A STATISTICAL ANALYSIS OF DETERMINANTS OF ROBBERIES IN WESTERN PROVINCE OF SRI LANKA.

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Degree of Master of Science in Business Statistics

Department of Mathematics

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DECLARATION OF THE CANDIDATE AND SUPERVISOR

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Senior Professor in Applied Statistics

Faculty of Engineering

University of Moratuwa

Sri Lanka

DEDICATION

This dissertation is dedicated to my dearest family for the sacrifice they made for me.

ACKNOWLEDGEMENTS

This research was completed with the assistance, ideas and encouragement from a lot of people. However, I would like to devote special thanks to people who extended their support in my humble acknowledgment.

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ABSTRACT

The growth of the robbery rate in the post conflict phase has been a major problem for the wellbeing of Sri Lankan society. Recant past various kind of frequent methods are being used for the robberies. This study was therefore focused to identify the associations among four different methods of robberies: type of robbery (single vs group), time of the day (day vs night), status of weapon used (yes or no) and mode of travelling (foot vs vehicle). The required data on daily basis (2013-2017) from the Western and Southern provinces were collected from the Crime Intelligence Analyzing Bureau of Sri Lanka Police. The chi-square analysis found that the number of robberies in the two provinces are significantly associated ($p < 0.05$) with type of robberies and the status of weapon used. The percentages of group robberies in southern province (73.9%) is significantly higher than that in western province (67.7%) irrespective of the type of robbers. The odds of group crimes in southern province is 1.35 times higher than that in western province. The odds of crimes without weapon in southern province (72%) is 1.21 times higher than that in western province (76%). It was also found that four methods of crimes are significantly associated pairwise. Irrespective of the province, the percentage of crimes during day time by single person (64%) is significantly higher than the percentage of crimes during day by a group (54%) and that when travelled by foot by a single person (62%) is significantly higher ($p < 0.05$) than the travelled by foot with a group (36%). Furthermore, the percentage of crimes without weapon by a single person (83%) is significantly higher than percentage of crimes without weapon by a group (63%). A log linear model found that in addition to main effects and 2-way effects, only the 3-way infraction between time of day, status of weapons uses and type of robbery is significant ($p < .05$) and the majority of the robberies occurred during day time without using weapon as a group. The inferences derived from this study can be used effectively to reduce the crimes in Sri Lanka, and in particularly day time crimes, without weapon by a single person. It is recommending to carry out similar analyses for other provinces too.

Keywords: crimes, log linear models, odd ratios, robberies

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CHAPTER 1

INTRODUCTION

1.1 General introduction

Since rise of grave crimes rates in Sri Lanka after the civil war which irritated life style and peace and harmony among the nationalities for 30 years (see Grave crime abstract publish in 2010 by Sri Lankan police department) the study was conducted to mitigate the issue by providing comprehensive quantitative analysis to identify the factors affecting for Grave crime. Developing country like Sri Lanka is heavily affected unless crimes rates under control it can be directly influenced for the social and economic performances of the country. Grave crimes have large impact of social well being of human and the families daily routine and dependents' educations and satisfaction (Ratnayaka, 2015).

A crime basically means that a damage or an action which harm to a body of a person or to a property. Actions against the government also concerned as crime. Crimes such as gang robberies, illegal droves, murder, deforestation were reported as severe crimes in late eighteenth centuries in Colombo city under British government. It was 404 per hundred thousand population, after permitting to Tamil and Muslims to settle in Colombo, population started increasing meanwhile crime rate also rapidly increased (Obesekara, 1975). With industrial revolution, society more economically diversified and become more sophisticated. People engaged with others in the social world more frequently through the technology in fact that made world more connected and information started flowing every seconds such actions directly influence improvement of crime rate.

Crime is a social phenomenon which has inclusive negative effects on the society moreover, showing rapid increase of the number of property crimes all over the country. The study focus on causes affecting the processes of investigation of reported crimes and the strengths and weaknesses of law performing sectors. Crime is an offence(Ganville, 1982) . It is a misdeed, and a single wrongdoing or a crime leads to two causes of action. Those two causes of actions are explained as "Civil wrong "and "Criminal

wrong .Obviously, a crime because, each criminal act embodies serious threat on the security and the virtuous life style of all in the society (Ganville, 1982). As stated in the book named “Legal Duties” written by C.K. Allen, that society may not be unaffected or safe by just paying compensation for a party jeopardized by whatever criminal act (Allen, 1996). Merely due to the absence of fixed definition to determine a crime, the decision that “crime is an action with end results of a criminality which produces a process of legal action in a criminal court, after his illustration of below mentioned statement in the journal titled “Current Legal Problems” published in 1995.

1.2 Definition of robberies and legislation

The definition of robbery upon which this thesis is which states: “A person is guilty of robbery if he steals, and immediately before or at the time of doing so, and in order to do so, he uses force on any person, or puts or seeks to put any person in fear of being then and there subjected to force.” From this definition it is worth highlighting that the use of force and / or fear distinguishes a robbery offence from an act of burglary. Furthermore, housebreaks and theft are classified as a property crime whereas robbery is classified as a violent property crime in the means of using force and making fear to victim appearing in front of.

Despite this distinction, a robbery offence covers a wide variety of different acts including bank robbery, mobile phone robbery and street robbery, regardless of the amount of money or any property. Sri Lankans' seem to take the offence of robbery more seriously than that of common theft, with the maximum custodial sentence being extended to ten years imprisonment. Robbery is charged under section 397 of the Penal code; 'theft is robbery if, in order to committing [the offence he] voluntarily causes [or attempts] to cause death, hurt [or] wrongful restraint'. The definition is very similar to English law, where the offence is chargeable under s8 Theft Act 1968; '[If at or immediately before] the time of theft [he] puts or seeks to put any person in fear of being subjected to force'.

The level of 'force' needed to satisfy the actus rues (physical aspect of the crime) of the legislation is outstandingly different from Sri Lankan law. In England a mere nudge so that someone loses their balance can be sufficient (this was shown in the case of

Dawson and James, 1978). So, in practice a relatively low level of physical contact can amount to force for the purpose of robbery. However, in the Penal Code it explicitly states there must be 'hurt' or an 'instant wrongful restraint'. This low level of force seems to conflict with the harsh custodial sentence given in England for this s8 offence, which ranges up to life imprisonment. The judge, however, can accommodate for the level of force at their discretion by deciding the sentence, although either custodial/community sentence or even a mere fine.

Precise definitions of the offence may vary between jurisdictions. Robbery is differentiated from other forms of theft (such as housebreak, shoplifting or car theft) by its inherently violent nature (a violent crime); whereas many lesser forms of theft are punished as misdemeanors, robbery is always a felony in jurisdictions that distinguish between the two. Under English law, most forms of theft are tribal either way, whereas robbery is tribal only on indictment. The word "rob" came via French from Late Latin words (e.g. deraubare) of Germanic origin, from Common Germanic raub -- "theft".

Among the types of robbery, armed robbery involving use of a weapon and aggravated robbery involving use of a deadly weapon or something that appears to be a deadly weapon. Highway robbery or "mugging" takes place outside or in a public place such as a sidewalk, street, or parking lot. Carjacking is the act of stealing a car from a victim by force.

1.2.1 Variation of crimes

There are few specific features namely, doing a crime, Illegality; prevalence of a social risk, and the action is subjected for a punishment etc., through which a crime can be identified. The other way of in-depth defining of crimes is to categorize the crime and to perform the defining. The categorization of crimes are attended differently in varied country contexts. The bureau of crimes in America used to categorize crimes in two ways, aggravated crimes and other crimes (FBI, 2016).

Criminal acts namely ; Homicides, rapes, robberies (Money / property) , assaulting, burglaries, ransacks are categorized as aggravated crimes and those crimes set on fire, defrauding property and money ; prostitution ; child abusing ; violating traffic laws ; are listed under ‘other ‘ crimes. Nevertheless, the commonly accepted categorization

which is popular in most of the countries is in two groupings namely 1. Crimes against the individual and 2. Crimes on property. It is elaborated that; Crimes against individual means the misdeeds done against men or women in a harmful manner. In this type of crimes a damage caused physically is predicted. Murdering, attempted assassination; assaulting; injuring; raping; abductions are some of the exemplars, the crimes such as, stealing, ransacks, accepting unauthorized property or goods, cheating, harmful actions, unrighteous entrance etc. are considered as illegal acts against property. The said property can be identified in three categories; Intellectual property, Immovable property and Movable property.

1.2.2 Legal provisions of crime

This can be explicated in simple terms that crimes such as avoiding justice and fairness, conspiracy, giving flawed evidence, insulting court of justice, violating traffic laws are mis-deed actions doing against criminal justice, and fairness. As per the Legal provisions, the sexual crimes are the unwarranted sexual acts such as abusing women, multi marriages, oppressive sexual acts, abnormal sexual acts, prostitution etc., Whereas, whatever misdeed or illegal action involved by the Government within its power structure in a country, is considered as political criminalities and when the, accused becomes the straightforward offender it is known as the victimless crime, and when the affluent social groups involved in criminal acts by manipulating their own professional status can be briefed those actions in simple terms as “white color crimes”.

1.2.3 Social impact on crimes

“Crimes” are notable and specific factors within the social conspiracies being faced by current Sri Lanka as a developing country. It is unquestionable that crimes are factors disturbing the development in any country. It is also un-debatable that when the background of crimes are discussed, there are causes affected within the modern society of Sri Lanka that, those socio-economic and political re-organizations happened after the decade of 1970 and the weaknesses of the educational policies in this country. An observable factor is that the open economic policy introduced in 1978 to stimulate foreign investors, also blasting the ‘closed economy’ prevailed between 1972 and 1976 has influenced vigorously on the current face of criminal actions. As a result, the

dimensional family systems prevailed within the traditional society had transformed gradually to the levels of nuclear family surroundings, together with urbanization and environmental pollution too, were emerged as forceful crises. In this context, money fronted society has emerged due to the fact that value of money became the decisive factor in respecting the society. In the said distorted social change series of criminal actions, sexual crimes, political based crimes together with varied types of misdeeds could be identified. In contrary, specific identification was possible within Sri Lanka on the nature of wrongdoings, as well as the faces of crimes and also about the victims of varied crimes.

