =          8.12790     |
|   Finite Sample: AIC =          8.13107     |
| Info. Criterion: BIC =          8.33335     |
| Info. Criterion:HQIC =          8.20444     |
| Number of support points =           3     |
| Weights in support scaled to 1/sqr(N)       |
+----------------------------------------------+
+---------+--------------+----------------+--------+--------+----------+
|Variable| Coefficient  | Standard Error |b/St.Er.|P[|Z|>z]| Mean of X|
+---------+--------------+----------------+--------+--------+----------+
---------+Characteristics in numerator of Prob[Y = 1]
 Constant|    1.59351069      1.47108727     1.083   .2787
 SRB     |    1.35058436       .35944586     3.757   .0002    .12266667
 SRS     |    1.77792444       .22701366     7.832   .0000    .26600000
 MLA     |    3.40356430      1.15885052     2.937   .0033    .06000000
 HLA     |     .63040625      2.20403997      .286   .7749    .06000000
 BUILDAR |    2.33625157       .33989039     6.874   .0000    .15333333
 TREE    |     .22696935       .18943997     1.198   .2309    .47466667
 BRIDG   |     .01876314       .00423167     4.434   .0000   6.51333333
 CULVER  |     .96565731       .29637820     3.258   .0011    .05333333
 BUSB    |    2.48213614      1.10899565     2.238   .0252    .08266667
 BUSS    |    1.19107354      2.36987934      .503   .6153    .03066667
 CURVE   |    2.25139458       .23316383     9.656   .0000    .24600000
 HUMP    |    2.37392633       .82740356     2.869   .0041    .15333333
 RUMBLE  |    2.21262422       .53389109     4.144   .0000    .07066667
 SDITCHB |    1.14435505       .23397792     4.891   .0000    .11533333
 SDITCHS |     .73151744       .32790895     2.231   .0257    .05600000
 DDITCHB |    1.23823961       .80327833     1.541   .1232    .03666667
 DDITCHS |     .64325635       .37073822     1.735   .0827    .12000000
 PATHBB  |     .84075007       .47685996     1.763   .0779    .05866667
 PATHBS  |     .01374723       .04823804      .285   .7757   -.60133333
```

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```
 INTER   |   -.00553798       .01967717      -.281   .7784   -.65933333
 PATHP   |   1.16609928       .34622665      3.368   .0008    .04800000
 ONPARKS |   3.69418631      2.05107383      1.801   .0717    .03066667
 OFPARKS |  -1.70448975      4.25314605      -.401   .6886    .01400000
 FSB     |    .06339070      6.28946751       .010   .9920    .01066667
 FSS     |   2.86121036       .60585577      4.723   .0000    .06066667
 EARTSB  |  -1.83879876      1.19686881     -1.536   .1245    .96533333
 EARTHS  |  -1.30375286       .79466899     -1.641   .1009    .99266667
 NONML   |    .06268481      1.55529956       .040   .9679    .04066667
---------+Characteristics in numerator of Prob[Y = 2]
 Constant|   1.06316007      1.62665878       .654   .5134
 SRB     |   1.51278707       .37280848      4.058   .0000    .12266667
 SRS     |   2.25960005       .25001529      9.038   .0000    .26600000
 MLA     |   4.79768551      1.15511649      4.153   .0000    .06000000
 HLA     |   4.43677496      2.16565033      2.049   .0405    .06000000
 BUILDAR |   2.68405681       .36391390      7.376   .0000    .15333333
 TREE    |    .03484637       .21808135       .160   .8730    .47466667
 BRIDG   |    .02172779       .00441911      4.917   .0000   6.51333333
 CULVER  |    .76672008       .37673791      2.035   .0418    .05333333
 BUSB    |   3.58351073      1.10525647      3.242   .0012    .08266667
 BUSS    |   1.72108459      2.27631840       .756   .4496    .03066667
 CURVE   |   2.62110220       .25833125     10.146   .0000    .24600000
 HUMP    |   5.18532419       .79967029      6.484   .0000    .15333333
 RUMBLE  |   3.07188299       .54523842      5.634   .0000    .07066667
 SDITCHB |   1.28604441       .28683534      4.484   .0000    .11533333
 SDITCHS |    .78746611       .40147617      1.961   .0498    .05600000
 DDITCHB |   1.18504587       .85800250      1.381   .1672    .03666667
 DDITCHS |    .50780624       .40527302      1.253   .2102    .12000000
 PATHBB  |   1.14834759       .50532773      2.272   .0231    .05866667
 PATHBS  |    .02522862       .05250028       .481   .6308   -.60133333
 INTER   |    .00163890       .03639264       .045   .9641   -.65933333
 PATHP   |   1.55995285       .36945162      4.222   .0000    .04800000
 ONPARKS |   4.08426214      2.05826869      1.984   .0472    .03066667
 OFPARKS |  -2.30966492      4.25705994      -.543   .5874    .01400000
 FSB     |   2.48728482      4.05313235       .614   .5394    .01066667
 FSS     |   2.97089428       .63992178      4.643   .0000    .06066667
 EARTSB  |  -2.15638971      1.22939087     -1.754   .0794    .96533333
 EARTHS  |  -1.58506207      1.00224864     -1.582   .1138    .99266667
 NONML   |   -.83695743      1.57509314      -.531   .5952    .04066667

+----------------------------------------------------------------------+
| Information Statistics for Discrete Choice Model.                    |
|                             M=Model MC=Constants Only   M0=No Model |
| Criterion F (log L)    -6037.92671       -6541.65965    -6591.67373 |
| LR Statistic vs. MC     1007.46588            .00000         .00000 |
| Degrees of Freedom        56.00000            .00000         .00000 |
| Prob. Value for LR          .00000            .00000         .00000 |
| Entropy for probs.      1104.93979        1598.13875     1647.91843 |
| Normalized Entropy          .67051            .96979        1.00000 |
| Entropy Ratio Stat.     1085.95728          99.55937         .00000 |
| Bayes Info Criterion       8.32360           8.99524        9.06193 |
| BIC(no model) - BIC         .73833            .06669         .00000 |
| Pseudo R-squared            .32949            .00000         .00000 |
| Pct. Correct Pred.        66.13333          39.86667       33.33333 |
| Means:        y=0    y=1    y=2    y=3    y=4    y=5    y=6   y>=7 |
| Outcome     .2160  .3987  .3853  .0000  .0000  .0000  .0000  .0000 |
| Pred.Pr     .2178  .3978  .3844  .0000  .0000  .0000  .0000  .0000 |
| Notes: Entropy computed as Sum(i)Sum(j)Pfit(i,j)*logPfit(i,j).       |
```

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```
|        Normalized entropy is computed against M0.                     |
|        Entropy ratio statistic is computed against M0.                |
|        BIC = 2*criterion - log(N)*degrees of freedom.                 |
|        If the model has only constants or if it has no constants,    |
|        the statistics reported here are not useable.                  |
+-----------------------------------------------------------------------+
Frequencies of actual & predicted outcomes
Predicted outcome has maximum probability.

            Predicted
------  ---------------  +  -----
Actual      0    1    2  |  Total
------  ---------------  +  -----
  0       211  111    2  |    324
  1        79  441   78  |    598
  2        21  217  340  |    578
------  ---------------  +  -----
Total     311  769  420  |   1500
-->
```

Step -4

```
+---------------------------------------------+
| Generalized Maximum Entropy (Logit)         |
| Maximum Likelihood Estimates                |
| Model estimated: Jan 24, 2012 at 00:34:19PM.|
| Dependent variable               CHOICE     |
| Weighting variable                 None     |
| Number of observations             1500     |
| Iterations completed                 10     |
| Log likelihood function       -6038.869     |
| Number of parameters                 56     |
| Info. Criterion: AIC =          8.12649     |
|   Finite Sample: AIC =          8.12944     |
| Info. Criterion: BIC =          8.32485     |
| Info. Criterion:HQIC =          8.20039     |
| Number of support points =            3     |
| Weights in support scaled to 1/sqr(N)       |
+---------------------------------------------+
+--------+--------------+----------------+--------+--------+----------+
|Variable| Coefficient  | Standard Error |b/St.Er.|P[|Z|>z]| Mean of X|
+--------+--------------+----------------+--------+--------+----------+
---------+Characteristics in numerator of Prob[Y = 1]
 Constant|    1.60119682      1.47098671     1.089   .2764
 SRB     |    1.34952419       .35965790     3.752   .0002    .12266667
 SRS     |    1.77525727       .22685867     7.825   .0000    .26600000
 MLA     |    3.34333479       .83781645     3.991   .0001    .06000000
 HLA     |     .46456924      1.74177210      .267   .7897    .06000000
 BUILDAR |    2.33697482       .33976760     6.878   .0000    .15333333
 TREE    |     .22475953       .18932242     1.187   .2352    .47466667
 BRIDG   |     .01872428       .00422907     4.428   .0000   6.51333333
 CULVER  |     .96174775       .29626572     3.246   .0012    .05333333
 BUSB    |    2.48512518      1.11147820     2.236   .0254    .08266667
 BUSS    |    1.14971119      2.40724659      .478   .6329    .03066667
 CURVE   |    2.24601132       .23299747     9.640   .0000    .24600000
 HUMP    |    2.38214235       .82605232     2.884   .0039    .15333333
 RUMBLE  |    2.20958433       .53389708     4.139   .0000    .07066667
```

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SDITCHB	1.14104966	.23381911	4.880	.0000	.11533333
SDITCHS	.72725353	.32776212	2.219	.0265	.05600000
DDITCHB	1.23142416	.80364830	1.532	.1255	.03666667
DDITCHS	.64191726	.37067462	1.732	.0833	.12000000
PATHBB	.84029846	.47690612	1.762	.0781	.05866667
PATHBS	.01364952	.04820999	.283	.7771	-.60133333
INTER	-.00559998	.02034049	-.275	.7831	-.65933333
PATHP	1.16341269	.34622630	3.360	.0008	.04800000
ONPARKS	3.65754093	2.01802234	1.812	.0699	.03066667
OFPARKS	-1.51724101	4.19164148	-.362	.7174	.01400000
FSB	.06926590	6.24245634	.011	.9911	.01066667
FSS	2.85604667	.60594583	4.713	.0000	.06066667
EARTSB	-1.84260856	1.19690710	-1.539	.1237	.96533333
EARTHS	-1.29942896	.79461818	-1.635	.1020	.99266667
	Characteristics in numerator of Prob[Y = 2]				
Constant	1.03017426	1.62608990	.634	.5264	
SRB	1.52649631	.37278611	4.095	.0000	.12266667
SRS	2.27514199	.25002823	9.100	.0000	.26600000
MLA	4.55932981	.84376829	5.404	.0000	.06000000
HLA	3.71566954	1.65870022	2.240	.0251	.06000000
BUILDAR	2.69123677	.36423431	7.389	.0000	.15333333
TREE	.03914358	.21839724	.179	.8578	.47466667
BRIDG	.02184444	.00441893	4.943	.0000	6.51333333
CULVER	.77878775	.37674072	2.067	.0387	.05333333
BUSB	3.59315016	1.10824196	3.242	.0012	.08266667
BUSS	1.82944081	2.31390072	.791	.4292	.03066667
CURVE	2.64279912	.25798290	10.244	.0000	.24600000
HUMP	5.20079709	.79914061	6.508	.0000	.15333333
RUMBLE	3.08691752	.54534408	5.660	.0000	.07066667
SDITCHB	1.29963085	.28704312	4.528	.0000	.11533333
SDITCHS	.80396734	.40066200	2.007	.0448	.05600000
DDITCHB	1.22446875	.85550959	1.431	.1524	.03666667
DDITCHS	.51052081	.40547843	1.259	.2080	.12000000
PATHBB	1.15303136	.50573208	2.280	.0226	.05866667
PATHBS	.02535699	.05255712	.482	.6295	-.60133333
INTER	.00198872	.03902903	.051	.9594	-.65933333
PATHP	1.57217622	.36958121	4.254	.0000	.04800000
ONPARKS	4.07733662	2.02501351	2.013	.0441	.03066667
OFPARKS	-2.13610712	4.18907047	-.510	.6101	.01400000
FSB	2.72119404	3.97745003	.684	.4939	.01066667
FSS	2.99866255	.63913988	4.692	.0000	.06066667
EARTSB	-2.13210258	1.22857729	-1.735	.0827	.96533333
EARTHS	-1.60499042	1.00251426	-1.601	.1094	.99266667

Information Statistics for Discrete Choice Model.	M=Model	MC=Constants Only	M0=No Model
Criterion F (log L)	-6038.86939	-6541.65965	-6591.67373
LR Statistic vs. MC	1005.58051	.00000	.00000
Degrees of Freedom	54.00000	.00000	.00000
Prob. Value for LR	.00000	.00000	.00000
Entropy for probs.	1105.76523	1598.13875	1647.91843
Normalized Entropy	.67101	.96979	1.00000
Entropy Ratio Stat.	1084.30641	99.55937	.00000
Bayes Info Criterion	8.31510	8.98549	9.05217
BIC(no model) - BIC	.73707	.06669	.00000
Pseudo R-squared	.32899	.00000	.00000
Pct. Correct Pred.	65.93333	39.86667	33.33333

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```
| Means:        y=0    y=1    y=2    y=3    y=4    y=5     y=6   y>=7 |
| Outcome     .2160  .3987  .3853  .0000  .0000  .0000  .0000  .0000 |
| Pred.Pr     .2178  .3978  .3844  .0000  .0000  .0000  .0000  .0000 |
| Notes: Entropy computed as Sum(i)Sum(j)Pfit(i,j)*logPfit(i,j).     |
|        Normalized entropy is computed against M0.                  |
|        Entropy ratio statistic is computed against M0.             |
|        BIC = 2*criterion - log(N)*degrees of freedom.              |
|        If the model has only constants or if it has no constants,  |
|        the statistics reported here are not useable.               |
+--------------------------------------------------------------------+
Frequencies of actual & predicted outcomes
Predicted outcome has maximum probability.

            Predicted
------  ---------------  +  -----
Actual      0    1    2  |  Total
------  ---------------  +  -----
  0       211  110    3  |    324
  1        79  435   84  |    598
  2        21  214  343  |    578
------  ---------------  +  -----
Total     311  759  430  |   1500
-->
```