1.2.4 Crimes and economic crisis

One other notable factors was that murdering for money on targeted seizing of financial assets based on economic factors, kidnapping or abduction, Getting ransoms, and other property based crimes were prevalent within the Sri Lankan society either in the shape of organized economic crimes or in the faces of dis-organized economic crimes. In the cases of doing economic and physical arbitrary discretion those attended in an organized manner such crimes are denoted as 'Organized economic crimes'.

The above measures are attended purely for economic benefits and an assorted gang's culture has inherited. The degree of supremacy within criminals is so powerful, in which the legal mechanism too, has become as a mallet. It is also a notable factor that the frail status of law being adopted on criminals has been a cause to emerge more criminals in the Sri Lankan Society. An increased attention of the society has been visible on strategies of the sudden earning of money among the disorganized economic crimes. Gambling is a specific move on same and organized gangs of criminals are be endowed with in a skillful manner. The aim of these types of gangs is to grab money either from the person handling betting transactions or from the croupier. When the profit distribution is concerned there is an invisible hierarchy and even those holding positions of such chain of command do not know those who are act in different positions. These types of crimes are done by breaking the law as they wish and continue in a new face with the usage of hand phones and also using computers to access internet. Also noticeable that these gangs are involved in abductions for money, provision of loans under higher rates of interest and importing harmful drugs and trafficking same.

As a whole, existence of an economic hierarchy within the economic network of the country, be equipped with capabilities inherent to them, be with personalities, ganging and the political sponsorship, sub cultural identities, leaderships are the features adopted within their organizations.

1.2.5 Changes of nature of crimes in Sri Lanka

After the decade of 1970 it was possible to identify specific change in the nature of crimes within the structure of societal setting with changes based on economic factors. In 1867 crime data collection was done according to this; murders, casual murdering, poisoning for robberies, money robberies, road robbery, stealing, illegal droves, damages by flame, rapping, unnatural offends, overreaching houses, and escaping from jail, 52,157 number of crimes were reported throughout the island in 1890 and among those crimes, there were 893 murders, robberies 499, stealing of property 16284 cycle stealing, 1886, severe injuries 2190, knife injuries 7,513, were there.

Police on egregious crimes within the categorization of crimes in Sri Lanka 26 egregious crimes were named while, categorizing it was divided into two categories, while one of them is related to physical and the other is related to properties. Grave crimes are very serious crimes for which a person will normally be prosecuted in a criminal court for a trial. In concerned with the data analysis done in the recent past revealed that a higher increase and growth of property related crimes among the most egregious criminal acts. As mentioned earlier too, the root cause for large majority of crimes are economic advantages. This has been well evidenced through the flow of criminal acts happened in Sri Lanka in recent times.

1.3 Modern picture of robbery

Criminologists, sociologists, and psychologists have sought to understand criminal activity in general, and rationalized robberies in particular, through examination of offender's characteristics, environment, psyche, and motivations. Some sociologists question the efficacy of the rational choice model to be applied to the crime of robbery. For example, Katz (1991) suggested that, Non rational violence makes sense as a way

of committing oneself to persist in robbery in the face of the risks and chaos inherent in the criminal event (Katz, 1991)

1.3.1 Robbery consequences: death, injury, and losses

A potential consequence of a robbery is the killing of the victim or, in rare cases, the killing of the offender in a thwarted robbery. More commonly, injuries occur in the context of robberies as offenders are frustrated by the victim's response and use force to, as Wright and Decker (1997) observed, establish "the illusion of impending death." Consideration of the number and rate of homicides that result from robberies is possible by examining data from the Supplemental Homicide Reports (SHR).

1.3.2 Continuous growth of robberies in numbers and methods.

The growth of the robbery rate in the post conflict phase has been a major problem for the wellbeing of Sri Lankan society. The entire society has suffering, which bad effects spreading across communities through unending happening of robbery. Over the incidents by incidents it was shown some kind of frequent methods were used for the robberies. That methods should be investigated to prevent robberies.

For analyzing the robbery methods and determine the combinations of methods it was identified most frequent crime methods as time of the day, weapon usage, single or grouped crime, travelling methods.

1.4 Research problem

Understanding the methods that contribute to robbery problem will help us to frame and determine effective measures, recognize key intervention methods, and select appropriate responses. Though no single factor completely accounts for the robbery problem, the interrelated dynamics among victims, locations, offenders, and routines all contribute to robbery patterns.

Robberies occur when motivated offenders encounter suitable victims in an environment that facilitates robbery. A robbery problem emerges when victims repeatedly encounter offenders in the same area. In short, a combination of circumstances will lead to a robbery, not any single circumstance. For example, a robbery is likely to occur when an offender, pressed for cash, spots a victim leaving the

places alone, heading toward a vulnerable area, isolated location. A pattern of robberies could occur if offenders notice people taking similar routes after leaving particular routings. Different types of routines can change offender, victim and location characteristics, thus altering robbery patterns (e.g., midweek work and school routines may produce different robbery patterns from weekend or holiday routines).

Depending on the specific details of a robbery problem, the relative importance of each side of will vary. Addressing any one method might reduce a problem, but addressing more than one side will better ensure that the robbery problem will decline. Though there are many data on crimes are stored, a statistical investigation on such data has been limited due to various reasons mainly due to lack of resource persons.

1.5 Objectives of the study

As described above objectives are:

- To investigate association among method of robbers
- To identify methods which are using by robbers for robberies
- To determine significant association between methods of robberies.
- To determine significant model which explaining the interaction of robberies and methods.

1.6 Significance of the study

This study was initiated to know influence of methods of robberies toward robbery commissioning such as how much associated effect on number of robberies. After acquiring comprehensive and pragmatic envisage about influence of methods on robberies through developed log linear model, law enforcement authorities can implement strategies to better prevention of robberies.

1.7 Organization of the dissertation

Organization structure of the dissertation is presented in this section as follows: Chapter 2 provides the comprehensive literature review on studies of factors affecting the crimes. Data description of the study along with the research methodology are described in Chapter 3. Association among five factors related to robberies is presented in Chapter 4. Modelling frequencies of robberies via log-linear approach is presented in Chapter

5. Finally, provides concluding remarks and recommendations for the future studies in Chapter 6.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This section explores the historical contribution of scholars and their work to understanding and giving contribution to criminological expertise, statistical basement of categorical data analyzing, and real-life evidence for understanding robbery crime scenarios.

2.2 Definition of crime

A crime is an unlawful act punishable by a state or other authority. The term crime does not have any simple or universally accepted definition, though statutory definitions have been provided for certain purposes. The content is based only the different procedures of criminal as distinct from civil cases can serve as a reliable distinguishing mark (The Definition of Crime, 1955). There is no legally defined delineation on Crime contained either in Sri Lanka Penal code or in English criminal law.

It is clear that there is an inherent common meaning on Crime in all conventionally described definitions. Criminal behavior is behavior in violation of the criminal law. No matter, what the degree of immorality, reprehensibility or indecency of an act; it is not a crime unless it is prohibited by the criminal law. The criminal law in turn, is defined conventionally as a body of specific rules regarding human conduct from other rules are, therefore, politically; specificity; uniformity and penal sanction. However, these are characteristics of an ideal, completely rationale system of criminal law; in practice the differences between the criminal law and other bodies of rules for human conduct are not clear-cut. Also, the ideal characteristics of the criminal law might not always be features of the criminal law in action.

2.3 Variation of crimes

There are few specific features namely, doing a crime, Illegality; prevalence of a social risk, and the action is subjected for a punishment etc., through which a crime can be identified. The other way of in-depth defining of crimes is to categorize the crime and to perform the defining. The categorization of crimes are attended differently in varied country contexts. The bureau of crimes in America used to categorize crimes in two ways, aggravated crimes and other crimes (FBI, 2016).

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It is elaborated that; crimes against individual means the misdeeds done against men or women in a harmful manner. In this type of crimes, a damage caused physically is predicted. Murdering, attempted assassination; assaulting; injuring; raping; abductions are some of the exemplars, the crimes such as, stealing, ransacks, accepting unauthorized property or goods, cheating, harmful actions, unrighteous entrance etc. are considered as illegal acts against property. The said property can be identified in three categories; Intellectual property, Immovable property and Movable property.

2.4 Robbery and legislation

The definition of robbery upon which this thesis is which states: “A person is guilty of robbery if he steals, and immediately before or at the time of doing so, and in order to do so, he uses force on any person, or puts or seeks to put any person in fear of being then and there subjected to force.” From this definition it is worth highlighting that the use of force and / or fear distinguishes a robbery offence from an act of burglary. Furthermore, burglary is classified as a property crime whereas robbery is classified as a violent crime.

Despite this distinction, a robbery offence covers a wide variety of different acts including bank robbery, mobile phone robbery and street robbery, regardless of the amount of money or any property.

The level of 'force' needed to satisfy the actus rues (physical aspect of the crime) of the legislation is outstandingly different from Sri Lankan law. In England a mere nudge so that someone loses their balance can be sufficient. This was shown in the case of (Dawson and James, 1978). So, in practice a relatively low level of physical contact can amount to force for the purpose of robbery. However, in the Penal Code it explicitly states there must be 'hurt' or an 'instant wrongful restraint'. This low level of force seems to conflict with the harsh custodial sentence given in England for this s8 offence, which ranges up to life imprisonment. The judge, however, can accommodate for the level of force at their discretion by deciding the sentence, albeit either custodial/community sentence or even a mere fine.