Step-5

```
+---------------------------------------------+
| Generalized Maximum Entropy (Logit)         |
| Maximum Likelihood Estimates                |
| Model estimated: Jan 24, 2012 at 00:35:39PM.|
| Dependent variable               CHOICE     |
| Weighting variable                 None     |
| Number of observations             1500     |
| Iterations completed                 10     |
| Log likelihood function       -6039.712     |
| Number of parameters                 54     |
| Info. Criterion: AIC =          8.12495     |
|   Finite Sample: AIC =          8.12769     |
| Info. Criterion: BIC =          8.31623     |
| Info. Criterion:HQIC =          8.19621     |
| Number of support points =            3     |
| Weights in support scaled to 1/sqr(N)       |
+---------------------------------------------+
+---------+--------------+----------------+--------+--------+----------+
|Variable| Coefficient  | Standard Error |b/St.Er.|P[|Z|>z]| Mean of X|
+---------+--------------+----------------+--------+--------+----------+
---------+Characteristics in numerator of Prob[Y = 1]
 Constant|    1.59750930      1.47097293     1.086   .2775
 SRB     |    1.35154741       .35971026     3.757   .0002    .12266667
 SRS     |    1.77452155       .22672038     7.827   .0000    .26600000
 MLA     |    3.34321700       .83734179     3.993   .0001    .06000000
 HLA     |     .45003133      1.83747722      .245   .8065    .06000000
 BUILDAR |    2.33471364       .33992380     6.868   .0000    .15333333
 TREE    |     .22617594       .18930156     1.195   .2322    .47466667
 BRIDG   |     .01872547       .00422721     4.430   .0000   6.51333333
 CULVER  |     .96282281       .29624459     3.250   .0012    .05333333
 BUSB    |    2.47632489      1.11110122     2.229   .0258    .08266667
 BUSS    |    1.24516005      2.71130936      .459   .6461    .03066667
```

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CURVE	2.24656623	.23297251	9.643	.0000	.24600000
HUMP	2.38397893	.82224243	2.899	.0037	.15333333
RUMBLE	2.20914825	.53379780	4.139	.0000	.07066667
SDITCHB	1.14137767	.23382035	4.881	.0000	.11533333
SDITCHS	.72717112	.32778165	2.218	.0265	.05600000
DDITCHB	1.23375641	.80317799	1.536	.1245	.03666667
DDITCHS	.64350152	.37043278	1.737	.0824	.12000000
PATHBB	.84048490	.47713312	1.762	.0781	.05866667
PATHBS	.01328983	.04811843	.276	.7824	-.60133333
INTER	-.00558639	.02018261	-.277	.7819	-.65933333
PATHP	1.16537569	.34607737	3.367	.0008	.04800000
ONPARKS	3.45798792	1.85423422	1.865	.0622	.03066667
OFPARKS	1.24724205	3.82183063	.326	.7442	.01400000
FSS	2.83909509	.59892001	4.740	.0000	.06066667
EARTSB	-1.84220323	1.19685408	-1.539	.1238	.96533333
EARTHS	-1.29854884	.79448207	-1.634	.1022	.99266667

---------+Characteristics in numerator of Prob[Y = 2]

Constant	1.04141209	1.62629858	.640	.5219	
SRB	1.51974070	.37292849	4.075	.0000	.12266667
SRS	2.26355207	.24973409	9.064	.0000	.26600000
MLA	4.54359499	.84308880	5.389	.0000	.06000000
HLA	3.84542553	1.75460030	2.192	.0284	.06000000
BUILDAR	2.69914756	.36392496	7.417	.0000	.15333333
TREE	.03379711	.21818346	.155	.8769	.47466667
BRIDG	.02176419	.00441550	4.929	.0000	6.51333333
CULVER	.76902067	.37644688	2.043	.0411	.05333333
BUSB	3.56523743	1.10846275	3.216	.0013	.08266667
BUSS	2.18468813	2.62598938	.832	.4054	.03066667
CURVE	2.63356253	.25763819	10.222	.0000	.24600000
HUMP	5.15854880	.79631666	6.478	.0000	.15333333
RUMBLE	3.07835690	.54505848	5.648	.0000	.07066667
SDITCHB	1.29576321	.28678729	4.518	.0000	.11533333
SDITCHS	.80127577	.40057886	2.000	.0455	.05600000
DDITCHB	1.19978387	.85709023	1.400	.1616	.03666667
DDITCHS	.52055939	.40488658	1.286	.1986	.12000000
PATHBB	1.15738595	.50574684	2.288	.0221	.05866667
PATHBS	.02586422	.05276416	.490	.6240	-.60133333
INTER	.00191445	.03845965	.050	.9603	-.65933333
PATHP	1.56265644	.36950412	4.229	.0000	.04800000
ONPARKS	3.80200027	1.86339724	2.040	.0413	.03066667
OFPARKS	.91769286	3.77697035	.243	.8080	.01400000
FSS	2.93129018	.63225982	4.636	.0000	.06066667
EARTSB	-2.14553828	1.22923225	-1.745	.0809	.96533333
EARTHS	-1.58715027	1.00181222	-1.584	.1131	.99266667

Information Statistics for Discrete Choice Model.

	M=Model	MC=Constants Only	M0=No Model
Criterion F (log L)	-6039.71220	-6541.65965	-6591.67373
LR Statistic vs. MC	1003.89490	.00000	.00000
Degrees of Freedom	52.00000	.00000	.00000
Prob. Value for LR	.00000	.00000	.00000
Entropy for probs.	1106.74321	1598.13875	1647.91843
Normalized Entropy	.67160	.96979	1.00000
Entropy Ratio Stat.	1082.35045	99.55937	.00000
Bayes Info Criterion	8.30647	8.97574	9.04242
BIC(no model) - BIC	.73595	.06669	.00000
Pseudo R-squared	.32840	.00000	.00000

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```
| Pct. Correct Pred.       65.93333          39.86667      33.33333 |
| Means:        y=0    y=1    y=2    y=3    y=4    y=5     y=6   y>=7 |
| Outcome     .2160  .3987  .3853  .0000  .0000  .0000  .0000  .0000 |
| Pred.Pr     .2178  .3978  .3844  .0000  .0000  .0000  .0000  .0000 |
| Notes: Entropy computed as Sum(i)Sum(j)Pfit(i,j)*logPfit(i,j).     |
|        Normalized entropy is computed against M0.                  |
|        Entropy ratio statistic is computed against M0.             |
|        BIC = 2*criterion - log(N)*degrees of freedom.              |
|        If the model has only constants or if it has no constants,  |
|        the statistics reported here are not useable.               |
+--------------------------------------------------------------------+
Frequencies of actual & predicted outcomes
Predicted outcome has maximum probability.

            Predicted
------  ---------------  +  -----
Actual      0    1    2  |  Total
------  ---------------  +  -----
  0       211  110    3  |    324
  1        79  435   84  |    598
  2        21  214  343  |    578
------  ---------------  +  -----
Total     311  759  430  |   1500
-->
```

Step-6

```
+---------------------------------------------+
| Generalized Maximum Entropy (Logit)         |
| Maximum Likelihood Estimates                |
| Model estimated: Jan 24, 2012 at 00:36:44PM.|
| Dependent variable               CHOICE     |
| Weighting variable                 None     |
| Number of observations             1500     |
| Iterations completed                  8     |
| Log likelihood function       -6040.376     |
| Number of parameters                 52     |
| Info. Criterion: AIC =          8.12317     |
|   Finite Sample: AIC =          8.12571     |
| Info. Criterion: BIC =          8.30736     |
| Info. Criterion:HQIC =          8.19179     |
| Number of support points =          3     |
| Weights in support scaled to 1/sqr(N)     |
+---------------------------------------------+
+--------+--------------+---------------+--------+--------+----------+
|Variable| Coefficient  | Standard Error |b/St.Er.|P[|Z|>z]| Mean of X|
+--------+--------------+---------------+--------+--------+----------+
---------+Characteristics in numerator of Prob[Y = 1]
 Constant|    1.60601323      1.47112875     1.092   .2750
 SRB     |    1.35070144       .35973054     3.755   .0002    .12266667
 SRS     |    1.77228954       .22667828     7.819   .0000    .26600000
 MLA     |    3.33601813       .83727768     3.984   .0001    .06000000
 HLA     |     .44146699      1.83740025      .240   .8101    .06000000
 BUILDAR |    2.33175835       .33988489     6.860   .0000    .15333333
 TREE    |     .21924654       .18909191     1.159   .2463    .47466667
 BRIDG   |     .01869065       .00422640     4.422   .0000   6.51333333
 CULVER  |     .95870266       .29620718     3.237   .0012    .05333333
 BUSB    |    2.48088970      1.11108732     2.233   .0256    .08266667
```

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```
 BUSS     |    1.25065917      2.71120367       .461   .6446     .03066667
 CURVE    |    2.25668347       .23290154      9.689   .0000     .24600000
 HUMP     |    2.37826188       .82219710      2.893   .0038     .15333333
 RUMBLE   |    2.20586590       .53387197      4.132   .0000     .07066667
 SDITCHB  |    1.13743394       .23378572      4.865   .0000     .11533333
 SDITCHS  |     .72400883       .32794786      2.208   .0273     .05600000
 DDITCHB  |    1.23122433       .80333186      1.533   .1254     .03666667
 DDITCHS  |     .64275133       .37044042      1.735   .0827     .12000000
 PATHBB   |     .83431985       .47727516      1.748   .0804     .05866667
 PATHBS   |     .01317299       .04808824       .274   .7841    -.60133333
 PATHP    |    1.16544447       .34608721      3.367   .0008     .04800000
 ONPARKS  |    3.45602905      1.85416636      1.864   .0623     .03066667
 OFPARKS  |    1.24524004      3.82172699       .326   .7446     .01400000
 FSS      |    2.83782384       .59882252      4.739   .0000     .06066667
 EARTSB   |   -1.84293831      1.19715263     -1.539   .1237     .96533333
 EARTHS   |   -1.29889111       .79446753     -1.635   .1021     .99266667
---------+Characteristics in numerator of Prob[Y = 2]
 Constant|     1.04314879      1.62652489       .641   .5213
 SRB      |    1.52066052       .37295997      4.077   .0000     .12266667
 SRS      |    2.26496409       .24973348      9.070   .0000     .26600000
 MLA      |    4.54492542       .84308355      5.391   .0000     .06000000
 HLA      |    3.84561885      1.75447835      2.192   .0284     .06000000
 BUILDAR  |    2.70046553       .36393006      7.420   .0000     .15333333
 TREE     |     .03280343       .21808601       .150   .8804     .47466667
 BRIDG    |     .02177074       .00441509      4.931   .0000    6.51333333
 CULVER   |     .77012184       .37639387      2.046   .0408     .05333333
 BUSB     |    3.56756575      1.10846469      3.218   .0013     .08266667
 BUSS     |    2.18636617      2.62586112       .833   .4051     .03066667
 CURVE    |    2.64006021       .25769203     10.245   .0000     .24600000
 HUMP     |    5.15965516       .79630032      6.480   .0000     .15333333
 RUMBLE   |    3.08020721       .54514682      5.650   .0000     .07066667
 SDITCHB  |    1.29728586       .28680731      4.523   .0000     .11533333
 SDITCHS  |     .80345517       .40071919      2.005   .0450     .05600000
 DDITCHB  |    1.19929658       .85737490      1.399   .1619     .03666667
 DDITCHS  |     .52189923       .40491113      1.289   .1974     .12000000
 PATHBB   |    1.15734386       .50587736      2.288   .0221     .05866667
 PATHBS   |     .02594768       .05280058       .491   .6231    -.60133333
 PATHP    |    1.56425786       .36954068      4.233   .0000     .04800000
 ONPARKS  |    3.80297253      1.86334391      2.041   .0413     .03066667
 OFPARKS  |     .91772363      3.77687309       .243   .8080     .01400000
 FSS      |    2.93107352       .63222132      4.636   .0000     .06066667
 EARTSB   |   -2.14774227      1.22958307     -1.747   .0807     .96533333
 EARTHS   |   -1.58879822      1.00182866     -1.586   .1128     .99266667

+--------------------------------------------------------------------+
| Information Statistics for Discrete Choice Model.                  |
|                           M=Model MC=Constants Only   M0=No Model |
| Criterion F (log L)    -6040.37568        -6541.65965  -6591.67373 |
| LR Statistic vs. MC     1002.56794             .00000       .00000 |
| Degrees of Freedom        50.00000             .00000       .00000 |
| Prob. Value for LR          .00000             .00000       .00000 |
| Entropy for probs.      1107.40549         1598.13875   1647.91843 |
| Normalized Entropy          .67200             .96979      1.00000 |
| Entropy Ratio Stat.     1081.02589           99.55937       .00000 |
| Bayes Info Criterion       8.29761            8.96599      9.03267 |
| BIC(no model) - BIC         .73506             .06669       .00000 |
| Pseudo R-squared            .32800             .00000       .00000 |
| Pct. Correct Pred.        65.93333           39.86667     33.33333 |
```

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```
| Means:        y=0    y=1    y=2    y=3    y=4    y=5     y=6   y>=7 |
| Outcome     .2160  .3987  .3853  .0000  .0000  .0000  .0000  .0000 |
| Pred.Pr     .2178  .3978  .3844  .0000  .0000  .0000  .0000  .0000 |
| Notes: Entropy computed as Sum(i)Sum(j)Pfit(i,j)*logPfit(i,j).      |
|        Normalized entropy is computed against M0.                   |
|        Entropy ratio statistic is computed against M0.              |
|        BIC = 2*criterion - log(N)*degrees of freedom.               |
|        If the model has only constants or if it has no constants,   |
|        the statistics reported here are not useable.                |
+---------------------------------------------------------------------+
Frequencies of actual & predicted outcomes
Predicted outcome has maximum probability.