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An observable factor is that the open economic policy introduced in 1978 to stimulate foreign investors, also blasting the 'closed economy' prevailed between 1972 and 1976 has influenced vigorously on the current face of criminal actions. As a result, the dimensional family systems prevailed within the traditional society had transformed gradually to the levels of nuclear family surroundings, together with urbanization and environmental pollution too, were emerged as forceful crises. In this context, money fronted society has emerged due to the fact that value of money became the decisive factor in respecting the society. In the said distorted social change series of criminal actions, sexual crimes, political based crimes together with varied types of misdeeds could be identified. In contrary, specific identification was possible within Sri Lanka on the nature of wrongdoings, as well as the faces of crimes and also about the victims of varied crimes.

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When the profit distribution is concerned there is an invisible hierarchy and even those holding positions of such chain of command do not know those who are act in different positions. These types of crimes are done by breaking the law as they wish and continue in a new face with the usage of hand phones and also using computers to access internet. Also, noticeable that these gangs are involved in abductions for money, provision of loans under higher rates of interest and importing harmful drugs and trafficking same. As a whole, existence of an economic hierarchy within the economic network of the country, be equipped with capabilities inherent to them, be with personalities, ganging and the political sponsorship, sub cultural identities, leaderships are the features adopted within their organizations.

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Grave crimes are very serious crimes for which a person will normally be prosecuted in a criminal court for a trial. In concerned with the data analysis done in the recent past revealed that a higher increase and growth of property related crimes among the most egregious criminal acts. As mentioned earlier too, the root cause for large majority of crimes are economic advantages. This has been well evidenced through the flow of criminal acts happened in Sri Lanka in recent times.

2.9 Empirical findings

Based on a review and test to the professional literature on socio-economic conditions and property crimes following the first-order autoregressive model Ralph C. Allen (1996) states that the absolute poverty measure is negatively related to each of the crime rates, and it is statistically significant for burglary and vehicle theft. On the other hand, the relative poverty measure is negatively related to each of the crime rates, but it is not statistically significant (Allen, 1996). However, despite some socio-economic variables such as ethnicity and urban-rural deviations, the present study does not intend to follow economic factors as its objectives mainly focus on socio-political and geographical fundamentals in Sri Lanka.

(Yih-Wu Liu and Richard H. Bee,1983) have modelled the relationship between property crimes and local economic conditions by employing a multi-factor model which includes economic, apprehension, seasonal and plant closing variables as the explanatory regressors and crimes against property as the dependent variable in the Youngstown Metropolitan of Ohio, USA. The study suggests that local property crimes are highly connected with the economic conditions of the area: as local economy proposers the unemployment rate decreases removing the economic reasons for property crimes at the growth of per capita income (Liu and Bee, 1983). Moreover, the geographical variables such as weather conditions and local plant closings have been detrimental to property crimes. According to the study, it can be partly explained the rising expenditures on uniformed police personnel is in response to rising property crime. However, some of the selected variables of present study such as police strength, ethnicity and urban-rural disparities have not been considered in the above study.

During the 1980-1983, Kent Bausman and Richard Goe (2004) have studied the relationship between employment volatility and property crimes using regression procedures across 683 U.S. metropolitan counties. According to the findings, increasing volatility of employment has resulted higher level of property crime and, when it comes to individual basis, some less severe forms of property crimes can be examined (Bausman and Goe, 2004). Even though it does not consider the correlation between the problem of economic marginalization owing to economic instability and property based crimes, this study focuses on the relationship between demographic characteristics of urban-rural boundaries and property crimes in the context of Sri Lanka.

Roy W. Ralston (1999) examines changes in rate of property crime reported to Police in the United States from 1958 to 1995 upon the variables of changes in rates of inflation; technological, cyclical, and frictional unemployment; arrest rates for property crimes disaggregated by race; the interaction of arrest rate and technological unemployment; and a measure of police provisioning. According to the findings, a significant positive relationship was evident on inflation, cyclical unemployment, frictional unemployment, and the interaction of white arrest rates and technological unemployment but police provisioning is not found to be significant (Ralston, 1999). This study is important in several aspects: it shows a significant relationship between race and property crimes which is considered ethnicity as a variable into the present study in the context of Sri Lanka. On the other hand, the study does not show a relationship between police strength/provisions and property crime in the United States.

Apparently, the problem of availability of studies in Sri Lanka and the limited corporation of the studies carried out in the external contexts to identify the specific importance of variables of the present study in relation to property based crimes have been the major issues in order to constitute the rationale of this study. Even though Ratnayaka (2015) shares many of similar variables with the present work, it has particularly focused on the urban crimes of MPD and provides overall map despite the importance of property based crimes in the Western Province of Sri Lanka. In some of the studies, although the seasonal effects is a vibrant dynamic to property crimes, it cannot be applied to a tropical context of the Western Province of Sri Lanka. Moreover, despite some of the traditional socio-economic standards such as unemployment,

punishments, living standards etc., this study intends to employ relatively specific variables to identify the contextual factors of property crimes.

Capable guardianship has been originally defined as the act of supervision, undertaken by ordinary citizens, for the purpose of crime prevention (Cohen and Felson, 1979). In this approach, guardians are defenders of crime, who can discourage crime through their presence, supervision, and intervention (Felson and Eckert, 2016; Reynald, 2009). In the meantime, the Routine Activity Theory argues that three elements must converge in time and space for crime to occur: a motivated offender, a suitable target/victim, and the absence of a capable guardian (Cohen and Felson, 1979).

The existing literature guardianship plays an important role in crime prevention. When capable guardians are present, crime is less likely to occur when motivated offenders and suitable targets converge in space and time (Cohen and Felson, 1979). Most guardianship studies support the theorized relationship between guardianship and crime that sufficient number of police officers in and area can help to reduce crime rate. For example higher levels of guardianship are found to be associated with lower levels of crime (Hollis-Peel, Reynald, van Bavel, Elffers & Welsh, 2011).

Similarly, studies from the United States and the United Kingdom have found that decreased levels of guardianship were related to increased risk of burglary and direct-contact predatory crimes (Cohen and Felson, 1979; Garofalo and Clark, 1992; Miethe, Stafford and Long, 1987; Miethe, Stafford and Sloane, 1990; Sampson and Wooldredge, 1987). Collectively, these studies reinforce the importance of guardianship in protecting people and properties from victimization. However, these studies relied on aggregate survey measures to operationalize this concept and often did not directly measure guardianship or supervision (Hollis-Peel et al., 2011).
Furthermore, no previous studies have examined how guardianship intensity is associated with PBCs.

The term “division” can be applied to a large territorial subdivision of province. Higher levels of urbanization and population density in a country are used to represent increased interactions between potential offenders and suitable targets. As a complementary theoretical perspective, the Routine Activity Theory focuses on how the convergence of motivated offenders, suitable targets and lack of guardianship creates opportunities for criminal activity (Cohen and Felson, 1979).

The intellectual roots of routine activity theory are varied, but primarily found in the ecological tradition (Burgess 1925; Shaw, Zorbaugh, McKay, and Cottrell 1929; Shaw and McKay 1942; Hawley 1950). The work of Chicago School researchers such as Burgess and Shaw, McKay and their colleagues (Shaw et al. 1929; Shaw and McKay 1942) is important to routine activity theory because they show that there is a systematic, special pattern to crime. Specifically, the Chicago School group found that crime was associated with proximity to the city center. Moreover, they argued that certain areas of the city consistently displayed characteristics such as poverty, large percentage of ethnic inhabitants, physical deterioration, and transient population.

Thus, these “zones in transition” seem to breed “traditions of delinquency” and thus act as less effective agents of community social control (Shaw and McKay 1942, p. 174). The effect of proximity to offenders using cities as the units of analysis examined the relationship between city size and criminal opportunity (Jackson 1984). Drawing on traditional ecological theories of urban life (Wirth 1938; Cohen and Felson 1979; Roncek 1981), Jackson (1984) argues that larger cities (defined as having 25,000 or more residents) have more problems of attenuated informal social controls than smaller cities and thus more crime.

2.10 Summary of the chapter 2

Based on review of empirical studies, it can be identified that the most of the studies are based on property-based crimes but them did not directly consider about robberies. Also, they have little attention about the associations among the time of the day, weapon usage, single or grouped crime and travelling methods. Nevertheless, the review is useful to identify few gaps in many studies and it was useful to analysis the present data and develop the necessary model.

CHAPTER 3

MATERIALS AND METHODS

3.1 Introduction

The objective of this chapter is to provide a materials and methods which were used to investigate the research questions. The first section of this chapter discusses about the source of the data. Then variables which are selected for this study. Finally, the chapter discusses the analysis strategy used in this study.

3.2 Secondary data

This study is based on secondary data which are Robbery statistical data from 2013 to 2017 from the database of crime intelligence analyzing bureau Sri Lanka police.

3.3 Identifying the variables

Province

In this study it was focusing on two provinces where the maximum number of robberies reported over the years we concerned.

1. Southern province
2. Western province.

Time of the day

For the convenience and compatibility of the study the time of the day was categorized for two ranges.

1. Time range between 0600 hours to 2400 hours as day.

2. Time range between 2400 hours to 0600 hours as night.

Weapons usage

It was categorized two categories for the usage of weapons

1. Weapon used

2. Weapon not used

Single or grouped crime

The criminals gathering for crime or doing individually was concerned here

1. Grouped
2. Single

Travelling methods

How criminals travelling for commissioning crimes was categorized in this fact.

1. Traveled by foot
2. Traveled by vehicle

3.4 Methods of data analyses

Data analysis done in several steps. Descriptive analysis techniques such as analysis of frequency tables were used to identify the association between provinces and various types of robberies. A log linear modelling was used to model the number of robberies with other independent variables.