            Predicted
------  ---------------  +  -----
Actual       0    1    2  |  Total
------  ---------------  +  -----
  0        211  110    3  |    324
  1         79  435   84  |    598
  2         21  214  343  |    578
------  ---------------  +  -----
Total      311  759  430  |   1500
-->
```

Step -7

```
+---------------------------------------------+
| Generalized Maximum Entropy (Logit)         |
| Maximum Likelihood Estimates                |
| Model estimated: Jan 24, 2012 at 00:37:55PM.|
| Dependent variable               CHOICE     |
| Weighting variable                 None     |
| Number of observations             1500     |
| Iterations completed                  8     |
| Log likelihood function       -6041.560     |
| Number of parameters                 50     |
| Info. Criterion: AIC =          8.12208     |
|   Finite Sample: AIC =          8.12443     |
| Info. Criterion: BIC =          8.29919     |
| Info. Criterion:HQIC =          8.18806     |
| Number of support points =          3     |
| Weights in support scaled to 1/sqr(N)     |
+---------------------------------------------+
+---------+--------------+----------------+--------+--------+----------+
|Variable| Coefficient  | Standard Error |b/St.Er.|P[|Z|>z]| Mean of X|
+---------+--------------+----------------+--------+--------+----------+
---------+Characteristics in numerator of Prob[Y = 1]
 Constant|    1.58701112      1.46941923     1.080   .2801
 SRB     |    1.34743604       .35883720     3.755   .0002    .12266667
 SRS     |    1.76846430       .22664708     7.803   .0000    .26600000
 MLA     |    3.32985886       .84023861     3.963   .0001    .06000000
 HLA     |     .81583034      1.77175418      .460   .6452    .06000000
 BUILDAR |    2.32929318       .33999878     6.851   .0000    .15333333
 TREE    |     .22347485       .18822997     1.187   .2351    .47466667
 BRIDG   |     .01866262       .00420280     4.441   .0000   6.51333333
 CULVER  |     .96081140       .29594726     3.247   .0012    .05333333
 BUSB    |    2.40831577      1.08875818     2.212   .0270    .08266667
 CURVE   |    2.25627839       .23282156     9.691   .0000    .24600000
```

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HUMP	2.54228898	.79624295	3.193	.0014	.15333333
RUMBLE	2.19976089	.53369834	4.122	.0000	.07066667
SDITCHB	1.13685678	.23375103	4.864	.0000	.11533333
SDITCHS	.72009998	.32775750	2.197	.0280	.05600000
DDITCHB	1.25011510	.80139515	1.560	.1188	.03666667
DDITCHS	.63271611	.37051988	1.708	.0877	.12000000
PATHBB	.83620426	.47817084	1.749	.0803	.05866667
PATHBS	.01236508	.04784227	.258	.7961	-.60133333
PATHP	1.16017259	.34593350	3.354	.0008	.04800000
ONPARKS	3.43243641	1.82637537	1.879	.0602	.03066667
OFPARKS	2.41718999	3.17008921	.762	.4458	.01400000
FSS	2.84019448	.59788473	4.750	.0000	.06066667
EARTSB	-1.81824993	1.19492881	-1.522	.1281	.96533333
EARTHS	-1.30603675	.79470237	-1.643	.1003	.99266667
Characteristics in numerator of Prob[Y = 2]					
Constant	.98091170	1.62350674	.604	.5457	
SRB	1.50093563	.37226045	4.032	.0001	.12266667
SRS	2.25685385	.24970785	9.038	.0000	.26600000
MLA	4.59013489	.84479406	5.433	.0000	.06000000
HLA	4.52626519	1.69233077	2.675	.0075	.06000000
BUILDAR	2.70249764	.36395709	7.425	.0000	.15333333
TREE	.06897136	.21621553	.319	.7497	.47466667
BRIDG	.02163779	.00439980	4.918	.0000	6.51333333
CULVER	.78046999	.37619062	2.075	.0380	.05333333
BUSB	3.44183827	1.08778753	3.164	.0016	.08266667
CURVE	2.62677854	.25747776	10.202	.0000	.24600000
HUMP	5.46196090	.76957931	7.097	.0000	.15333333
RUMBLE	3.08541392	.54454147	5.666	.0000	.07066667
SDITCHB	1.29092756	.28650694	4.506	.0000	.11533333
SDITCHS	.79476212	.40033566	1.985	.0471	.05600000
DDITCHB	1.24146759	.85112587	1.459	.1447	.03666667
DDITCHS	.50101679	.40538270	1.236	.2165	.12000000
PATHBB	1.17541538	.50611278	2.322	.0202	.05866667
PATHBS	.02714498	.05329570	.509	.6105	-.60133333
PATHP	1.55458693	.36869890	4.216	.0000	.04800000
ONPARKS	3.73987827	1.83629645	2.037	.0417	.03066667
OFPARKS	2.27821541	3.11815481	.731	.4650	.01400000
FSS	2.90564637	.63163447	4.600	.0000	.06066667
EARTSB	-2.10189339	1.22559278	-1.715	.0863	.96533333
EARTHS	-1.58166842	1.00224840	-1.578	.1145	.99266667

Information Statistics for Discrete Choice Model.

	M=Model	MC=Constants Only	M0=No Model
Criterion F (log L)	-6041.55987	-6541.65965	-6591.67373
LR Statistic vs. MC	1000.19957	.00000	.00000
Degrees of Freedom	48.00000	.00000	.00000
Prob. Value for LR	.00000	.00000	.00000
Entropy for probs.	1108.85021	1598.13875	1647.91843
Normalized Entropy	.67288	.96979	1.00000
Entropy Ratio Stat.	1078.13646	99.55937	.00000
Bayes Info Criterion	8.28944	8.95624	9.02292
BIC(no model) - BIC	.73349	.06669	.00000
Pseudo R-squared	.32712	.00000	.00000
Pct. Correct Pred.	65.93333	39.86667	33.33333

Means:	y=0	y=1	y=2	y=3	y=4	y=5	y=6	y>=7
Outcome	.2160	.3987	.3853	.0000	.0000	.0000	.0000	.0000
Pred.Pr	.2178	.3978	.3844	.0000	.0000	.0000	.0000	.0000

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```
| Notes: Entropy computed as Sum(i)Sum(j)Pfit(i,j)*logPfit(i,j).      |
|        Normalized entropy is computed against M0.                   |
|        Entropy ratio statistic is computed against M0.              |
|        BIC = 2*criterion - log(N)*degrees of freedom.               |
|        If the model has only constants or if it has no constants,   |
|        the statistics reported here are not useable.                |
+---------------------------------------------------------------------+
Frequencies of actual & predicted outcomes
Predicted outcome has maximum probability.

            Predicted
------  ---------------  +  -----
Actual      0    1    2  |  Total
------  ---------------  +  -----
  0       211  110    3  |    324
  1        79  435   84  |    598
  2        21  214  343  |    578
------  ---------------  +  -----
Total     311  759  430  |   1500
-->
```

Step 8

```
+--------------------------------------------+
| Generalized Maximum Entropy (Logit)        |
| Maximum Likelihood Estimates               |
| Model estimated: Jan 24, 2012 at 00:40:00PM.|
| Dependent variable                  CHOICE |
| Weighting variable                    None |
| Number of observations                1500 |
| Iterations completed                     8 |
| Log likelihood function        -6042.267 |
| Number of parameters                    48 |
| Info. Criterion: AIC =           8.12036 |
|   Finite Sample: AIC =           8.12252 |
| Info. Criterion: BIC =           8.29038 |
| Info. Criterion:HQIC =           8.18370 |
| Number of support points =             3 |
| Weights in support scaled to 1/sqr(N)      |
+--------------------------------------------+
+---------+--------------+----------------+--------+--------+----------+
|Variable| Coefficient  | Standard Error |b/St.Er.|P[|Z|>z]| Mean of X|
+---------+--------------+----------------+--------+--------+----------+
---------+Characteristics in numerator of Prob[Y = 1]
 Constant|    1.59366200     1.46965648     1.084   .2782
 SRB     |    1.35005963      .35917016     3.759   .0002    .12266667
 SRS     |    1.77177293      .22660825     7.819   .0000    .26600000
 MLA     |    3.32892897      .84019650     3.962   .0001    .06000000
 HLA     |     .81270213     1.77222534      .459   .6465    .06000000
 BUILDAR |    2.33343260      .33998308     6.863   .0000    .15333333
 TREE    |     .22020686      .18810820     1.171   .2417    .47466667
 BRIDG   |     .01865783      .00420235     4.440   .0000   6.51333333
 CULVER  |     .95999517      .29576458     3.246   .0012    .05333333
 BUSB    |    2.41319890     1.08812013     2.218   .0266    .08266667
 CURVE   |    2.26028092      .23272453     9.712   .0000    .24600000
 HUMP    |    2.54169623      .79612364     3.193   .0014    .15333333
 RUMBLE  |    2.19995287      .53376634     4.122   .0000    .07066667
```

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SDITCHB	1.13961225	.23382004	4.874	.0000	.11533333
SDITCHS	.68529689	.32471551	2.110	.0348	.05600000
DDITCHB	1.24861249	.80170836	1.557	.1194	.03666667
DDITCHS	.63269928	.37064088	1.707	.0878	.12000000
PATHBB	.83560660	.47813992	1.748	.0805	.05866667
PATHP	1.16095679	.34595705	3.356	.0008	.04800000
ONPARKS	3.43755674	1.82537556	1.883	.0597	.03066667
OFPARKS	2.42235585	3.16899834	.764	.4446	.01400000
FSS	2.84175392	.59780176	4.754	.0000	.06066667
EARTSB	-1.82171853	1.19522297	-1.524	.1275	.96533333
EARTHS	-1.30876052	.79477297	-1.647	.0996	.99266667
Characteristics in numerator of Prob[Y = 2]					
Constant	.98958609	1.62373667	.609	.5422	
SRB	1.50351912	.37259284	4.035	.0001	.12266667
SRS	2.26077013	.24965259	9.056	.0000	.26600000
MLA	4.58710695	.84474380	5.430	.0000	.06000000
HLA	4.52207571	1.69277912	2.671	.0076	.06000000
BUILDAR	2.70691049	.36396097	7.437	.0000	.15333333
TREE	.06430544	.21611250	.298	.7660	.47466667
BRIDG	.02162711	.00439917	4.916	.0000	6.51333333
CULVER	.77833760	.37613601	2.069	.0385	.05333333
BUSB	3.44974276	1.08717269	3.173	.0015	.08266667
CURVE	2.63024421	.25740140	10.218	.0000	.24600000
HUMP	5.46034402	.76943691	7.097	.0000	.15333333
RUMBLE	3.08432656	.54461929	5.663	.0000	.07066667
SDITCHB	1.29385907	.28658502	4.515	.0000	.11533333
SDITCHS	.75976948	.39785775	1.910	.0562	.05600000
DDITCHB	1.23935739	.85138893	1.456	.1455	.03666667
DDITCHS	.50009339	.40549271	1.233	.2175	.12000000
PATHBB	1.17313778	.50609959	2.318	.0204	.05866667
PATHP	1.55815152	.36849528	4.228	.0000	.04800000
ONPARKS	3.75059615	1.83535889	2.044	.0410	.03066667
OFPARKS	2.27806145	3.11718394	.731	.4649	.01400000
FSS	2.90566553	.63156463	4.601	.0000	.06066667
EARTSB	-2.10532204	1.22587352	-1.717	.0859	.96533333
EARTHS	-1.58441667	1.00234270	-1.581	.1139	.99266667

```
+----------------------------------------------------------------------+
| Information Statistics for Discrete Choice Model.                    |
|                           M=Model MC=Constants Only   M0=No Model    |
| Criterion F (log L)    -6042.26672       -6541.65965   -6591.67373   |
| LR Statistic vs. MC      998.78586            .00000        .00000   |
| Degrees of Freedom        46.00000            .00000        .00000   |
| Prob. Value for LR          .00000            .00000        .00000   |
| Entropy for probs.      1109.37213        1598.13875    1647.91843   |
| Normalized Entropy          .67320            .96979       1.00000   |
| Entropy Ratio Stat.     1077.09262          99.55937        .00000   |
| Bayes Info Criterion       8.28063           8.94648       9.01317   |
| BIC(no model) - BIC         .73254            .06669        .00000   |
| Pseudo R-squared            .32680            .00000        .00000   |
| Pct. Correct Pred.        65.93333          39.86667      33.33333   |
| Means:        y=0    y=1    y=2    y=3    y=4    y=5    y=6   y>=7   |
| Outcome      .2160  .3987  .3853  .0000  .0000  .0000  .0000  .0000  |
| Pred.Pr      .2178  .3978  .3844  .0000  .0000  .0000  .0000  .0000  |
| Notes: Entropy computed as Sum(i)Sum(j)Pfit(i,j)*logPfit(i,j).       |
|        Normalized entropy is computed against M0.                    |
|        Entropy ratio statistic is computed against M0.               |
|        BIC = 2*criterion - log(N)*degrees of freedom.                |
```

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```
|        If the model has only constants or if it has no constants,  |
|        the statistics reported here are not useable.               |
+--------------------------------------------------------------------+
Frequencies of actual & predicted outcomes
Predicted outcome has maximum probability.