3.4.1 Chi-Square analysis: 2-way frequency table

A frequency distribution is an overview of all distinct values in some variable and the number of times they occur. It tells how frequencies are distributed over values. Frequency distributions are mostly used for summarizing categorical variables. These result in higher order tables and charts that don't give insight into data. In this case, 2-way frequency tables and histograms are the way to go as they visualize frequencies for *intervals* of values rather than each distinct value. In typical two factors (A & B) having 2 levels each can be illustrated as shown below.

Typical Frequency table of 2x2

A	B		**Total**
	B_1	B_2	
A_1	f_{11}	f_{12}	$f_{1.}$
A_2	f_{21}	f_{22}	$f_{2.}$
Total	$f_{.1}$	$f_{.2}$	$f_{..}$

Let $\{f_{ij}\}$ = observed frequency of the row category = i and column category=j

Let p_{ij} = p(observation falling into $(i,j)^{th}$ cell

= p(observation falling to the i^{th} row and observation falling to the j^{th} column)

= p(observation falling to the i^{th} row) * p(observation falling to the j^{th} column)

If the null hypothesis H_0 : Factor A is independent of factor B is accepted.

Let the expected frequency of the (ij)th cell be e_{ij} (say)

Thus $e_{ij} = f_{ij} x p_{ij} = observed$ freq in (i, j)th cell x corresponding probability

$e_{ij} = f_{ij} x p_{ij} = observed$ freq in (i, j)th cell x product of marginal probabilities

That is $e_{ij} = f^* p_{i.} * p_{.j}$ if Ho is true.

$$\hat{e}_{ij} = f_{..} * \frac{f_{i.}}{f_{..}} * \frac{f_{.j}}{f_{..}} \text{ (since } \hat{p}_{i.} = \frac{f_{i.}}{f_{..}} \text{ and } \hat{p}_{.j} = \frac{f_{.j}}{f_{..}}$$

$$= \frac{f_{i.} * f_{.j}}{f_{..}} = \frac{Total \text{ freq of the ith row} * \text{total freq. of j th col}}{\text{total frequency}}$$

The test statistic for H0 is: $\mathbf{X^2} = \sum \frac{(observed - expected)2}{expected} \sim \chi^2_{1=(2-1)x(2-1)}$

Three Common Statistics used to test the above hypothesis are:

- Pearson Chi-sqiare (Exact)
- Yates Correction (Continuity correction)
- Likelihhod Ratio

Chisquare statistic = $X^2 = \sum \frac{(observed - expected)2}{expected}$

Yates Correction chi-square = $\sum \frac{(|\mathbf{observed - expected}| - \mathbf{0.5})^2}{(\mathbf{expected})}$

Likelihhod Ratio = $\sum \text{observed} * \log\left(\frac{\text{observed}}{\text{expected}}\right)$

3.4.2 Log linear model

When contingency tables are consisted of more than two variables, the frequency table approach is not feasible. Of the variety of models introduced by many authors to analyse categorical data, log linear models are more popular and commonly used for searching relationships among the variables in multi-way contingency tables, in particularly when there is no difference between response variable and explanatory variables.

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The loglinear analysis is an extension of the two-way contingency table where the conditional relationship between two or more discrete, categorical variables are analyzed by taking the natural logarithm of the cell frequencies table multi-way contingency tables that involve three or more variables. The loglinear model is one of th**e** specialized cases of generalized linear model for Poisson distributed data. The variables investiagted using loglinear models are known as, response variables.

3.4.3 Notations used for log linear models

Consider a two-way table in which the row-variable A has categories (levels) i=1,2…i and the column-variable B has categories j=1,2,...,j. A multiplicative model that reproduces the cell frequencies as follows

$$e_{ij} = f_{..} \times p_{i.} \times p_{.j}$$

Because of its multiplicative form, the above formula is difficult to work with. However, if we take the logarithm of both sides, we can rewrite it as

$$log\left(e_{ij}\right) = log\left(f_{..}\right) + log\left(p_{i.}\right) + log\left(p_{.j}\right)$$

This shows that log expected frequency for the cell (i,j) can be expressed as an additive function of effects of i^{th} row and j^{th} column

The above equation can now be written as

$$log\left(e_{ij}\right) = \mu + \lambda_i^A + \lambda_j^B + \lambda_{ij}^{AB}$$

Where,

$log\left(e_{ij}\right)$ = log of the expected cell frequency in the for cell(ij)

μ = overall mean of the natural log of the expected frequencies

λ_i^A = main effect for variable A

λ_j^B = main effect for variable B

λ_{ij}^{AB} = the interaction effect for variable A and B

3.4.4 Goodness of fit test

When dealing with several competing models, the relative quality of each model must be considered. The quality of a model, as measured by its goodness of fit to the data, may be tested using either of two chi-square statistics: The Pearson chi-square statistic and the likelihood-ratio statistic.

In the log linear models, all main effects terms, 2- way interactions, 3-way interactions etc. can be examined. Once the model has been fitted, it is necessary to decide which model provides the best fit. The overall goodness of fit of a model is assessed by comparing the expected frequencies to the observed cell frequencies for each model.

The likelihood ratio is more commonly used to test a model fit. This is a powerful statistic because it is minimized in maximum likelihood estimation, the $G^2 = L^2$ statistic is given by

$$G^2 = 2\sum f_{ij}\ log\left(\frac{f_{ij}}{e_{ij}}\right) = 2\sum\left(observed\right) log\left(\frac{observed}{exp\,ected}\right)$$

Under Ho, G^2 is a chi square distribution with the degrees of freedom (df) equal to the number of lambda terms set equal to zero. Therefore, the L^2 statistic tests the residual

frequency that is not accounted for by the effect in the model (the λ parameters set equal to zero).

The larger the L^2 relative to the available degrees of freedom, the more the expected frequencies depart from the actual cell entries and so the larger L^2 values imply that the model does not fit the data and consequently, the model is rejected.

CHAPTER 4

ASSOCIATION AMONG FIVE FACTORS RELATED TO ROBERIES

4.1 Distribution of various factors related to robberies

4.1.1 Distribution by provinces

The Table 4.1 illustrates the provinces of the concerned for robberies of the sample.

Table 4.1: Provinces of the concerned for robberies

Province	Frequency	Percentage (%)
Southern	706	25.6
Western	2052	74.4
Total	2758	100.0

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It can be seen on the Table that the majority belongs western province. This account for 74.4% of the total number of robberies while 25.6% of robberies belongs to the southern province. The corresponding frequency bar chart is also shown in Fug. 4.1.

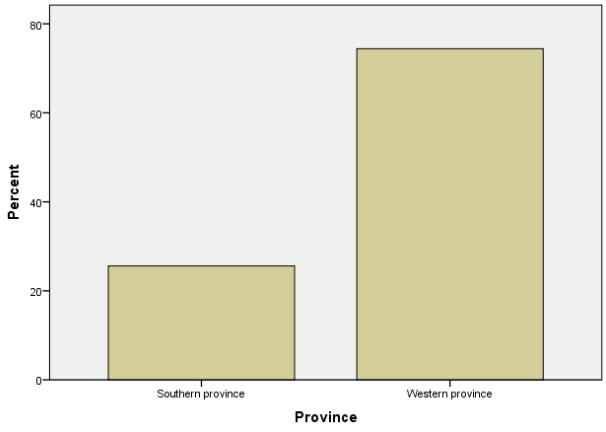

Figure 4.1: Frequency distribution of robberies in the selected two provinces

4.1.2 Distribution by grouped (or singled robberies)

Table 4.2: Distribution of the grouped or ungrouped robberies

Method	Frequency	Percentage (%)
Grouped	1912	69.3
Ungrouped	846	30.7
Total	2758	100.0

The results in Table 4.2 shows that out of the 2758 total number of robberies, the majority belongs to the category of grouped. This account for 69.3% of the total number of robberies while only 30.7% of the robberies belongs to the ungrouped category. The corresponding bar chart is shown in Fig. 4.2. Furthermore, using hypothesis testing under two binomial distributions, it can be concluded with 95% significance that the grouped robberies are significantly higher than single robberies (Z = 3.18, p= 0.001) irrespective of the province.

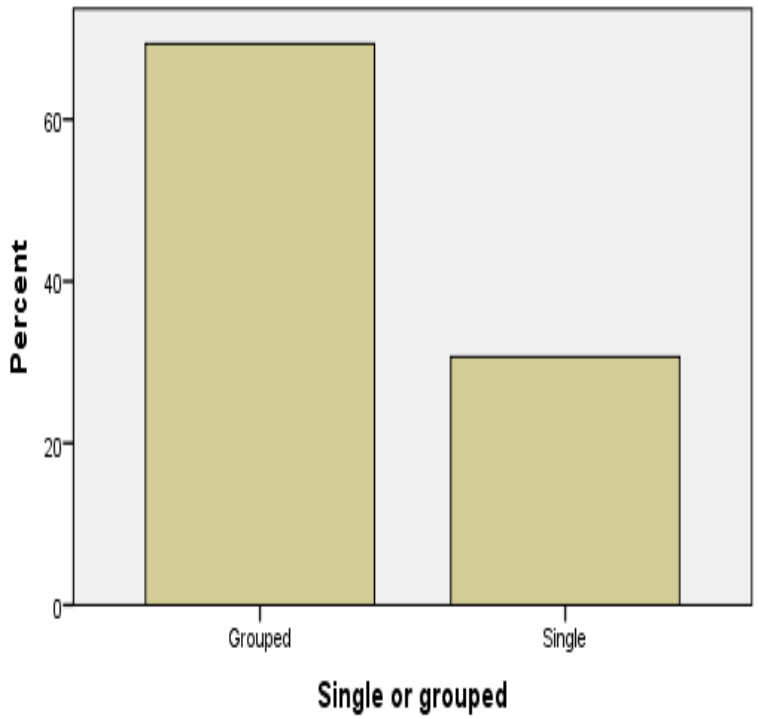

Figure 4.2: Frequency distribution of single or grouped robberies

4.1.3 Distribution of usage of weapons

Table 4.3: Distribution of the weapons usage

Weapons usage	Frequency	Percentage (%)
Weapon not Used	1902	69.0
Weapon Used	856	31.0
Total	2758	100.0

Table 4.3 indicates the distribution of the weapons usage for robberies out of the 2758 total number of robberies the majority belongs to the category of weapon not used. This account for 69.0% of the total number of robberies while only 31.0% of the robberies belongs to the weapon used category. The distribution is further illustrated inFig.4.3.

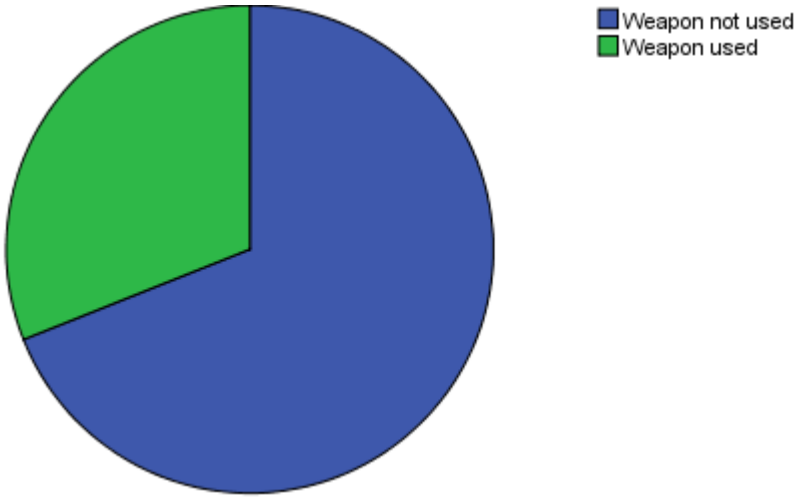

Figure 4.3: Distribution of the status of the weapon usage

4.1.4 Distribution of mode of travelling

Table 4.4: Distribution of the used travelling methods for the robberies

Travelling methods	Frequency	Percentage (%)
On Foot	1213	44.0
On Vehicle	1545	56.0
Total	2758	100.0

Table 4.4 as well as Fig. 4.4 indicates the distribution of the travelling methods for the robberies. Results indicate that 56.0% of the total number of robberies occurred while travelling and the balance 44.0% of the robberies belongs to the travelling by foot irrespective of the province.

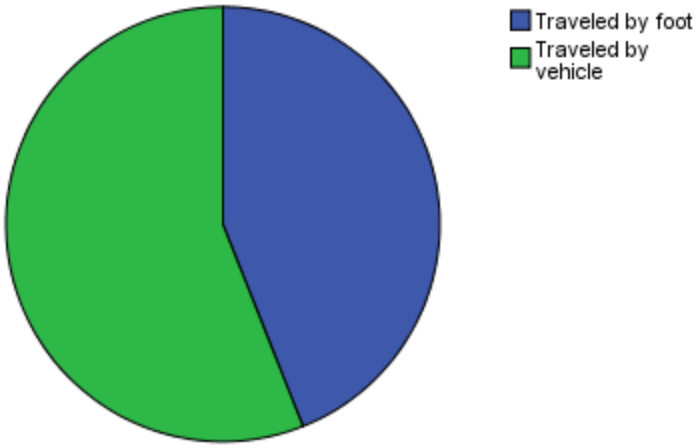

Figure 4.4: Distribution of travelling model for robberies

4.1.5 Distribution of time range

The pattern of occurring robberies in time range: day vs night is shown in Table 4.5 and it is further illustrated in Fig. 4.5 as well.

Table 4.5: Distribution of the time ranges of the robberies

Time range	Frequency	Percentage (%)
Day	1577	57.2
Night	1181	42.8
Total	2758	100.0

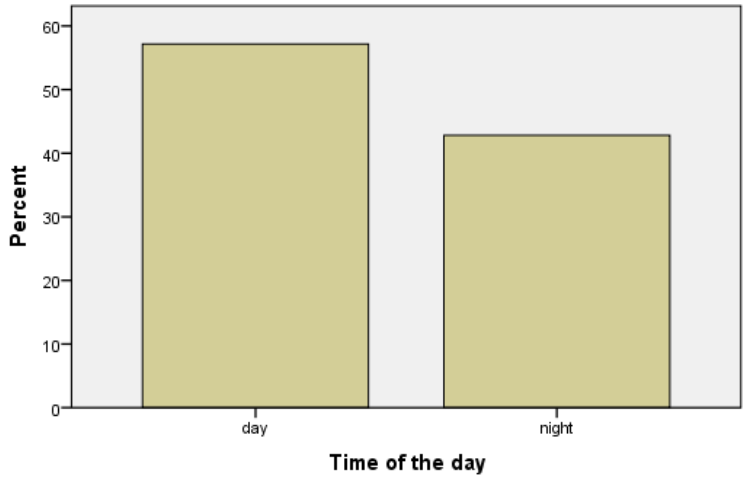

Figure 4.5: Distribution of robberies by time range

Table 4.5 shows that in the sample, out of the 2758 total number of robberies the majority belongs to the day time. This account for 57.2% of the total number of robberies while 42.8% of robberies belongs to the night time category.

4.2 Association between provinces and methods of robberies.

4.2.1 Provinces vs category of robberies

Table 4.6: Results of cross tabulation of province vs category of robberies (single or group)

			Single or Group		Total
			Grouped	Single	
Province	Southern	Count	522	184	706
		% within province	73.90%	26.10%	100.00%
	Western	Count	1390	662	2052
		% within province	67.70%	32.30%	100.00%
Total		Count	1912	846	2758
		% within province	69.30%	30.70%	100.00%

It was fond that the odd ratio for province (southern province/western province) = 1.35 and the corresponding 95% CI is [1.115, 1.637].

Table 4.7 Results of Chi-square Tests for data in Table 4.6

Type of Chi-square	Value	Df	P – Value
Pearson Chi-Square	9.492	1	0.002
Continuity Correction	9.202	1	0.002
Likelihood Ratio	9.688	1	0.002

Table 4.7 indicates that the likelihood ratio test is significant (x_1^2 = 9.688, p=0.002). Thus it can be concluded with 95% confidence that there is a significant association between province and single or grouped method confirming that single or group method robberies are significantly influenced by the province. The percentage of group robberies in southern province (73.9%) is significantly higher than the percentage of group robberies in western province (67.7%) while the percentage of single robberies in southern province (26.1%) is significantly lower than the percentage of single robberies in western province (32.3%). Furthermore, it can be concluded that grouped robberies are significantly higher than the corresponding single crimes in both provinces. The value of odd ratio 1.35 suggests that the odd of group crime in southern province is 1.35 times higher than that in western province. That is, group crimes in southern province is likely to occur 1.35 times higher compared to that in western province.

4.2.2 Province vs time of the day

Table 4.8 Results of cross tabulation of province vs time of the day

			Time of the day		Total
			Day	Night	
Province	Southern	Count	388	318	706
		% within province	55.00%	45.00%	100.00%
	Western	Count	1189	863	2052
		% within province	57.90%	42.10%	100.00%
Total		Count	1577	1181	2758
		% within province	57.20%	42.80%	100.00%

Table 4.9 Likelihood Ratio test results to identify the association between province vs time of the day

	Value	Df	P - Value
Pearson Chi-Square	1.913	1	0.167
Continuity Correction	1.793	1	0.181
Likelihood Ratio	1.908	1	0.167

The odd ratio for province (southern province/western province) = 0.88 and the corresponding 95% CI =[0.745, 1.057].

Table 4.9 indicates that the likelihood ratio test is not significant (chi-1.908, *p*=0.167). The odd ratio is also not significantly different from one as 1 belongs to the 95% confidence interval. Thus, it can be concluded with 95% confidence that there is no significant association between province and time of the day. However, percentage robberies during day time is slightly (55%) higher than that of night time (45%) in both provinces.

4.2.3 Province and weapon usage

Table 4.10 Cross tabulation of province vs weapon usage

			Weapon usage		Total
			Weapon not used	Weapon used	
Province	Southern	Count	508	198	706
		% within province	72.00%	28.00%	100.00%
	Western	Count	1394	658	2052
		% within province	67.90%	32.10%	100.00%
Total		count	1902	856	2758
		% within province	69.00%	31.00%	100.00%

Table 4.11 Likelihood Ratio test results to identify the association between province vs weapon usage

	Value	Df	P - Value
Pearson Chi-Square	3.968	1	0.046
Continuity Correction	3.782	1	0.052
Likelihood Ratio	4.018	1	0.045

The odd ratio for province (southern province/western province) = 1.211 and the corresponding 95% CI =[1.003, 1.462].

Table 4.11 indicates that the likelihood ratio test is significant (chi-4.018, *p*=0.045). Thus it can be concluded with 95% confidence that there is significant association between province and weapon usage. The percentage of robberies without weapons in Southern province (72%) is significantly higher than that in Western province (67%).

The value of odd ratio 1.003 suggests that the odd of crimes using weapons in southern province is 1.003 times higher than that in western province. That is, weapon crimes in southern province is likely to occur 1.003 times higher compared to that in western province.