            Predicted
------  ---------------  +  -----
Actual      0    1    2  |  Total
------  ---------------  +  -----
  0       211  110    3  |    324
  1        79  435   84  |    598
  2        21  214  343  |    578
------  ---------------  +  -----
Total     311  759  430  |   1500
-->
```

Step 9

```
+---------------------------------------------+
| Generalized Maximum Entropy (Logit)         |
| Maximum Likelihood Estimates                |
| Model estimated: Jan 24, 2012 at 00:43:49PM.|
| Dependent variable               CHOICE     |
| Weighting variable                 None     |
| Number of observations             1500     |
| Iterations completed                  8     |
| Log likelihood function       -6042.620     |
| Number of parameters                 46     |
| Info. Criterion: AIC =          8.11816     |
|   Finite Sample: AIC =          8.12014     |
| Info. Criterion: BIC =          8.28110     |
| Info. Criterion:HQIC =          8.17886     |
| Number of support points =            3     |
| Weights in support scaled to 1/sqr(N)       |
+---------------------------------------------+
+---------+--------------+----------------+--------+--------+----------+
|Variable| Coefficient   | Standard Error |b/St.Er.|P[|Z|>z]| Mean of X|
+---------+--------------+----------------+--------+--------+----------+
---------+Characteristics in numerator of Prob[Y = 1]
 Constant|    1.61185028     1.47011109     1.096   .2729
 SRB     |    1.34350511      .35808756     3.752   .0002     .12266667
 SRS     |    1.76843854      .22652932     7.807   .0000     .26600000
 MLA     |    3.32710729      .84092853     3.956   .0001     .06000000
 HLA     |    1.93639249     1.47180917     1.316   .1883     .06000000
 BUILDAR |    2.32785659      .33978845     6.851   .0000     .15333333
 TREE    |     .21947300      .18807992     1.167   .2432     .47466667
 BRIDG   |     .01861737      .00419616     4.437   .0000    6.51333333
 CULVER  |     .95874060      .29570621     3.242   .0012     .05333333
 BUSB    |    2.32990097     1.07147917     2.174   .0297     .08266667
 CURVE   |    2.25761149      .23259906     9.706   .0000     .24600000
 HUMP    |    2.52961844      .79428228     3.185   .0014     .15333333
 RUMBLE  |    2.19738778      .53372161     4.117   .0000     .07066667
 SDITCHB |    1.13703669      .23374783     4.864   .0000     .11533333
 SDITCHS |     .68213458      .32460624     2.101   .0356     .05600000
 DDITCHB |    1.22971065      .80168077     1.534   .1251     .03666667
 DDITCHS |     .63132275      .37048657     1.704   .0884     .12000000
 PATHBB  |     .84308778      .47902075     1.760   .0784     .05866667
```

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```
 PATHP   |    1.15993693       .34583523     3.354   .0008    .04800000
 ONPARKS |    3.55129161      1.87475169     1.894   .0582    .03066667
 FSS     |    2.84942866       .59793932     4.765   .0000    .06066667
 EARTSB  |   -1.83785294      1.19569936    -1.537   .1243    .96533333
 EARTHS  |   -1.30757293       .79467571    -1.645   .0999    .99266667
---------+Characteristics in numerator of Prob[Y = 2]
 Constant|    1.00560694      1.62467575      .619   .5359
 SRB     |    1.49613666       .37157344     4.026   .0001    .12266667
 SRS     |    2.25377087       .24962348     9.029   .0000    .26600000
 MLA     |    4.58589535       .84538116     5.425   .0000    .06000000
 HLA     |    5.62212074      1.37771695     4.081   .0000    .06000000
 BUILDAR |    2.70618340       .36325715     7.450   .0000    .15333333
 TREE    |     .06418660       .21605392      .297   .7664    .47466667
 BRIDG   |     .02156888       .00439390     4.909   .0000   6.51333333
 CULVER  |     .77521019       .37602479     2.062   .0392    .05333333
 BUSB    |    3.36694342      1.07225000     3.140   .0017    .08266667
 CURVE   |    2.62439072       .25715916    10.205   .0000    .24600000
 HUMP    |    5.44582326       .76751838     7.095   .0000    .15333333
 RUMBLE  |    3.08098462       .54451918     5.658   .0000    .07066667
 SDITCHB |    1.29145124       .28641078     4.509   .0000    .11533333
 SDITCHS |     .75849780       .39740791     1.909   .0563    .05600000
 DDITCHB |    1.21790491       .85336001     1.427   .1535    .03666667
 DDITCHS |     .50196101       .40506176     1.239   .2153    .12000000
 PATHBB  |    1.18243675       .50702138     2.332   .0197    .05866667
 PATHP   |    1.55408418       .36835413     4.219   .0000    .04800000
 ONPARKS |    3.82777778      1.88367461     2.032   .0421    .03066667
 FSS     |    2.89532934       .62945371     4.600   .0000    .06066667
 EARTSB  |   -2.12214735      1.22712299    -1.729   .0837    .96533333
 EARTHS  |   -1.57777311      1.00202090    -1.575   .1154    .99266667

+---------------------------------------------------------------------+
| Information Statistics for Discrete Choice Model.                   |
|                            M=Model MC=Constants Only   M0=No Model |
| Criterion F (log L)    -6042.61950        -6541.65965   -6591.67373 |
| LR Statistic vs. MC      998.08029             .00000        .00000 |
| Degrees of Freedom        44.00000             .00000        .00000 |
| Prob. Value for LR          .00000             .00000        .00000 |
| Entropy for probs.      1109.89700         1598.13875    1647.91843 |
| Normalized Entropy          .67351             .96979       1.00000 |
| Entropy Ratio Stat.     1076.04287           99.55937        .00000 |
| Bayes Info Criterion       8.27135            8.93673       9.00342 |
| BIC(no model) - BIC         .73207             .06669        .00000 |
| Pseudo R-squared            .32649             .00000        .00000 |
| Pct. Correct Pred.        65.93333           39.86667      33.33333 |
| Means:        y=0    y=1    y=2    y=3    y=4    y=5    y=6   y>=7 |
| Outcome     .2160  .3987  .3853  .0000  .0000  .0000  .0000  .0000 |
| Pred.Pr     .2179  .3977  .3844  .0000  .0000  .0000  .0000  .0000 |
| Notes: Entropy computed as Sum(i)Sum(j)Pfit(i,j)*logPfit(i,j).      |
|        Normalized entropy is computed against M0.                   |
|        Entropy ratio statistic is computed against M0.              |
|        BIC = 2*criterion - log(N)*degrees of freedom.               |
|        If the model has only constants or if it has no constants,   |
|        the statistics reported here are not useable.                |
+---------------------------------------------------------------------+
Frequencies of actual & predicted outcomes
Predicted outcome has maximum probability.

            Predicted
```

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```
------  ---------------  +  -----
Actual      0    1    2  |  Total
------  ---------------  +  -----
  0       211  110    3  |    324
  1        79  435   84  |    598
  2        21  214  343  |    578
------  ---------------  +  -----
Total     311  759  430  |   1500
-->
```

Step -10

```
+----------------------------------------------+
| Generalized Maximum Entropy (Logit)          |
| Maximum Likelihood Estimates                 |
| Model estimated: Jan 24, 2012 at 00:45:49PM.|
| Dependent variable               CHOICE      |
| Weighting variable                 None      |
| Number of observations             1500      |
| Iterations completed                  8      |
| Log likelihood function       -6043.524      |
| Number of parameters                 44      |
| Info. Criterion: AIC =          8.11670      |
|   Finite Sample: AIC =          8.11851      |
| Info. Criterion: BIC =          8.27255      |
| Info. Criterion:HQIC =          8.17476      |
| Number of support points =          3      |
| Weights in support scaled to 1/sqr(N)        |
+----------------------------------------------+
+--------+--------------+----------------+--------+--------+----------+
|Variable| Coefficient  | Standard Error |b/St.Er.|P[|Z|>z]| Mean of X|
+--------+--------------+----------------+--------+--------+----------+
---------+Characteristics in numerator of Prob[Y = 1]
 Constant|    1.91272464      1.44994769     1.319   .1871
 SRB     |    1.37068848       .35682775     3.841   .0001    .12266667
 SRS     |    1.75723933       .22620964     7.768   .0000    .26600000
 MLA     |    3.18860460       .83204335     3.832   .0001    .06000000
 HLA     |    1.79935827      1.46646005     1.227   .2198    .06000000
 BUILDAR |    2.30078669       .33858439     6.795   .0000    .15333333
 BRIDG   |     .01788028       .00412281     4.337   .0000   6.51333333
 CULVER  |     .84473056       .27804258     3.038   .0024    .05333333
 BUSB    |    2.39421427      1.06882835     2.240   .0251    .08266667
 CURVE   |    2.24617649       .23204111     9.680   .0000    .24600000
 HUMP    |    2.43828085       .79098028     3.083   .0021    .15333333
 RUMBLE  |    2.15181894       .53417105     4.028   .0001    .07066667
 SDITCHB |    1.12554622       .23244455     4.842   .0000    .11533333
 SDITCHS |     .72061576       .32419920     2.223   .0262    .05600000
 DDITCHB |    1.18265586       .80428836     1.470   .1414    .03666667
 DDITCHS |     .66971328       .36854107     1.817   .0692    .12000000
 PATHBB  |     .83196910       .47737235     1.743   .0814    .05866667
 PATHP   |    1.20257457       .34458178     3.490   .0005    .04800000
 ONPARKS |    3.50157276      1.87170504     1.871   .0614    .03066667
 FSS     |    2.81862901       .59614501     4.728   .0000    .06066667
 EARTSB  |   -1.95512993      1.19572542    -1.635   .1020    .96533333
 EARTHS  |   -1.34163048       .79376087    -1.690   .0910    .99266667
---------+Characteristics in numerator of Prob[Y = 2]
 Constant|    1.11060294      1.60120783      .694   .4879
 SRB     |    1.50687849       .37032314     4.069   .0000    .12266667
```

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```
 SRS     |    2.26197610       .24902289      9.083   .0000     .26600000
 MLA     |    4.54951930       .83390811      5.456   .0000     .06000000
 HLA     |    5.59225309      1.36968391      4.083   .0000     .06000000
 BUILDAR |    2.70718443       .36162741      7.486   .0000     .15333333
 BRIDG   |     .02128281       .00432117      4.925   .0000    6.51333333
 CULVER  |     .74855160       .35656283      2.099   .0358     .05333333
 BUSB    |    3.39753159      1.06851958      3.180   .0015     .08266667
 CURVE   |    2.62792585       .25665782     10.239   .0000     .24600000
 HUMP    |    5.43282137       .76246281      7.125   .0000     .15333333
 RUMBLE  |    3.10411671       .54282046      5.718   .0000     .07066667
 SDITCHB |    1.28318843       .28603360      4.486   .0000     .11533333
 SDITCHS |     .79915879       .39694763      2.013   .0441     .05600000
 DDITCHB |    1.17438751       .85880463      1.367   .1715     .03666667
 DDITCHS |     .53283872       .40289564      1.323   .1860     .12000000
 PATHBB  |    1.19671540       .50461523      2.372   .0177     .05866667
 PATHP   |    1.59474393       .36624877      4.354   .0000     .04800000
 ONPARKS |    3.82753660      1.88023863      2.036   .0418     .03066667
 FSS     |    2.90262742       .62687752      4.630   .0000     .06066667
 EARTSB  |   -2.19478794      1.22783829     -1.788   .0739     .96533333
 EARTHS  |   -1.58171391      1.00094886     -1.580   .1141     .99266667

+----------------------------------------------------------------------+
| Information Statistics for Discrete Choice Model.                    |
|                            M=Model MC=Constants Only   M0=No Model |
| Criterion F (log L)     -6043.52399        -6541.65965   -6591.67373 |
| LR Statistic vs. MC       996.27132             .00000        .00000 |
| Degrees of Freedom         42.00000             .00000        .00000 |
| Prob. Value for LR           .00000             .00000        .00000 |
| Entropy for probs.       1110.85852         1598.13875    1647.91843 |
| Normalized Entropy           .67410             .96979       1.00000 |
| Entropy Ratio Stat.      1074.11982           99.55937        .00000 |
| Bayes Info Criterion        8.26280            8.92698       8.99367 |
| BIC(no model) - BIC          .73087             .06669        .00000 |
| Pseudo R-squared             .32590             .00000        .00000 |
| Pct. Correct Pred.         66.00000           39.86667      33.33333 |
| Means:       y=0     y=1     y=2     y=3     y=4     y=5     y=6   y>=7 |
| Outcome     .2160   .3987   .3853   .0000   .0000   .0000   .0000   .0000 |
| Pred.Pr     .2179   .3977   .3844   .0000   .0000   .0000   .0000   .0000 |
| Notes: Entropy computed as Sum(i)Sum(j)Pfit(i,j)*logPfit(i,j).       |
|        Normalized entropy is computed against M0.                    |
|        Entropy ratio statistic is computed against M0.               |
|        BIC = 2*criterion - log(N)*degrees of freedom.                |
|        If the model has only constants or if it has no constants,   |
|        the statistics reported here are not useable.                 |
+----------------------------------------------------------------------+
Frequencies of actual & predicted outcomes
Predicted outcome has maximum probability.

             Predicted
------  ---------------  +  -----
Actual       0    1    2  |  Total
------  ---------------  +  -----
  0        211  110    3  |    324
  1         80  435   83  |    598
  2         21  213  344  |    578
------  ---------------  +  -----
Total      312  758  430  |   1500
-->
```

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Step 11

```
+---------------------------------------------+
| Generalized Maximum Entropy (Logit)         |
| Maximum Likelihood Estimates                |
| Model estimated: Jan 24, 2012 at 00:48:32PM.|
| Dependent variable               CHOICE     |
| Weighting variable                 None     |
| Number of observations             1500     |
| Iterations completed                  8     |
| Log likelihood function       -6044.856     |
| Number of parameters                 42     |
| Info. Criterion: AIC =          8.11581     |
|   Finite Sample: AIC =          8.11746     |
| Info. Criterion: BIC =          8.26458     |
| Info. Criterion:HQIC =          8.17123     |
| Number of support points =            3     |
| Weights in support scaled to 1/sqr(N)       |
+---------------------------------------------+
+--------+--------------+----------------+--------+--------+----------+
|Variable| Coefficient  | Standard Error |b/St.Er.|P[|Z|>z]| Mean of X|
+--------+--------------+----------------+--------+--------+----------+
---------+Characteristics in numerator of Prob[Y = 1]
 Constant|    3.07293147      1.22293506     2.513   .0120
 SRB     |    1.37424552       .35584342     3.862   .0001    .12266667
 SRS     |    1.78739120       .22496537     7.945   .0000    .26600000
 MLA     |    3.16825690       .83201288     3.808   .0001    .06000000
 HLA     |    1.84760069      1.46766741     1.259   .2081    .06000000
 BUILDAR |    2.29497432       .33868415     6.776   .0000    .15333333
 BRIDG   |     .01841158       .00426937     4.312   .0000   6.51333333
 CULVER  |     .92092695       .27790423     3.314   .0009    .05333333
 BUSB    |    2.39862720      1.06949563     2.243   .0249    .08266667
 CURVE   |    2.23261345       .23160808     9.640   .0000    .24600000
 HUMP    |    2.42497631       .79085375     3.066   .0022    .15333333
 RUMBLE  |    2.13284734       .53382196     3.995   .0001    .07066667
 SDITCHB |    1.09026690       .23121244     4.715   .0000    .11533333
 SDITCHS |     .69819233       .32395759     2.155   .0311    .05600000
 DDITCHS |     .61668161       .36752908     1.678   .0934    .12000000
 PATHBB  |     .78644635       .47527262     1.655   .0980    .05866667
 PATHP   |    1.18612707       .34385620     3.449   .0006    .04800000
 ONPARKS |    3.47754016      1.87409958     1.856   .0635    .03066667
 FSS     |    2.82209020       .59607827     4.734   .0000    .06066667
 EARTSB  |   -3.06563197       .93624983    -3.274   .0011    .96533333
 EARTHS  |   -1.37241540       .79458097    -1.727   .0841    .99266667
---------+Characteristics in numerator of Prob[Y = 2]
 Constant|    2.26218830      1.38218039     1.637   .1017
 SRB     |    1.51070601       .36939297     4.090   .0000    .12266667
 SRS     |    2.29275179       .24784290     9.251   .0000    .26600000
 MLA     |    4.52977756       .83353631     5.434   .0000    .06000000
 HLA     |    5.63963244      1.37163016     4.112   .0000    .06000000
 BUILDAR |    2.70135454       .36165542     7.469   .0000    .15333333
 BRIDG   |     .02181255       .00446060     4.890   .0000   6.51333333
 CULVER  |     .82214573       .35642915     2.307   .0211    .05333333
 BUSB    |    3.40115049      1.06921608     3.181   .0015    .08266667
 CURVE   |    2.61480747       .25535318    10.240   .0000    .24600000
 HUMP    |    5.41951601       .76229531     7.109   .0000    .15333333
 RUMBLE  |    3.08550274       .54215413     5.691   .0000    .07066667
```