4.2.4 Province and travelling method

Table 4.12 Cross tabulation of province vs travelling method

			Travelling method		Total
			Traveled by foot	Traveled by a vehicle	
Province	Southern	Count	301	405	706
		% within province	42.60%	57.40%	100.00%
	Western	count	912	1140	2052
		% within province	44.40%	55.60%	100.00%
Total		count	1213	1545	2758
		% within province	44.00%	56.00%	100.00%

Table 4.13 Likelihood Ratio test results to identify the association between province vs travelling method

	Value	Df	P - Value
Pearson Chi-Square	0.698	1	0.403
Continuity Correction	0.627	1	0.429
Likelihood Ratio	0.699	1	0.403

The odd ratio for province (southern province/western province) = 0.929 and the corresponding 95% CI =[0.782, 1.104].

Table 4.13 indicates that the likelihood ratio test is not significant (chi-0.699, *p*=0.403) confirming that there is no significant association between province and travelling method. The odd ratio is also not significant different from 1.

4.3 Association between type of crimes (single vs groped) other 3 factors

4.3.1 Association between type of crime and time of day

Table 4.14 Cross tabulation of single or grouped method vs time of the day

			Time of the day		Total
			Day	Night	
Single or grouped	Grouped	Count	1033	879	1912
		Raw percentages	54.0%	46.0%	100%
	Single	Count	544	302	846
		Raw percentages	64.3%	35.7%	100%
Total		Count	1577	1181	2758
		% within Single or grouped	57.2%	42.8%	100.00%

Table 4.15 Likelihood Ratio test results to identify the association between single or grouped method and time of the day

	Value	Df	P - Value
Pearson Chi-Square	25.291	1	0.000
Continuity Correction	24.873	1	0.000
Likelihood Ratio	25.563	1	0.000

Table 4.15 indicates that the likelihood ratio test is significant (chi-25.563, *p*=0.00). It can be concluded with 95% confidence that there is significant association between single or grouped method and time of the day. The percentage of crimes during day time by single person (64%) is significantly higher than the percentage of crimes during day by group (54%).

4.3.2 Association between single or grouped method and travelling method

Table 4.16 Crosstabulation of single or grouped method vs travelling method

			Travelling method		Total
			Traveled by foot	Traveled by vehicle	
Single or grouped	Grouped	Count	690	1222	1912
		% within Single or grouped	36.10%	63.90%	100%
	Single	Count	523	323	846
		% within Single or grouped	61.80%	38.20%	100%
Total		Count	1213	1545	2758
		% within Single or grouped	44.00%	56.00%	100%

Table 4.17 Likelihood Ratio test results to identify the association between single or grouped method and travelling method

	Value	Df	P - Value
Pearson Chi-Square	157.625	1	0.0
Continuity Correction	156.583	1	0.0
Likelihood Ratio	157.666	1	0.0

Table 4.17 indicates that the likelihood ratio test is significant (chi-157.67, p=0.00). It can be concluded with 95% confidence that there is significant association between single or grouped method and travelling method. The percentage of robberies reported when travelled by foot by a single person (62%) is significantly higher than the percentage of robberies reported when travelled by foot with a group (36%).

4.3.3 Association between type of crimes and weapon usage

Table 4.18 Cross tabulation of single or grouped method vs weapon usage

			Weapon usage		Total
			Weapon not used	Weapon used	
Single or grouped	Grouped	Count	1198	714	1912
		% within Single or grouped	62.70%	37.30%	100.00 %
	Single	Count	704	142	846
		% within Single or grouped	83.20%	16.80%	100.00 %
Total		Count	1902	856	2758
		% within Single or grouped	69.00%	31.00%	100.00 %

Table 4.19 Likelihood Ratio test results to identify the association between single or grouped method and weapon usage

	Value	Df	P - Value
Pearson Chi-Square	115.808	1	0.000
Continuity Correction	114.85	1	0.000
Likelihood Ratio	124.297	1	0.000

As the likelihood ratio test is significant (p = 0.00), it can be concluded with 95% confidence that there is significant association between single or grouped method and weapon usage. The percentage of crimes without weapon by a single person (83%) is significantly higher than percentage of crimes without weapon by a group (63%).

4.4 Association between time of the day and other 2 factors

4.4.1 Association between time of the day and travelling method

Table 4.20 Cross tabulation of time of the day vs travelling method

			Travelling methods		Total
			Traveled by foot	Traveled by vehicle	
Time of the day	Day	Count	566	1011	1577
		% within Time of the day	35.9%	64.1%	100%
	Night	Count	647	534	1181
		% within Time of the day	54.8%	45.2%	100%
Total		Count	1213	1545	2758
		% within Time of the day	44.0%	56.0%	100%

Table 4.21 Likelihood Ratio test results to identify the association between time of the day and travelling method

	Value	Df	P - Value
Pearson Chi-Square	97.835	1	0.000
Continuity Correction	97.07	1	0.000
Likelihood Ratio	98.059	1	0.000

Based on the results in Table 4.21, it can be concluded with 95% confidence that there is significant association between time of the day and travelling method. The percentage of crimes when travelled by foot during night (55%) is significantly higher than the percentage of crimes when travelled by foot during day (34%). The percentage of crimes when travelled by vehicle during day (64%) is significantly higher than the percentage of crimes when travelled by vehicle during night (45%).

4.4.2 Association between time of the day and weapon usage

Table 4.22 Cross tabulation of time of the day vs weapon usage

			Weapon usage		Total
			Weapon not used	Weapon used	
Time of the day	Day	Count	1165	412	1577
		% within Time of the day	73.90%	26.10%	100%
	night	Count	737	444	1181
		% within Time of the day	62.40%	37.60%	100%
Total		Count	1902	856	2758
		% within Time of the day	69.00%	31.00%	100%

Table 4.23 Likelihood Ratio test results to identify the association between time of the day and weapon usage

	Value	Df	P - Value
Pearson Chi-Square	41.505	1	0.000
Continuity Correction	40.97	1	0.000
Likelihood Ratio	41.282	1	0.000

Table 4.23 indicates that the likelihood ratio test is significant (chi-41.28, p=0.00). It can be concluded with 95% confidence that there is significant association between time of the day and weapon usage

4.5 Association between travelling method and weapon usage

Table 4.24 Cross tabulation of travelling method vs weapon usage

			Weapons usage		Total
			not used	used	
Travelling methods	Traveled by foot	Count	820	393	1213
		% within Travelling methods	67.6%	32.4%	100%
	Traveled by vehicle	Count	1082	463	1545
		% within Travelling methods	70.0%	30.0%	100%
Total		Count	1902	856	2758
		% within Travelling methods	69.0%	31.0%	100%

Table 4.25 Likelihood Ratio test results to identify the association between travelling method and weapon usage

	Value	Df	P - Value
Pearson Chi-Square	1.877	1	0.171
Continuity Correction	1.765	1	0.184
Likelihood Ratio	1.874	1	0.171

Results in Table 4.25 indicate that there is no significant association between travelling method and weapon usage.

4.6 Summary of chapter 4

The grouped robberies are significantly higher than the single robberies irrespective of the province. There is a significant association between province and single or grouped method. The percentage of robberies without weapons in Southern province is significantly higher than that in Western province. The percentage of crimes during day time by single person is significantly higher than the percentage of crimes during day by group. The percentage of robberies reported when travelled by foot by a single person is significantly higher than the percentage of robberies reported when travelled by foot with a group. The percentage of crimes without weapon by a single person is significantly higher than percentage of crimes without weapon by a group. The percentage of crimes when travelled by foot during night is significantly higher than the percentage of crimes when travelled by foot during day. The percentage of crimes when travelled by vehicle during day is significantly higher than the percentage of crimes when travelled by vehicle during night.

CHAPTER 5

MODELLING FREQUENCIES OF ROBBERIES VIA LOG-LINEAR APPROACH

5.1 Background

When contingency tables are consisted of more than two variables, the frequency table approach is not feasible and, in such situation, log linear models are more popular and commonly used for searching relationships among the variables in multi-way contingency tables, in particularly when there is no difference between response variable and explanatory variables. Thus, in this section, taking the response variable as the frequencies of robberies and the explanatory variables as the frequency of other variables (Table 5.1) are analyzed.

Table 5.1 Five factors and the levels used for log linear model

Variable	Categories
Province = P	1 = southern 2 = western
Single or Grouped = S	1 = grouped 2 = single
Time range (Day or Night) = T	1 = day 2 = night
Travelling Method = M	1 = on foot 2 = on vehicle
Weapon used or not used = W	1 = weapon not used 2 = weapon used

5.2 Results of testing k-way effects for log linear models

Log linear model was fitted to all data with five variables using backward elimination method starting from the full model. The useful outputs obtained are shown in Tables 5.2-5.4.

Table 5.2 – Observed and expected cell counts

Province	Single or Group	Time of The Day	Travelling method	Weapon usage	Observed		Expected	
					Count	%	Count	%
Southern	Grouped	Day	Foot	Not Used	57	2.1%	49.88	1.8%
				Used	14	0.5%	17.38	0.6%
			Vehicle	Not Used	153	5.5%	152.16	5.5%
				Used	54	2.0%	53.36	1.9%
		Night	Foot	Not Used	59	2.1%	60.35	2.2%
				Used	63	2.3%	61.36	2.2%
			Vehicle	Not Used	82	3.0%	87.32	3.2%
				Used	40	1.5%	40.21	1.5%
	Single	Day	Foot	Not Used	47	1.7%	54.13	2.0%
				Used	11	0.4%	7.62	0.3%
			Vehicle	Not Used	46	1.7%	46.84	1.7%
				Used	6	0.2%	6.64	0.2%
		Night	Foot	Not Used	42	1.5%	40.65	1.5%
				Used	8	0.3%	9.65	0.3%
			Vehicle	Not Used	22	0.8%	16.68	0.6%
				Used	2	0.1%	1.79	0.1%
Western	Grouped	Day	Foot	Not Used	119	4.3%	126.73	4.6%
				Used	73	2.6%	74.67	2.7%
			Vehicle	Not Used	382	13.9 %	382.23	13.9%
				Used	181	6.6%	176.59	6.4%
		Night	Foot	Not Used	162	5.9%	154.26	5.6%
				Used	143	5.2%	145.38	5.3%
			Vehicle	Not Used	184	6.7%	185.08	6.7%
				Used	146	5.3%	145.05	5.3%
	Single	Day	Foot	Not Used	198	7.2%	190.27	6.9%
				Used	47	1.7%	45.33	1.6%
			Vehicle	Not Used	163	5.9%	162.77	5.9%
				Used	26	0.9%	30.41	1.1%
		Night	Foot	Not Used	136	4.9%	143.75	5.2%
				Used	34	1.2%	31.62	1.1%
			Vehicle	Not Used	50	1.8%	48.92	1.8%
				Used	8	0.3%	8.95	0.3%

Table 5.3 Results of goodness-of-fit test

	Chi-Square	Df	Sig.
Likelihood Ratio	0.000	0	.
Pearson	0.000	0	.

Table 5.2 indicates that the observed and expected counts for each combination of categories under the full model. Thus, it is obvious that chi-square statistics are zero due to the full model (Table 5.3). Results in Table 5.2 indicate that percentage crimes under 16 different combination (2x2x2x2) with respect to total crimes in both provinces are higher in Western province than Southern province for all 16 categories (Figure. 5.1). The list of the 16 categories are given in Appendix A. Among 16 categories the highest percentage of robberies have occurred by day time group using vehicle without weapon. The corresponding percentages are 13.9% (western) and 5.5% (southern).

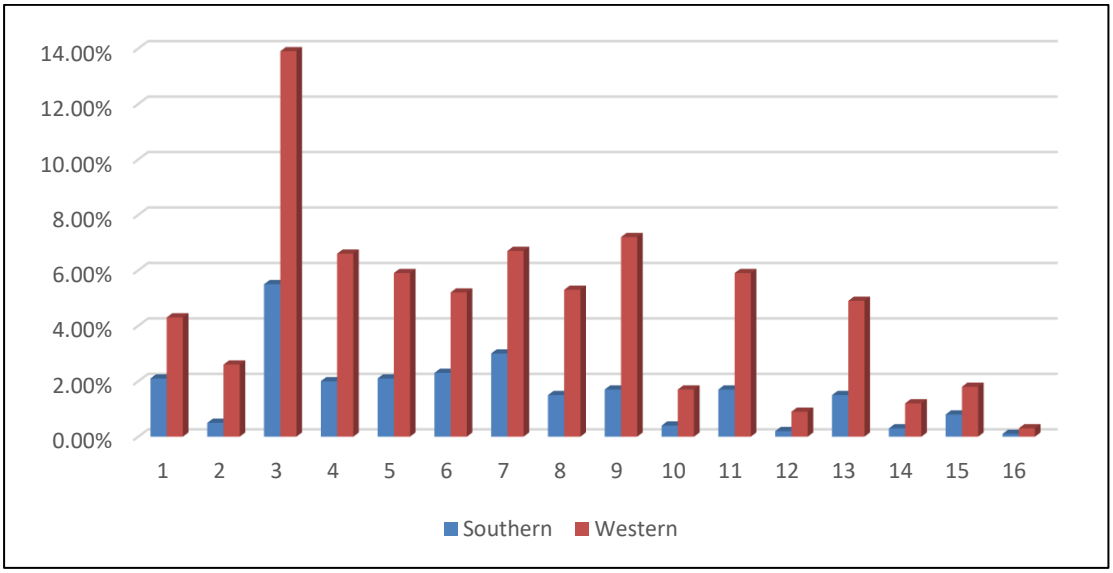

Figure. 5.1 Percentage crimes under 16 different combination

The results of sequential hypothesis under the following hypothesis tests:

H_{01}: k way (k=1,2,3,4,5) and higher order effects are zero (k=1,2,3,4,5) and

H_{02}: k effects (k=1,2,3,4,5) are zero are shown in Table 5.4.

Table 5.4 Results of K-Way and Higher-Order Effects

K		df	Likelihood Ratio		Pearson		Number of Iterations
			Chi-Square	Sig.	Chi-Square	Sig.	
K-way and Higher Order Effects[a]	1	31	2134.77	0.000	2384.927	0.000	0
	2	26	522.06	0.000	499.262	0.000	2
	3	16	22.59	0.125	22.886	0.117	5
	4	6	8.73	0.189	8.473	0.205	3
	5	1	0.91	0.339	0.973	0.324	4
K-way Effects[b]	1	5	1612.70	0.000	1885.665	0.000	0
	2	10	499.47	0.000	476.376	0.000	0
	3	10	13.86	0.179	14.412	0.155	0
	4	5	7.82	0.167	7.501	0.186	0
	5	1	0.92	0.339	0.973	0.324	0
a. Tests that k-way and higher order effects are zero.							
b. Tests that k-way effects are zero.							

In Table 5.4 shows the results of K-way and higher-order effects (Part I). The results in part I tells that which components can be removed and removing every effect from the model would significantly affect the fit the model with Pearson chi-square and their relevant p values. In this table of k=1, removing one-way effect and any of the higher order effect is significant (p=0.00) and also when k=2 , removing two way effect and any of the higher order effect is also significantly (p=0.000). When k=3 and above, removing three-way effects and any of the higher order effect is not significant (p=0.117). These results confirm that the best fitted model can contain only first and second order effects only.

In part II of Table 5.4 indicates that when k=1, inclusion of one way effects (main effects) such as, province, single or grouped, time range (day or night), method of travelling, weapon used and not used have a significantly effect as the Pearson test statistics (1885.665, p= 0.000) is significant. Similarly when it is k=2 , inclusion of two way effects (two way interaction effects) would be significant for the model as the Pearson test statistic is significant (476.376 and p-value is 0.000 and less than 0.05 significant level.

Rest of the k-way effects both statistics are not significant. Thus removing 3rd order and higher order of interactions will not be significantly effect for fit the model. The fitted parameters for the model with main effects and 2-way interaction effects are shown in Table 5.5.

Table 5.5 Parameter estimates of the model with main and 2-way effects only

Parameter	Estimate	Std. Error	Z	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Constant	2.375	.140	16.932	.000	2.100	2.650
[P = 1]	-1.420	.148	-9.627	.000	-1.709	-1.131
[P = 2]	0[a]	.	.	.	.	.
[S = 1]	2.548	.129	19.714	.000	2.295	2.802
[S = 2]	0[a]	.	.	.	.	.
[T = 1]	.874	.120	7.282	.000	.639	1.110
[T = 2]	0[a]	.	.	.	.	.
[M = 1]	1.333	.119	11.215	.000	1.100	1.566
[M = 2]	0[a]	.	.	.	.	.
[W = 1]	1.466	.128	11.457	.000	1.216	1.717
[W = 2]	0[a]	.	.	.	.	.
[P = 1] * [M = 1]	-.018	.093	-.188	.851	-.201	.165
[P = 1] * [M = 2]	0[a]	.	.	.	.	.
[P = 2] * [M = 1]	0[a]	.	.	.	.	.
[P = 2] * [M = 2]	0[a]	.	.	.	.	.
[S = 1] * [M = 1]	-1.264	.092	-13.762	.000	-1.445	-1.084
[S = 1] * [M = 2]	0[a]	.	.	.	.	.
[S = 2] * [M = 1]	0[a]	.	.	.	.	.
[S = 2] * [M = 2]	0[a]	.	.	.	.	.
[T = 1] * [M = 1]	-.922	.084	-11.010	.000	-1.086	-.758
[T = 1] * [M = 2]	0[a]	.	.	.	.	.
[T = 2] * [M = 1]	0[a]	.	.	.	.	.
[T = 2] * [M = 2]	0[a]	.	.	.	.	.
[M = 1] * [W = 1]	-.271	.090	-3.006	.003	-.447	-.094
[M = 1] * [W = 2]	0[a]	.	.	.	.	.
[M = 2] * [W = 1]	0[a]	.	.	.	.	.
[M = 2] * [W = 2]	0[a]	.	.	.	.	.
[P = 1] * [S = 1]	.339	.104	3.268	.001	.136	.542
[P = 1] * [S = 2]	0[a]	.	.	.	.	.
[P = 2] * [S = 1]	0[a]	.	.	.	.	.
[P = 2] * [S = 2]	0[a]	.	.	.	.	.
[P = 1] * [T = 1]	-.127	.091	-1.396	.163	-.306	.051
[P = 1] * [T = 2]	0[a]	.	.	.	.	.
[P = 2] * [T = 1]	0[a]	.	.	.	.	.
[P = 2] * [T = 2]	0[a]	.	.	.	.	.
[P = 1] * [W = 1]	.275	.099	2.777	.005	.081	.469
[P = 1] * [W = 2]	0[a]	.	.	.	.	.
[P = 2] * [W = 1]	0[a]	.	.	.	.	.
[P = 2] * [W = 2]	0[a]	.	.	.	.	.
[S = 1] * [T = 1]	-.602	.094	-6.434	.000	-.785	-.419
[S = 1] * [T = 2]	0[a]	.	.	.	.	.
[S = 2] * [T = 1]	0[a]	.	.	.	.	.
[S = 2] * [T = 2]	0[a]	.	.	.	.	.
[S = 1] * [W = 1]	-1.141	.108	-10.568	.000	-1.353	-.930
[S = 1] * [W = 2]	0[a]	.	.	.	.	.
[S = 2] * [W = 1]	0[a]	.	.	.	.	.
[S = 2] * [W = 2]	0[a]	.	.	.	.	.
[T = 1] * [W = 1]	.418	.087	4.796	.000	.247	.588
[T = 1] * [W = 2]	0[a]	.	.	.	.	.
[T = 2] * [W = 1]	0[a]	.	.	.	.	.
[T = 2] * [W = 2]	0[a]	.	.	.	.	.

a. This parameter is set to zero because it is redundant.
b. Model: Poisson
c. Design: Constant + P + S + T + M + W + P * M + S * M + T * M + M * W + P * S + P * T + P * W + S * T + S * W + T * W

Results in Table 5.5 clearly indicate that all the main effects are significant claiming that, number of robberies are significantly different between two levels of each factor. Furthermore, results indicate that all the 2-way interactions are significant except P*T. The fitted log linear model can be written in the form of

$$log\left(e_{ijklm}\right) = \mu + \lambda_i^P + \lambda_j^S + \lambda_k^T + \lambda_l^M + \lambda_m^W + \lambda_{il}^{PM} + \lambda_{jl}^{SM} + \lambda_{kl}^{TM} + \lambda_{lm}^{MW} + \lambda_{ij}^{PS} + \lambda_{ik}^{PT} + \lambda_{im}^{PW} + \lambda_{jk}^{ST} + \lambda_{jm}^{SW} + \lambda_{km}^{TW}$$

Where = is the effect of i[th] level of the factor P and

= is the 2-way effect S and T at the levels of i and j respectively.