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```
 SDITCHB |    1.24936448       .28416097     4.397   .0000    .11533333
 SDITCHS |     .77752187       .39630375     1.962   .0498    .05600000
 DDITCHS |     .48184669       .39949752     1.206   .2278    .12000000
 PATHBB  |    1.15336446       .50237952     2.296   .0217    .05866667
 PATHP   |    1.57915370       .36465733     4.331   .0000    .04800000
 ONPARKS |    3.80427272      1.88250905     2.021   .0433    .03066667
 FSS     |    2.90557408       .62673231     4.636   .0000    .06066667
 EARTSB  |   -3.29914489       .95976161    -3.437   .0006    .96533333
 EARTHS  |   -1.61099479      1.00190914    -1.608   .1079    .99266667

+----------------------------------------------------------------------+
| Information Statistics for Discrete Choice Model.                    |
|                             M=Model MC=Constants Only   M0=No Model |
| Criterion F (log L)    -6044.85583       -6541.65965   -6591.67373 |
| LR Statistic vs. MC      993.60764            .00000        .00000 |
| Degrees of Freedom        40.00000            .00000        .00000 |
| Prob. Value for LR          .00000            .00000        .00000 |
| Entropy for probs.      1112.29845        1598.13875    1647.91843 |
| Normalized Entropy          .67497            .96979       1.00000 |
| Entropy Ratio Stat.     1071.23997          99.55937        .00000 |
| Bayes Info Criterion       8.25483           8.91723       8.98392 |
| BIC(no model) - BIC         .72909            .06669        .00000 |
| Pseudo R-squared            .32503            .00000        .00000 |
| Pct. Correct Pred.        66.06667          39.86667      33.33333 |
| Means:        y=0    y=1    y=2    y=3    y=4    y=5     y=6   y>=7 |
| Outcome     .2160  .3987  .3853  .0000  .0000  .0000  .0000  .0000 |
| Pred.Pr     .2179  .3977  .3844  .0000  .0000  .0000  .0000  .0000 |
| Notes: Entropy computed as Sum(i)Sum(j)Pfit(i,j)*logPfit(i,j).      |
|        Normalized entropy is computed against M0.                    |
|        Entropy ratio statistic is computed against M0.               |
|        BIC = 2*criterion - log(N)*degrees of freedom.                |
|        If the model has only constants or if it has no constants,   |
|        the statistics reported here are not useable.                 |
+----------------------------------------------------------------------+
Frequencies of actual & predicted outcomes
Predicted outcome has maximum probability.

            Predicted
------  ---------------  +  -----
Actual      0    1    2  |  Total
------  ---------------  +  -----
  0       213  108    3  |    324
  1        81  434   83  |    598
  2        21  213  344  |    578
------  ---------------  +  -----
Total     315  755  430  |   1500
-->
```

Step 12

```
+----------------------------------------------+
| Generalized Maximum Entropy (Logit)          |
| Maximum Likelihood Estimates                 |
| Model estimated: Jan 24, 2012 at 00:51:18PM.|
| Dependent variable                CHOICE     |
| Weighting variable                  None     |
| Number of observations              1500     |
| Iterations completed                   8     |
```

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```
| Log likelihood function       -6046.800     |
| Number of parameters                 40     |
| Info. Criterion: AIC =          8.11573     |
|   Finite Sample: AIC =          8.11723     |
| Info. Criterion: BIC =          8.25742     |
| Info. Criterion:HQIC =          8.16852     |
| Number of support points =            3     |
| Weights in support scaled to 1/sqr(N)       |
+---------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
Characteristics in numerator of Prob[Y = 1]					
Constant	1.70358412	.93000270	1.832	.0670	
SRB	1.36715638	.35554957	3.845	.0001	.12266667
SRS	1.75920301	.22444790	7.838	.0000	.26600000
MLA	3.14265662	.83232540	3.776	.0002	.06000000
HLA	1.83192343	1.47174448	1.245	.2132	.06000000
BUILDAR	2.20442624	.33399388	6.600	.0000	.15333333
BRIDG	.01807045	.00422239	4.280	.0000	6.51333333
CULVER	.84581749	.27713577	3.052	.0023	.05333333
BUSB	2.36259609	1.07201284	2.204	.0275	.08266667
CURVE	2.20466721	.23078040	9.553	.0000	.24600000
HUMP	2.34783909	.79158511	2.966	.0030	.15333333
RUMBLE	2.09436547	.53350146	3.926	.0001	.07066667
SDITCHB	1.08220011	.23059931	4.693	.0000	.11533333
SDITCHS	.68026236	.32259097	2.109	.0350	.05600000
DDITCHS	.94108354	.33767578	2.787	.0053	.12000000
PATHBB	.80828450	.47573884	1.699	.0893	.05866667
PATHP	1.17338342	.34299549	3.421	.0006	.04800000
ONPARKS	3.51620689	1.87728544	1.873	.0611	.03066667
FSS	2.70332765	.59185905	4.568	.0000	.06066667
EARTSB	-3.03870663	.93482044	-3.251	.0012	.96533333
Characteristics in numerator of Prob[Y = 2]					
Constant	.65754525	.95638196	.688	.4917	
SRB	1.50216582	.36898743	4.071	.0000	.12266667
SRS	2.26108733	.24702561	9.153	.0000	.26600000
MLA	4.50019386	.83359123	5.399	.0000	.06000000
HLA	5.61989024	1.37599010	4.084	.0000	.06000000
BUILDAR	2.60830451	.35696350	7.307	.0000	.15333333
BRIDG	.02144344	.00441390	4.858	.0000	6.51333333
CULVER	.74682866	.35472169	2.105	.0353	.05333333
BUSB	3.36479693	1.07153086	3.140	.0017	.08266667
CURVE	2.58311241	.25424481	10.160	.0000	.24600000
HUMP	5.33673504	.76235796	7.000	.0000	.15333333
RUMBLE	3.04331312	.54164737	5.619	.0000	.07066667
SDITCHB	1.23673752	.28333108	4.365	.0000	.11533333
SDITCHS	.75688104	.39491727	1.917	.0553	.05600000
DDITCHS	.81103994	.37385031	2.169	.0301	.12000000
PATHBB	1.17247178	.50276150	2.332	.0197	.05866667
PATHP	1.56390330	.36360300	4.301	.0000	.04800000
ONPARKS	3.84045152	1.88565476	2.037	.0417	.03066667
FSS	2.78408464	.62243056	4.473	.0000	.06066667
EARTSB	-3.26884152	.95818204	-3.412	.0006	.96533333

```
+----------------------------------------------------------------------+
| Information Statistics for Discrete Choice Model.                    |
|                            M=Model MC=Constants Only   M0=No Model |
```

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```
| Criterion F (log L)    -6046.80009      -6541.65965   -6591.67373 |
| LR Statistic vs. MC      989.71912           .00000        .00000 |
| Degrees of Freedom        38.00000           .00000        .00000 |
| Prob. Value for LR          .00000           .00000        .00000 |
| Entropy for probs.      1114.12760       1598.13875    1647.91843 |
| Normalized Entropy          .67608           .96979       1.00000 |
| Entropy Ratio Stat.     1067.58166         99.55937        .00000 |
| Bayes Info Criterion       8.24767          8.90748       8.97417 |
| BIC(no model) - BIC         .72650           .06669        .00000 |
| Pseudo R-squared            .32392           .00000        .00000 |
| Pct. Correct Pred.        65.80000         39.86667      33.33333 |
| Means:       y=0    y=1    y=2    y=3    y=4    y=5    y=6   y>=7 |
| Outcome     .2160  .3987  .3853  .0000  .0000  .0000  .0000  .0000 |
| Pred.Pr     .2179  .3977  .3844  .0000  .0000  .0000  .0000  .0000 |
| Notes: Entropy computed as Sum(i)Sum(j)Pfit(i,j)*logPfit(i,j).     |
|        Normalized entropy is computed against M0.                   |
|        Entropy ratio statistic is computed against M0.              |
|        BIC = 2*criterion - log(N)*degrees of freedom.               |
|        If the model has only constants or if it has no constants,   |
|        the statistics reported here are not useable.                |
+---------------------------------------------------------------------+
Frequencies of actual & predicted outcomes
Predicted outcome has maximum probability.

            Predicted
------  ---------------  +  -----
Actual      0    1    2  |  Total
------  ---------------  +  -----
  0       215  106    3  |    324
  1        87  428   83  |    598
  2        23  211  344  |    578
------  ---------------  +  -----
Total     325  745  430  |   1500
-->
```

Step 13

```
+----------------------------------------------+
| Generalized Maximum Entropy (Logit)          |
| Maximum Likelihood Estimates                 |
| Model estimated: Jan 24, 2012 at 00:56:31PM.|
| Dependent variable               CHOICE      |
| Weighting variable                 None      |
| Number of observations             1500      |
| Iterations completed                  8      |
| Log likelihood function       -6045.392      |
| Number of parameters                 42      |
| Info. Criterion: AIC =          8.11652      |
|   Finite Sample: AIC =          8.11818      |
| Info. Criterion: BIC =          8.26529      |
| Info. Criterion:HQIC =          8.17195      |
| Number of support points =            3      |
| Weights in support scaled to 1/sqr(N)        |
+----------------------------------------------+
+---------+--------------+----------------+--------+--------+----------+
|Variable| Coefficient  | Standard Error |b/St.Er.|P[|Z|>z]| Mean of X|
+---------+--------------+----------------+--------+--------+----------+
---------+Characteristics in numerator of Prob[Y = 1]
```

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```
 Constant|     .53278845      1.20613313       .442   .6587
 SRB     |    1.36297360       .35655449      3.823   .0001     .12266667
 SRS     |    1.72937103       .22573345      7.661   .0000     .26600000
 MLA     |    3.16387349       .83233124      3.801   .0001     .06000000
 HLA     |    1.78137981      1.47033326      1.212   .2257     .06000000
 BUILDAR |    2.21431145       .33425844      6.625   .0000     .15333333
 BRIDG   |     .01754470       .00407686      4.303   .0000    6.51333333
 CULVER  |     .76787741       .27668332      2.775   .0055     .05333333
 BUSB    |    2.35851979      1.07123597      2.202   .0277     .08266667
 CURVE   |    2.21908631       .23125331      9.596   .0000     .24600000
 HUMP    |    2.36531868       .79173960      2.987   .0028     .15333333
 RUMBLE  |    2.11509651       .53387303      3.962   .0001     .07066667
 SDITCHB |    1.11877128       .23188094      4.825   .0000     .11533333
 SDITCHS |     .70365443       .32287752      2.179   .0293     .05600000
 DDITCHB |    1.21986491       .80881169      1.508   .1315     .03666667
 DDITCHS |     .98662877       .33861255      2.914   .0036     .12000000
 PATHBB  |     .85534088       .47793113      1.790   .0735     .05866667
 PATHP   |    1.18966907       .34374177      3.461   .0005     .04800000
 ONPARKS |    3.53824923      1.87476219      1.887   .0591     .03066667
 FSS     |    2.70429261       .59227134      4.566   .0000     .06066667
 EARTSB  |   -1.88786979      1.20095829     -1.572   .1160     .96533333
---------+Characteristics in numerator of Prob[Y = 2]
 Constant|    -.50455981      1.24529320      -.405   .6853
 SRB     |    1.49766776       .36993286      4.048   .0001     .12266667
 SRS     |    2.23054949       .24824400      8.985   .0000     .26600000
 MLA     |    4.52062122       .83393409      5.421   .0000     .06000000
 HLA     |    5.57043457      1.37381975      4.055   .0001     .06000000
 BUILDAR |    2.61809064       .35726444      7.328   .0000     .15333333
 BRIDG   |     .02091845       .00427558      4.893   .0000    6.51333333
 CULVER  |     .67163634       .35444175      1.895   .0581     .05333333
 BUSB    |    3.36144275      1.07071318      3.139   .0017     .08266667
 CURVE   |    2.59687026       .25558753     10.160   .0000     .24600000
 HUMP    |    5.35406021       .76259440      7.021   .0000     .15333333
 RUMBLE  |    3.06350754       .54233839      5.649   .0000     .07066667
 SDITCHB |    1.27161530       .28524646      4.458   .0000     .11533333
 SDITCHS |     .77931717       .39559621      1.970   .0488     .05600000
 DDITCHB |    1.20928342       .86319516      1.401   .1612     .03666667
 DDITCHS |     .85454109       .37745375      2.264   .0236     .12000000
 PATHBB  |    1.21722633       .50509411      2.410   .0160     .05866667
 PATHP   |    1.57907708       .36522165      4.324   .0000     .04800000
 ONPARKS |    3.86160548      1.88325695      2.050   .0403     .03066667
 FSS     |    2.78540697       .62289342      4.472   .0000     .06066667
 EARTSB  |   -2.12543302      1.23305034     -1.724   .0848     .96533333

+---------------------------------------------------------------------+
| Information Statistics for Discrete Choice Model.                   |
|                           M=Model MC=Constants Only   M0=No Model |
| Criterion F (log L)    -6045.39206       -6541.65965   -6591.67373 |
| LR Statistic vs. MC      992.53517            .00000        .00000 |
| Degrees of Freedom        40.00000            .00000        .00000 |
| Prob. Value for LR          .00000            .00000        .00000 |
| Entropy for probs.      1112.61035        1598.13875    1647.91843 |
| Normalized Entropy          .67516            .96979       1.00000 |
| Entropy Ratio Stat.     1070.61616          99.55937        .00000 |
| Bayes Info Criterion       8.25554           8.91723       8.98392 |
| BIC(no model) - BIC         .72838            .06669        .00000 |
| Pseudo R-squared            .32484            .00000        .00000 |
| Pct. Correct Pred.        65.80000          39.86667      33.33333 |
```

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```
| Means:        y=0    y=1    y=2    y=3    y=4    y=5     y=6   y>=7 |
| Outcome     .2160  .3987  .3853  .0000  .0000  .0000  .0000  .0000 |
| Pred.Pr     .2179  .3977  .3844  .0000  .0000  .0000  .0000  .0000 |
| Notes: Entropy computed as Sum(i)Sum(j)Pfit(i,j)*logPfit(i,j).     |
|        Normalized entropy is computed against M0.                  |
|        Entropy ratio statistic is computed against M0.             |
|        BIC = 2*criterion - log(N)*degrees of freedom.              |
|        If the model has only constants or if it has no constants,  |
|        the statistics reported here are not useable.               |
+--------------------------------------------------------------------+
Frequencies of actual & predicted outcomes
Predicted outcome has maximum probability.

            Predicted
------  ---------------  +  -----
Actual       0    1    2  |  Total
------  ---------------  +  -----
  0        213  108    3  |    324
  1         85  430   83  |    598
  2         23  211  344  |    578
------  ---------------  +  -----
Total      321  749  430  |   1500
-->
```

Step 14

```
+----------------------------------------------+
| Generalized Maximum Entropy (Logit)          |
| Maximum Likelihood Estimates                 |
| Model estimated: Jan 24, 2012 at 00:58:13PM.|
| Dependent variable               CHOICE      |
| Weighting variable                 None      |
| Number of observations             1500      |
| Iterations completed                  8      |
| Log likelihood function       -6045.718      |
| Number of parameters                 42      |
| Info. Criterion: AIC =          8.11696      |
|   Finite Sample: AIC =          8.11861      |
| Info. Criterion: BIC =          8.26573      |
| Info. Criterion:HQIC =          8.17238      |
| Number of support points =          3      |
| Weights in support scaled to 1/sqr(N)        |
+----------------------------------------------+
+---------+--------------+----------------+--------+--------+----------+
|Variable| Coefficient  | Standard Error |b/St.Er.|P[|Z|>z]| Mean of X|
+---------+--------------+----------------+--------+--------+----------+
---------+Characteristics in numerator of Prob[Y = 1]
 Constant|   -1.35372695      .15057775    -8.990   .0000
 SRB     |    1.36549665      .35900312     3.804   .0001    .12266667
 SRS     |    1.72044193      .22598094     7.613   .0000    .26600000
 MLA     |    3.16454352      .82772436     3.823   .0001    .06000000
 HLA     |     .43352320     1.81979452      .238   .8117    .06000000
 BUILDAR |    2.20920705      .33436050     6.607   .0000    .15333333
 BRIDG   |     .01757722      .00409959     4.288   .0000   6.51333333
 CULVER  |     .71658169      .27353263     2.620   .0088    .05333333
 BUSB    |    2.48264050     1.10921081     2.238   .0252    .08266667
 BUSS    |    1.78045140     2.35948403      .755   .4505    .03066667
```

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CURVE	2.22853869	.23024503	9.679	.0000	.24600000
HUMP	2.14162275	.80863507	2.648	.0081	.15333333
RUMBLE	2.16289687	.53247711	4.062	.0000	.07066667
SDITCHB	1.12829382	.23195301	4.864	.0000	.11533333
SDITCHS	.70548702	.32287785	2.185	.0289	.05600000
DDITCHB	2.32096253	.62250481	3.728	.0002	.03666667
DDITCHS	1.02025464	.33524065	3.043	.0023	.12000000
PATHBB	.86967113	.47768904	1.821	.0687	.05866667
PATHP	1.20594580	.34336269	3.512	.0004	.04800000
ONPARKS	3.53593738	1.86710344	1.894	.0583	.03066667
FSS	2.69596011	.59321245	4.545	.0000	.06066667
---------+Characteristics in numerator of Prob[Y = 2]					
Constant	-2.64925926	.19597596	-13.518	.0000	
SRB	1.50849788	.37205623	4.054	.0001	.12266667
SRS	2.21661421	.24829272	8.927	.0000	.26600000
MLA	4.50079896	.83061479	5.419	.0000	.06000000
HLA	3.95325615	1.73644061	2.277	.0228	.06000000
BUILDAR	2.61291787	.35736007	7.312	.0000	.15333333
BRIDG	.02107339	.00429628	4.905	.0000	6.51333333
CULVER	.61697642	.35191241	1.753	.0796	.05333333
BUSB	3.53807309	1.10536765	3.201	.0014	.08266667
BUSS	2.54409368	2.25846422	1.126	.2600	.03066667
CURVE	2.63701553	.25384111	10.388	.0000	.24600000
HUMP	5.02210004	.77806613	6.455	.0000	.15333333
RUMBLE	3.14458108	.54045872	5.818	.0000	.07066667
SDITCHB	1.29145343	.28582348	4.518	.0000	.11533333
SDITCHS	.79129641	.39574946	1.999	.0456	.05600000
DDITCHB	2.45873185	.66404747	3.703	.0002	.03666667
DDITCHS	.94161518	.36961891	2.548	.0108	.12000000
PATHBB	1.22143495	.50516161	2.418	.0156	.05866667
PATHP	1.62082153	.36367758	4.457	.0000	.04800000
ONPARKS	3.87312169	1.87576395	2.065	.0389	.03066667
FSS	2.79228782	.62337466	4.479	.0000	.06066667

```
+----------------------------------------------------------------------+
| Information Statistics for Discrete Choice Model.                    |
|                           M=Model MC=Constants Only   M0=No Model    |
| Criterion F (log L)    -6045.71847      -6541.65965   -6591.67373    |
| LR Statistic vs. MC      991.88237           .00000        .00000    |
| Degrees of Freedom        40.00000           .00000        .00000    |
| Prob. Value for LR          .00000           .00000        .00000    |
| Entropy for probs.      1112.28656       1598.13875    1647.91843    |
| Normalized Entropy          .67496           .96979       1.00000    |
| Entropy Ratio Stat.     1071.26375         99.55937        .00000    |
| Bayes Info Criterion       8.25598          8.91723       8.98392    |
| BIC(no model) - BIC         .72794           .06669        .00000    |
| Pseudo R-squared            .32504           .00000        .00000    |
| Pct. Correct Pred.        66.06667         39.86667      33.33333    |
| Means:        y=0    y=1    y=2    y=3    y=4    y=5    y=6   y>=7    |
| Outcome     .2160  .3987  .3853  .0000  .0000  .0000  .0000  .0000   |
| Pred.Pr     .2178  .3978  .3844  .0000  .0000  .0000  .0000  .0000   |
| Notes: Entropy computed as Sum(i)Sum(j)Pfit(i,j)*logPfit(i,j).       |
|        Normalized entropy is computed against M0.                    |
|        Entropy ratio statistic is computed against M0.               |
|        BIC = 2*criterion - log(N)*degrees of freedom.                |
|        If the model has only constants or if it has no constants,    |
|        the statistics reported here are not useable.                 |
+----------------------------------------------------------------------+
```

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```
Frequencies of actual & predicted outcomes
Predicted outcome has maximum probability.

            Predicted
------  ---------------  +  -----
Actual       0    1    2  |  Total
------  ---------------  +  -----
  0        213  107    4  |    324
  1         85  429   84  |    598
  2         23  206  349  |    578
------  ---------------  +  -----
Total      321  742  437  |   1500
-->
```

Step 15

```
+----------------------------------------------+
| Generalized Maximum Entropy (Logit)          |
| Maximum Likelihood Estimates                 |
| Model estimated: Jan 24, 2012 at 01:00:33PM.|
| Dependent variable                CHOICE     |
| Weighting variable                  None     |
| Number of observations              1500     |
| Iterations completed                   8     |
| Log likelihood function        -6047.013     |
| Number of parameters                  40     |
| Info. Criterion: AIC =           8.11602     |
|   Finite Sample: AIC =           8.11752     |
| Info. Criterion: BIC =           8.25770     |
| Info. Criterion:HQIC =           8.16880     |
| Number of support points =             3     |
| Weights in support scaled to 1/sqr(N)        |
+----------------------------------------------+
+--------+--------------+----------------+--------+--------+----------+
|Variable| Coefficient  | Standard Error |b/St.Er.|P[|Z|>z]| Mean of X|
+--------+--------------+----------------+--------+--------+----------+
---------+Characteristics in numerator of Prob[Y = 1]
 Constant|   -1.34955169       .15031068    -8.978   .0000
 SRB     |    1.35613586       .35708631     3.798   .0001    .12266667
 SRS     |    1.71171452       .22585469     7.579   .0000    .26600000
 MLA     |    3.16164573       .83225981     3.799   .0001    .06000000
 HLA     |    1.76206643      1.46331586     1.204   .2285    .06000000
 BUILDAR |    2.20445261       .33419822     6.596   .0000    .15333333
 BRIDG   |     .01747250       .00406649     4.297   .0000   6.51333333
 CULVER  |     .71499561       .27331519     2.616   .0089    .05333333
 BUSB    |    2.34417708      1.07185162     2.187   .0287    .08266667
 CURVE   |    2.22380972       .23001619     9.668   .0000    .24600000
 HUMP    |    2.36763878       .79221355     2.989   .0028    .15333333
 RUMBLE  |    2.15706803       .53226338     4.053   .0001    .07066667
 SDITCHB |    1.12526600       .23177800     4.855   .0000    .11533333
 SDITCHS |     .70212968       .32264010     2.176   .0295    .05600000
 DDITCHB |    2.31731343       .62264846     3.722   .0002    .03666667
 DDITCHS |    1.01325325       .33522977     3.023   .0025    .12000000
 PATHBB  |     .88025242       .47896780     1.838   .0661    .05866667
 PATHP   |    1.20185690       .34324030     3.502   .0005    .04800000
 ONPARKS |    3.54303881      1.87200657     1.893   .0584    .03066667
 FSS     |    2.69047305       .59229742     4.542   .0000    .06066667
```

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```
---------+Characteristics in numerator of Prob[Y = 2]
 Constant|   -2.63012388      .19488198   -13.496   .0000
 SRB     |    1.48713798      .37048841     4.014   .0001     .12266667
 SRS     |    2.20227744      .24818900     8.873   .0000     .26600000
 MLA     |    4.52071078      .83394860     5.421   .0000     .06000000
 HLA     |    5.53601481     1.36670849     4.051   .0001     .06000000
 BUILDAR |    2.60132881      .35713007     7.284   .0000     .15333333
 BRIDG   |     .02079825      .00426883     4.872   .0000    6.51333333
 CULVER  |     .60810057      .35188631     1.728   .0840     .05333333
 BUSB    |    3.35799329     1.07115841     3.135   .0017     .08266667
 CURVE   |    2.62029696      .25346780    10.338   .0000     .24600000
 HUMP    |    5.34763100      .76327376     7.006   .0000     .15333333
 RUMBLE  |    3.13541808      .54000339     5.806   .0000     .07066667
 SDITCHB |    1.28060512      .28531082     4.488   .0000     .11533333
 SDITCHS |     .77915716      .39555685     1.970   .0489     .05600000
 DDITCHB |    2.46303685      .66280827     3.716   .0002     .03666667
 DDITCHS |     .92196907      .37008224     2.491   .0127     .12000000
 PATHBB  |    1.23954275      .50610742     2.449   .0143     .05866667
 PATHP   |    1.61421149      .36323241     4.444   .0000     .04800000
 ONPARKS |    3.87756553     1.88054076     2.062   .0392     .03066667
 FSS     |    2.77466740      .62269343     4.456   .0000     .06066667

+----------------------------------------------------------------------+
| Information Statistics for Discrete Choice Model.                    |
|                            M=Model MC=Constants Only   M0=No Model |
| Criterion F (log L)    -6047.01324        -6541.65965   -6591.67373 |
| LR Statistic vs. MC      989.29281             .00000        .00000 |
| Degrees of Freedom        38.00000             .00000        .00000 |
| Prob. Value for LR          .00000             .00000        .00000 |
| Entropy for probs.      1114.03580         1598.13875    1647.91843 |
| Normalized Entropy          .67603             .96979       1.00000 |
| Entropy Ratio Stat.     1067.76527           99.55937        .00000 |
| Bayes Info Criterion       8.24795            8.90748       8.97417 |
| BIC(no model) - BIC         .72621             .06669        .00000 |
| Pseudo R-squared            .32397             .00000        .00000 |
| Pct. Correct Pred.        66.06667           39.86667      33.33333 |
| Means:        y=0    y=1    y=2    y=3    y=4    y=5    y=6   y>=7 |
| Outcome      .2160  .3987  .3853  .0000  .0000  .0000  .0000  .0000 |
| Pred.Pr      .2178  .3977  .3844  .0000  .0000  .0000  .0000  .0000 |
| Notes: Entropy computed as Sum(i)Sum(j)Pfit(i,j)*logPfit(i,j).      |
|        Normalized entropy is computed against M0.                    |
|        Entropy ratio statistic is computed against M0.               |
|        BIC = 2*criterion - log(N)*degrees of freedom.                |
|        If the model has only constants or if it has no constants,   |
|        the statistics reported here are not useable.                 |
+----------------------------------------------------------------------+
Frequencies of actual & predicted outcomes
Predicted outcome has maximum probability.

            Predicted
------  ---------------  +  -----
Actual      0    1    2  |  Total
------  ---------------  +  -----
  0       213  107    4  |    324
  1        85  429   84  |    598
  2        23  206  349  |    578
------  ---------------  +  -----
Total     321  742  437  |   1500
```

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-->

Step 16

```
+---------------------------------------------+
| Generalized Maximum Entropy (Logit)         |
| Maximum Likelihood Estimates                |
| Model estimated: Jan 24, 2012 at 01:03:38PM.|
| Dependent variable               CHOICE     |
| Weighting variable                 None     |
| Number of observations             1500     |
| Iterations completed                  8     |
| Log likelihood function       -6049.737     |
| Number of parameters                 40     |
| Info. Criterion: AIC =          8.11965     |
|   Finite Sample: AIC =          8.12115     |
| Info. Criterion: BIC =          8.26134     |
| Info. Criterion:HQIC =          8.17243     |
| Number of support points =            3     |
| Weights in support scaled to 1/sqr(N)       |
+---------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
Characteristics in numerator of Prob[Y = 1]					
Constant	.17420668	1.21262775	.144	.8858	
SRB	1.34613928	.35587372	3.783	.0002	.12266667
SRS	1.70198600	.22580482	7.537	.0000	.26600000
MLA	3.11134647	.83342829	3.733	.0002	.06000000
HLA	1.74779230	1.47857683	1.182	.2372	.06000000
BUILDAR	2.12036237	.33251713	6.377	.0000	.15333333
BRIDG	.01677551	.00396250	4.234	.0000	6.51333333
BUSB	2.10328365	1.07165006	1.963	.0497	.08266667
CURVE	2.16968554	.23032356	9.420	.0000	.24600000
HUMP	2.29425447	.79500406	2.886	.0039	.15333333
RUMBLE	2.01445634	.53225921	3.785	.0002	.07066667
SDITCHB	1.21725427	.22927460	5.309	.0000	.11533333
SDITCHS	.68504055	.32091055	2.135	.0328	.05600000
DDITCHB	1.61942302	.82270188	1.968	.0490	.03666667
DDITCHS	1.21413367	.32993111	3.680	.0002	.12000000
PATHBB	1.18586406	.48165493	2.462	.0138	.05866667
PATHP	1.15848416	.34212446	3.386	.0007	.04800000
ONPARKS	3.55452454	1.88299540	1.888	.0591	.03066667
FSS	2.56268896	.59162121	4.332	.0000	.06066667
EARTSB	-1.46472055	1.20348683	-1.217	.2236	.96533333
Characteristics in numerator of Prob[Y = 2]					
Constant	-.85663179	1.25245361	-.684	.4940	
SRB	1.48190455	.36921087	4.014	.0001	.12266667
SRS	2.20877371	.24802364	8.905	.0000	.26600000
MLA	4.47405457	.83475524	5.360	.0000	.06000000
HLA	5.54048838	1.38282047	4.007	.0001	.06000000
BUILDAR	2.53253182	.35519247	7.130	.0000	.15333333
BRIDG	.02022575	.00416248	4.859	.0000	6.51333333
BUSB	3.11697659	1.07048546	2.912	.0036	.08266667
CURVE	2.55412130	.25430188	10.044	.0000	.24600000
HUMP	5.29230540	.76532470	6.915	.0000	.15333333
RUMBLE	2.97074202	.54037872	5.498	.0000	.07066667

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```
 SDITCHB |   1.36208967       .28369717     4.801   .0000    .11533333
 SDITCHS |    .76155600       .39419145     1.932   .0534    .05600000
 DDITCHB |   1.59227316       .87844353     1.813   .0699    .03666667
 DDITCHS |   1.06768680       .37101255     2.878   .0040    .12000000
 PATHBB  |   1.53164614       .50983685     3.004   .0027    .05866667
 PATHP   |   1.55076161       .36359669     4.265   .0000    .04800000
 ONPARKS |   3.87753775      1.89148520     2.050   .0404    .03066667
 FSS     |   2.65510517       .62213100     4.268   .0000    .06066667
 EARTSB  |  -1.71959012      1.23619501    -1.391   .1642    .96533333

+----------------------------------------------------------------------+
| Information Statistics for Discrete Choice Model.                    |
|                              M=Model MC=Constants Only   M0=No Model |
| Criterion F (log L)    -6049.73699       -6541.65965   -6591.67373 |
| LR Statistic vs. MC      983.84532            .00000        .00000 |
| Degrees of Freedom        38.00000            .00000        .00000 |
| Prob. Value for LR          .00000            .00000        .00000 |
| Entropy for probs.      1116.67979        1598.13875    1647.91843 |
| Normalized Entropy          .67763            .96979       1.00000 |
| Entropy Ratio Stat.     1062.47728          99.55937        .00000 |
| Bayes Info Criterion       8.25158           8.90748       8.97417 |
| BIC(no model) - BIC         .72258            .06669        .00000 |
| Pseudo R-squared            .32237            .00000        .00000 |
| Pct. Correct Pred.        65.53333          39.86667      33.33333 |
| Means:       y=0    y=1    y=2    y=3    y=4    y=5     y=6   y>=7 |
| Outcome     .2160  .3987  .3853  .0000  .0000  .0000  .0000  .0000 |
| Pred.Pr     .2178  .3977  .3844  .0000  .0000  .0000  .0000  .0000 |
| Notes: Entropy computed as Sum(i)Sum(j)Pfit(i,j)*logPfit(i,j).      |
|        Normalized entropy is computed against M0.                   |
|        Entropy ratio statistic is computed against M0.              |
|        BIC = 2*criterion - log(N)*degrees of freedom.               |
|        If the model has only constants or if it has no constants,  |
|        the statistics reported here are not useable.                |
+----------------------------------------------------------------------+
Frequencies of actual & predicted outcomes
Predicted outcome has maximum probability.

            Predicted
------  ---------------  +  -----
Actual      0    1    2  |  Total
------  ---------------  +  -----
  0       227   94    3  |    324
  1       103  412   83  |    598
  2        26  208  344  |    578
------  ---------------  +  -----
Total     356  714  430  |   1500
-->
```

Step 17

```
+---------------------------------------------+
| Generalized Maximum Entropy (Logit)         |
| Maximum Likelihood Estimates                |
| Model estimated: Jan 24, 2012 at 01:06:08PM.|
| Dependent variable              CHOICE      |
| Weighting variable                None      |
| Number of observations            1500      |
```

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```
| Iteration completed                8      |
| Log likelihood function      -6050.818    |
| Number of parameters              38      |
| Info. Criterion: AIC =         8.11842    |
|   Finite Sample: AIC =         8.11978    |
| Info. Criterion: BIC =         8.25303    |
| Info. Criterion:HQIC =         8.16857    |
| Number of support points =         3    |
| Weights in support scaled to 1/sqr(N)     |
+-------------------------------------------+
+--------+--------------+----------------+--------+--------+----------+
|Variable| Coefficient  | Standard Error |b/St.Er.|P[|Z|>z]| Mean of X|
+--------+--------------+----------------+--------+--------+----------+
---------+Characteristics in numerator of Prob[Y = 1]
 Constant|   -1.29070623      .14765655    -8.741   .0000
 SRB     |    1.34112189      .35640833     3.763   .0002    .12266667
 SRS     |    1.69576038      .22615938     7.498   .0000    .26600000
 MLA     |    3.11368390      .83323600     3.737   .0002    .06000000
 HLA     |    1.74418359     1.47165909     1.185   .2359    .06000000
 BUILDAR |    2.11979479      .33264085     6.373   .0000    .15333333
 BRIDG   |     .01681031      .00397105     4.233   .0000   6.51333333
 BUSB    |    2.10468300     1.07173219     1.964   .0496    .08266667
 CURVE   |    2.17629549      .22929986     9.491   .0000    .24600000
 HUMP    |    2.30341840      .79493480     2.898   .0038    .15333333
 RUMBLE  |    2.05102099      .53037377     3.867   .0001    .07066667
 SDITCHB |    1.21813057      .22924842     5.314   .0000    .11533333
 SDITCHS |     .68565600      .32095919     2.136   .0327    .05600000
 DDITCHB |    2.42113342      .62242713     3.890   .0001    .03666667
 DDITCHS |    1.22271730      .32770521     3.731   .0002    .12000000
 PATHBB  |    1.19022710      .48161075     2.471   .0135    .05866667
 PATHP   |    1.16814609      .34182304     3.417   .0006    .04800000
 ONPARKS |    3.55521702     1.88016709     1.891   .0586    .03066667
 FSS     |    2.56006724      .59171317     4.327   .0000    .06066667
---------+Characteristics in numerator of Prob[Y = 2]
 Constant|   -2.58445014      .19039169   -13.574   .0000
 SRB     |    1.47324300      .36979128     3.984   .0001    .12266667
 SRS     |    2.19205079      .24824610     8.830   .0000    .26600000
 MLA     |    4.48014065      .83468627     5.367   .0000    .06000000
 HLA     |    5.52119132     1.37590957     4.013   .0001    .06000000
 BUILDAR |    2.52551552      .35529609     7.108   .0000    .15333333
 BRIDG   |     .02021913      .00417421     4.844   .0000   6.51333333
 BUSB    |    3.13055392     1.07049534     2.924   .0035    .08266667
 CURVE   |    2.58171009      .25227924    10.234   .0000    .24600000
 HUMP    |    5.29341065      .76552923     6.915   .0000    .15333333
 RUMBLE  |    3.04056178      .53767449     5.655   .0000    .07066667
 SDITCHB |    1.36597912      .28383438     4.813   .0000    .11533333
 SDITCHS |     .76436817      .39442070     1.938   .0526    .05600000
 DDITCHB |    2.56231134      .66309180     3.864   .0001    .03666667
 DDITCHS |    1.11940969      .36446052     3.071   .0021    .12000000
 PATHBB  |    1.53339054      .50972473     3.008   .0026    .05866667
 PATHP   |    1.58569690      .36170732     4.384   .0000    .04800000
 ONPARKS |    3.89085339     1.88870695     2.060   .0394    .03066667
 FSS     |    2.65681371      .62203183     4.271   .0000    .06066667

+-----------------------------------------------------------------+
| Information Statistics for Discrete Choice Model.              |
|                          M=Model MC=Constants Only   M0=No Model |
| Criterion F (log L)    -6050.81814       -6541.65965   -6591.67373 |
```

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```
| LR Statistic vs. MC      981.68302              .00000         .00000 |
| Degrees of Freedom        36.00000              .00000         .00000 |
| Prob. Value for LR          .00000              .00000         .00000 |
| Entropy for probs.      1117.63821          1598.13875     1647.91843 |
| Normalized Entropy          .67821              .96979        1.00000 |
| Entropy Ratio Stat.     1060.56044            99.55937         .00000 |
| Bayes Info Criterion       8.24327             8.89773        8.96442 |
| BIC(no model) - BIC         .72114              .06669         .00000 |
| Pseudo R-squared            .32179              .00000         .00000 |
| Pct. Correct Pred.        65.80000            39.86667       33.33333 |
| Means:       y=0    y=1    y=2    y=3    y=4    y=5     y=6   y>=7 |
| Outcome     .2160  .3987  .3853  .0000  .0000  .0000  .0000  .0000 |
| Pred.Pr     .2178  .3978  .3844  .0000  .0000  .0000  .0000  .0000 |
| Notes: Entropy computed as Sum(i)Sum(j)Pfit(i,j)*logPfit(i,j).       |
|        Normalized entropy is computed against M0.                   |
|        Entropy ratio statistic is computed against M0.              |
|        BIC = 2*criterion - log(N)*degrees of freedom.               |
|        If the model has only constants or if it has no constants,   |
|        the statistics reported here are not useable.                |
+----------------------------------------------------------------------+
Frequencies of actual & predicted outcomes
Predicted outcome has maximum probability.

            Predicted
------  ---------------  +  -----
Actual       0    1    2  |  Total
------  ---------------  +  -----
  0        227   93    4  |    324
  1        103  411   84  |    598
  2         26  203  349  |    578
------  ---------------  +  -----
Total      356  707  437  |   1500
-->
```

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Appendix D
Model validation

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Appendix Table D1 Compare of model predicted speed limit and experts chosen speed limit for model validation

Segment No.	Predicted speed limit from Model (km/h)	Experts Chose Model Speed Limit (nos.)	Experts Chose Model Speed Limit (%)
66	60	7	70
67	60	7	70
68	60	6	60
69	60	3	30
70	60	7	70
71	60	7	70
72	60	7	70
73	60	7	70
74	40	6	60
75	80	3	30
76	80	9	90
77	80	9	90
78	60	6	60
79	60	6	60
80	40	6	60
81	80	3	30
82	60	6	60
83	60	7	70
84	40	9	90
85	40	9	90
86	60	7	70
87	60	8	80
88	60	8	80
89	40	5	50
90	60	5	50

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Appendix Table D1 (Continued)

Segment No.	Predicted speed limit from Model (km/h)	Experts Chose Model Speed Limit (nos.)	Experts Chose Model Speed Limit (%)
176	60	6	60
177	80	8	80
178	40	10	100
179	40	10	100
180	40	3	30
181	60	6	60
182	80	6	60
183	60	6	60
184	60	7	70
185	60	5	50
186	60	7	70
187	40	9	90
188	40	7	70
189	40	9	90
190	40	10	100
191	40	10	100
192	40	6	60
193	60	8	80
194	60	8	80
195	60	7	70
196	60	5	50
197	80	6	60
198	60	6	60
199	60	4	40
200	60	6	60

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Appendix Table D2 Calculation for model validation

Experts Chose Model Speed Limit (%) (X)	**Segments (nos.) (f)**	**(fx)**
100	4	400
90	6	540
80	5	400
70	12	840
60	14	840
50	4	200
40	1	40
30	4	120
20	0	0
10	0	0
0	0	0
Total ∑fx	**50**	3380
Average		**67.6**

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Appendix E
Determination of variables speed limits

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Appendix Table E1 Effective coefficient values of significant variables

Variables	Coefficient Value		No.	Effective Coefficient Value (ASC + Coefficient Value* No)	
	60 km/hr	40 km/hr		60 km/hr	40 km/hr
SRB	1.34112189	1.47324300	2	1.39153755	0.362036
SRS	1.69576038	2.19205079	1	0.40505415	-0.3924
			2	2.10081453	1.799651
MLA	3.11368390	4.48014065	1	1.82297767	1.895691
HLA		5.52119132	1	-1.29070623	2.936741
BUILDAR	2.11979479	2.52551552	1	0.82908856	-0.05893
BRIDG	0.01681031	0.02021913	77	0.000	-1.02758
			128	0.86101345	0.000
			200	2.07135577	1.459376
BUSB	2.10468300	3.13055392	1	0.81397677	0.546104
CURVE	2.17629549	2.58171009	1	0.88558926	-0.00274
HUMP	2.30341840	5.29341065	1	1.01271217	2.708961
			2	3.31613057	8.002371
RUMBLE	2.05102099	3.04056178	1	0.76031476	0.456112
SDITCHB	1.21813057	1.36597912	1	-0.07257566	-1.21847
SDITCHS	0.68565600		1	-0.60505023	-2.58445
DDITCHB	2.42113342	2.56231134	1	1.13042719	-0.02214
DDITCHS	1.22271730	1.11940969	1	-0.06798893	-1.46504
PATHBB	1.19022710	1.53339054	1	-0.10047913	-1.05106
PATHP	1.16814609	1.58569690	1	-0.12256014	-0.99875
			2	1.04558595	0.586944
ONPARKS		3.89085339	1	-1.29070623	1.306403
FSS	2.56006724	2.65681371	1	1.26936101	0.072364
			2	3.82942825	2.729177

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Appendix Table E2 Suitable speed limits for significant variables

Variables	No.	Effective Coefficient Value			Speed Limit (km/hr)
		80 km/hr	60 km/hr	40 km/hr	
SRB	2	0	1.39153755	0.362036	60
SRS	1	0	0.40505415	-0.3924	60
	2	0	2.10081453	1.799651	60
MLA	1	0	1.82297767	1.895691	40
HLA	1	0	-1.29070623	2.936741	40
BUILDAR	1	0	0.82908856	-0.05893	60
BRIDG	77	0	0.000	-1.02758	80
	128	0	0.86101345	0.000	60
	200	0	2.07135577	1.459376	60
BUSB	1	0	0.81397677	0.546104	60
CURVE	1	0	0.88558926	-0.00274	60
HUMP	1	0	1.01271217	2.708961	40
	2	0	3.31613057	8.002371	40
RUMBLE	1	0	0.76031476	0.456112	60
SDITCHB	1	0	-0.07257566	-1.21847	80
SDITCHS	1	0	-0.60505023	-2.58445	80
DDITCHB	1	0	1.13042719	-0.02214	60
DDITCHS	1	0	-0.06798893	-1.46504	80
PATHBB	1	0	-0.10047913	-1.05106	80
PATHP	1	0	-0.12256014	-0.99875	80
	2	0	1.04558595	0.586944	60
ONPARKS	1	0	-1.29070623	1.306403	40
FSS	1	0	1.26936101	0.072364	60
	2	0	3.82942825	2.729177	60

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Appendix F
Speed limits determination

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Appendix Table F1 Segmental and posted speed limits of road no. N5

Segment No.	Probability			Segmental Speed Limit (Km/hr)	Posted Speed limit (Km/hr)
	80 km/hr	60 Km/hr	40 km/hr		
1	0.02	0.64	0.34	60	40
2	0.05	0.15	0.80	40	
3	0.03	0.47	0.50	40	
4	0.23	0.55	0.23	60	60
5	0.69	0.24	0.07	80	
6	0.24	0.54	0.22	60	
7	0.45	0.42	0.13	80	
8	0.00	0.04	0.95	40	40
9	0.04	0.14	0.82	40	
10	0.42	0.44	0.14	60	
11	0.08	0.57	0.35	60	
12	0.44	0.39	0.16	80	80
13	0.23	0.55	0.23	60	
14	0.69	0.24	0.07	80	
15	0.45	0.42	0.13	80	
16	0.23	0.55	0.23	60	40
17	0.01	0.37	0.62	40	
18	0.00	0.00	1.00	40	
19	0.72	0.22	0.06	80	
20	0.01	0.47	0.52	40	

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Appendix Table F1 (Continued)

Segment No.	Probability			Segmental Speed Limit (Km/hr)	Posted Speed Limit (Km/hr)
	80 km/hr	60 Km/hr	40 km/hr		
21	0.06	0.70	0.24	60	60
22	0.02	0.50	0.48	60	
23	0.09	0.67	0.25	60	
24	0.09	0.67	0.25	60	
25	0.74	0.20	0.06	80	
26	0.31	0.47	0.21	60	
27	0.02	0.46	0.51	40	
28	0.23	0.55	0.23	60	
29	0.08	0.63	0.30	60	
30	0.01	0.10	0.89	40	
31	0.08	0.60	0.33	60	
32	0.08	0.60	0.33	60	
33	0.00	0.08	0.92	40	40
34	0.11	0.58	0.30	60	
35	0.00	0.07	0.93	40	
36	0.00	0.12	0.88	40	
37	0.04	0.44	0.53	40	
38	0.31	0.47	0.21	60	60
39	0.19	0.56	0.24	60	
40	0.08	0.63	0.30	60	

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Appendix Table F1 (Continued)

Segment No.	Probability			Segmental Speed Limit (Km/hr)	Posted Speed Limit (Km/hr)
	80 km/hr	60 Km/hr	40 km/hr		
41	0.01	0.47	0.52	40	40
42	0.00	0.04	0.96	40	
43	0.02	0.05	0.93	40	
44	0.06	0.64	0.31	60	
45	0.00	0.02	0.98	40	
46	0.00	0.00	1.00	40	
47	0.00	0.01	0.99	40	
48	0.00	0.00	1.00	40	
49	0.02	0.62	0.36	60	
50	0.00	0.50	0.50	40	
51	0.07	0.46	0.48	40	
52	0.06	0.74	0.20	60	60
53	0.31	0.47	0.21	60	
54	0.01	0.68	0.31	60	
55	0.62	0.34	0.05	80	
56	0.18	0.63	0.19	60	
57	0.08	0.63	0.30	60	
58	0.11	0.58	0.30	60	
59	0.45	0.42	0.13	80	
60	0.45	0.42	0.13	80	
61	0.21	0.45	0.33	60	
62	0.00	0.07	0.93	40	40
63	0.04	0.14	0.81	40	
64	0.01	0.61	0.37	60	
65	0.00	0.12	0.88	40	

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Appendix Table F1 (Continued)

Segment No.	Probability			Segmental Speed Limit (Km/hr)	Posted Speed Limit (Km/hr)
	80 km/hr	60 Km/hr	40 km/hr		
66	0.05	0.57	0.38	60	60
67	0.04	0.63	0.33	60	
68	0.03	0.63	0.34	60	
69	0.20	0.61	0.19	60	
70	0.21	0.55	0.24	60	
71	0.08	0.60	0.33	60	
72	0.08	0.60	0.33	60	
73	0.04	0.60	0.36	60	
74	0.01	0.03	0.96	40	
75	0.67	0.25	0.07	80	80
76	0.74	0.20	0.06	80	
77	0.74	0.20	0.06	80	
78	0.03	0.56	0.42	60	60
79	0.07	0.57	0.36	60	
80	0.00	0.44	0.56	40	
81	0.70	0.23	0.07	80	
82	0.02	0.66	0.31	60	
83	0.00	0.56	0.44	60	
84	0.00	0.00	1.00	40	40
85	0.00	0.01	0.99	40	
86	0.21	0.45	0.33	60	

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Appendix Table F1 (Continued)

Segment No.	Probability			Segmental Speed Limit (Km/hr)	Posted Speed Limit (Km/hr)
	80 km/hr	60 Km/hr	40 km/hr		
87	0.16	0.63	0.21	60	60
88	0.20	0.61	0.19	60	
89	0.01	0.47	0.52	40	
90	0.01	0.54	0.46	60	
91	0.46	0.43	0.11	80	
92	0.02	0.62	0.36	60	
93	0.00	0.38	0.62	40	
94	0.02	0.66	0.31	60	
95	0.17	0.63	0.21	60	
96	0.02	0.53	0.45	60	
97	0.02	0.45	0.53	40	40
98	0.00	0.01	0.99	40	
99	0.02	0.17	0.82	40	
100	0.46	0.43	0.11	80	

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Appendix Table F2 Segmental and posted speed limits of road no. N6

Segment No.	Probability			Segmental Speed Limit	Posted Speed Limit
	80 km/hr	60 Km/hr	40 km/hr		
101	0.00	0.00	1.00	40	40
102	0.31	0.47	0.21	60	
103	0.74	0.20	0.06	80	
104	0.31	0.47	0.21	60	
105	0.74	0.20	0.06	80	80
106	0.31	0.47	0.21	60	
107	0.74	0.20	0.06	80	
108	0.44	0.40	0.16	80	
109	0.74	0.20	0.06	80	
110	0.00	0.20	0.80	40	40
111	0.31	0.47	0.21	60	
112	0.74	0.20	0.06	80	
113	0.31	0.47	0.21	60	
114	0.00	0.00	1.00	40	
115	0.24	0.54	0.22	60	
116	0.45	0.42	0.13	80	80
117	0.74	0.20	0.06	80	
118	0.74	0.20	0.06	80	
119	0.02	0.64	0.34	60	60
120	0.31	0.47	0.21	60	
121	0.24	0.54	0.22	60	
122	0.31	0.47	0.21	60	
123	0.23	0.55	0.23	60	
124	0.74	0.20	0.06	80	
125	0.74	0.20	0.06	80	
126	0.23	0.55	0.23	60	
127	0.18	0.50	0.32	60	
128	0.03	0.60	0.37	60	

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Appendix Table F2 (Continued)

Segment No.	Probability			Segmental Speed Limit (Km/hr)	Posted Speed Limit (Km/hr)
	80 km/hr	60 Km/hr	40 km/hr		
129	0.00	0.08	0.92	40	40
130	0.00	0.01	0.99	40	
131	0.00	0.01	0.99	40	
132	0.01	0.36	0.63	40	
133	0.00	0.49	0.50	40	
134	0.07	0.59	0.34	60	60
135	0.07	0.59	0.34	60	
136	0.23	0.55	0.23	60	
137	0.03	0.60	0.37	60	
138	0.06	0.45	0.49	40	40
139	0.00	0.57	0.43	60	
140	0.02	0.05	0.93	40	
141	0.00	0.00	1.00	40	
142	0.00	0.00	1.00	40	
143	0.00	0.00	1.00	40	
144	0.07	0.45	0.48	40	
145	0.03	0.04	0.93	40	
146	0.74	0.20	0.06	80	80
147	0.74	0.20	0.06	80	
148	0.01	0.58	0.41	60	
149	0.74	0.20	0.06	80	

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Appendix Table F2 (Continued)

Segment No.	Probability			Segmental Speed Limit	Posted Speed Limit
	80 km/hr	60 Km/hr	40 km/hr		
150	0.31	0.47	0.21	60	60
151	0.23	0.55	0.23	60	
152	0.45	0.42	0.13	80	
153	0.15	0.62	0.22	60	
154	0.74	0.20	0.06	80	
155	0.00	0.00	1.00	40	
156	0.45	0.42	0.13	80	80
157	0.21	0.64	0.15	60	
158	0.62	0.34	0.05	80	
159	0.62	0.34	0.05	80	
160	0.45	0.42	0.13	80	
161	0.62	0.34	0.05	80	
162	0.45	0.42	0.13	80	
163	0.44	0.42	0.13	80	
164	0.15	0.71	0.15	60	40
165	0.00	0.01	0.99	40	
166	0.00	0.00	1.00	40	
167	0.42	0.44	0.14	60	60
168	0.15	0.71	0.15	60	
169	0.00	0.01	0.99	40	
170	0.04	0.57	0.39	60	
171	0.74	0.20	0.06	80	
172	0.23	0.55	0.23	60	
173	0.23	0.55	0.23	60	
174	0.23	0.55	0.23	60	
175	0.00	0.55	0.44	60	
176	0.23	0.55	0.23	60	
177	0.74	0.20	0.06	80	

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Appendix Table F2 (Continued)

Segment No.	Probability			Segmental Speed Limit (Km/hr)	Posted Speed Limit (Km/hr)
	80 km/hr	60 Km/hr	40 km/hr		
178	0.00	0.00	1.00	40	40
179	0.00	0.02	0.98	40	
180	0.20	0.06	0.74	40	
181	0.21	0.64	0.15	60	60
182	0.74	0.20	0.06	80	
183	0.23	0.55	0.23	60	
184	0.02	0.64	0.34	60	
185	0.08	0.63	0.30	60	
186	0.03	0.60	0.37	60	
187	0.00	0.01	0.99	40	40
188	0.00	0.01	0.99	40	
189	0.00	0.00	1.00	40	
190	0.00	0.00	1.00	40	
191	0.00	0.00	1.00	40	
192	0.00	0.01	0.99	40	
193	0.01	0.53	0.46	60	60
194	0.15	0.71	0.15	60	
195	0.15	0.71	0.15	60	
196	0.03	0.73	0.25	60	
197	0.74	0.20	0.06	80	
198	0.15	0.71	0.15	60	
199	0.11	0.58	0.30	60	
200	0.15	0.71	0.15	60	

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Appendix G
List of experts

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List of Experts

Sl. No.	Expert Name	Position
1	Mr. Parimal Bikash Sutrodhor	Additional Chief Engineer Roads and Highways Department
2	Mr. Abu Saleh Md.Nuruzzaman	Executive Engineer Roads and Highways Department
3	Mr. Shishir Kanti Routh P.Eng .	Executive Engineer Roads and Highways Department
4	Mr. S.M Shafiqul Islam	Executive Engineer Roads and Highways Department
5	Mr. Md. Zikrul Islam	Executive Engineer Roads and Highways Department
6	Mr. Sheikh Hasibur Rahman	Executive Engineer Roads and Highways Department
7	Ms. Parveen Sultana	Executive Engineer, Roads and Highways Department
8	Mr. Mohammad Ziaul Haider	Executive Engineer Roads and Highways Department
9	Mr. Asif Ahmed	Executive Engineer Roads and Highways Department
10	Mr. A.B.M Sertajur Rahman	Sub Divisional Engineer Roads and Highways Department

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CURRICULUM VITAE

NAME : Mr. Md. Mohibul Haque

BIRTH DATE : September 5, 1974

BIRTH PLACE : Kushtia, Bangladesh

EDUCATION :

YEAR	INSTITUTE	DEGREE/DIPLOMA
1999	Bangladesh University of Engineering & Technology Dhaka, Bangladesh	B.Sc.Eng. (Civil Engg.)
2012	Kasetsart University Bangkok, Thailand	M.Eng. (Civil Engineering)

POSITION/TITLE : Sub Divisional Engineer, RHD

WORK PLACE : Roads and Highways Department, Ministry of Communication, Sarak Bhaban, Ramna, Dhaka

SCHOLARSHIP/AWARDS : Thailand International Development Cooperation Agency (TICA), 2010-2011

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