= expected values

5.3 Results of partial association

Partial association table simply bread down the table its components parts. Thus, it is known previously output removing all the one-way effects and two-way effects (interactions) significantly effect for fit the model and we don't know which of the two-way interactions actually having the effects. Also, we can identify which are the significantly effecting interactions from all four-way interactions and three-way interactions. The corresponding output is shown in Table 5.6.

Table 5.6 SPSS output for partial associations

Effect	df	Partial Chi-Square	Sig.	Number of Iterations
P*S*T*M	1	.004	.947	4
P*S*T*W	1	3.037	.081	3
P*S*M*W	1	.523	.470	3
P*T*M*W	1	6.343	.012	3
S*T*M*W	1	.003	.956	4
P*S*T	1	1.396	.237	3
P*S*M	1	1.116	.291	4
P*T*M	1	.007	.932	3
S*T*M	1	.926	.336	4
P*S*W	1	.076	.783	4
P*T*W	1	.704	.402	3
S*T*W	1	6.886	.009	4
P*M*W	1	.666	.414	4
S*M*W	1	1.603	.206	4
T*M*W	1	.649	.420	3
P*S	1	10.921	.001	5
P*T	1	1.945	.163	5
S*T	1	42.556	.000	5
P*M	1	.035	.851	5
S*M	1	201.002	.000	4
T*M	1	125.405	.000	5
P*W	1	7.855	.005	5
S*W	1	125.651	.000	5
T*W	1	22.992	.000	5
M*W	1	9.041	.003	5
P	1	685.829	.000	2
S	1	422.948	.000	2
T	1	57.056	.000	2
M	1	40.062	.000	2
W	1	406.810	.000	2

Table 5.6 indicates that the all main effects are significant ($p < 0.05$). Furthermore, it indicates all two-way interactions except the P*T ($p = 0.163$) and P*M ($p = 0.851$) are significant as the corresponding p-vales are less than 5%. Of the 10 combinations of 3-way interactions, only S*T*W is significant ($p=0.009$). Furthermore, the results indicate that out of 5 combinations of 4-way interactions, only the interaction, P*T*M*W is significant as the corresponding partial Chi-Square test statistics is 6.343

and p value is 0.012. Thus according to the concept of hierarchical modelling, a model can be developed with main effect and the significant interaction terms. Nevertheless, it is better to use stepwise method and according the results of backward elimination are shown in Table 5.7.

5.4 Summary Results of Backward Elimination Methods

Table 5.7 Results backward elimination method.

Step[a]			Effects	Chi-Square[c]	df	Sig.	Number of Iterations
0	Generating Class[b]		P*S*T*M*W	0.000	0		
	Deleted Effect	1	P*S*T*M*W	.915	1	.339	4
1	Generating Class[b]		P*S*T*M, P*S*T*W, P*S*M*W, P*T*M*W, S*T*M*W	.915	1	.339	
	Deleted Effect	1	P*S*T*M	.004	1	.947	4
		2	P*S*T*W	3.037	1	.081	3
		3	P*S*M*W	.523	1	.470	3
		4	P*T*M*W	6.343	1	.012	3
		5	S*T*M*W	.003	1	.956	4
2	Generating Class[b]		P*S*T*M, P*S*T*W, P*S*M*W, P*T*M*W	.918	2	.632	
	Deleted Effect	1	P*S*T*M	.005	1	.943	4
		2	P*S*T*W	3.044	1	.081	4
		3	P*S*M*W	.526	1	.468	4
		4	P*T*M*W	6.377	1	.012	3
3	Generating Class[b]		P*S*T*W, P*S*M*W, P*T*M*W, S*T*M	.923	3	.820	
	Deleted Effect	1	P*S*T*W	3.077	1	.079	4
		2	P*S*M*W	.521	1	.470	4
		3	P*T*M*W	6.623	1	.010	4
		4	S*T*M	.921	1	.337	5
4	Generating Class[b]		P*S*T*W, P*T*M*W, S*T*M, P*S*M, S*M*W	1.444	4	.836	
	Deleted Effect	1	P*S*T*W	2.593	1	.107	4
		2	P*T*M*W	6.120	1	.013	4
		3	S*T*M	.972	1	.324	5
		4	P*S*M	.928	1	.335	4
		5	S*M*W	1.570	1	.210	5

Table 5.7 Results backward elimination method (continued).

Step[a]			Effects	Chi-Square[c]	df	Sig.	Number of Iterations
5	Generating Class[b]		P*S*T*W, P*T*M*W, S*T*M, S*M*W	2.372	5	.796	
	Deleted Effect	1	P*S*T*W	2.763	1	.096	4
		2	P*T*M*W	6.307	1	.012	4
		3	S*T*M	1.027	1	.311	5
		4	S*M*W	1.738	1	.187	5
6	Generating Class[b]		P*S*T*W, P*T*M*W, S*M*W	3.399	6	.757	
	Deleted Effect	1	P*S*T*W	2.817	1	.093	4
		2	P*T*M*W	6.247	1	.012	5
		3	S*M*W	1.847	1	.174	6
7	Generating Class[b]		P*S*T*W, P*T*M*W, S*M	5.246	7	.630	
	Deleted Effect	1	P*S*T*W	2.649	1	.104	5
		2	P*T*M*W	6.257	1	.012	5
		3	S*M	201.846	1	.000	2
8	Generating Class[b]		P*T*M*W, S*M, P*S*T, P*S*W, S*T*W	7.896	8	.444	
	Deleted Effect	1	P*T*M*W	4.817	1	.028	6
		2	S*M	200.422	1	.000	3
		3	P*S*T	1.190	1	.275	5
		4	P*S*W	.075	1	.784	5
		5	S*T*W	6.167	1	.013	5
9	Generating Class[b]		P*T*M*W, S*M, P*S*T, S*T*W	7.971	9	.537	
	Deleted Effect	1	P*T*M*W	4.771	1	.029	6
		2	S*M	200.507	1	.000	3
		3	P*S*T	1.235	1	.266	5
		4	S*T*W	6.094	1	.014	5
10	Generating Class[b]		P*T*M*W, S*M, S*T*W, P*S	9.206	10	.513	

a. At each step, the effect with the largest significance level for the Likelihood Ratio Change is deleted, provided the significance level is larger than .050.

b. Statistics are displayed for the best model at each step after step 0.

c. For 'Deleted Effect', this is the change in the Chi-Square after the effect is deleted from the model.

Backward elimination method starts with saturation model with five factors and then sequentially delete a variable at a time. Thus the backward elimination in SPSS begins from the highest order effect, in this case it is P*S*T*M*W interaction. As that effect the highest order interaction is not significant (x_1^2 = 0.915, p = 0.339) it is removed at the beginning.

Next step is for four-way interactions. Step one (1) generating class are P*S*T*M, P*S*T*W, P*S*M*W, P*T*M*W, S*T*M*W and from all of them only P*T*M*W likelihood ratio statistics is 6.343 and P-Value is .012, interaction is significant. Rest of the all interactions are not significant.

Step 2, we can notice that S*T*M*W has been removed from the model as likelihood ratio statistics is .003 and P-value is .956, it was the largest P-value. New generating class is P*S*T*M, P*S*T*W, P*S*M*W, P*T*M*W and they are reevaluated. From all of four-way interactions only P*T*M*W interaction is significant as likelihood ratio statistics is 6.377and P-Value is .012.

Step 3, we can notice that P*S*T*M interaction is removed from the model as likely hood ratio statistics is .005 and P-Value is .943, it was the largest p-value. Also here S*T*M, three way interaction was added. New generating class is P*S*T*W, P*S*M*W, P*T*M*W, S*T*M and they are reevaluated. Only P*T*M*W interaction is significant as likely hood statistics is 6.623 and P-Value is .010. rest of the all interactions are not significant.

Step 4, we can notice that P*S*M*W interaction is removed from the model as it has likely hood statistics .521 and highest P-Value of .470. New generating class is P*S*T*W, P*T*M*W, S*T*M, P*S*M, S*M*W and P*S*M, S*M*W were newly added and reevaluated. Only P*T*M*W interaction is significant as likely hood ratio is 6.120 and P-Value is .013. Rest of the all interactions are not significant.

Step 5, we can notice that P*S*M interaction is removed from the model as it has likely hood statistics .928 and highest P-Value of .335.new generating class is P*S*T*W, P*T*M*W, S*T*M, S*M*W and reevaluated the model. Only P*T*M*W interaction is significant as likelihood ratio is 6.307 and P-value is 0.012. Rest of the all interactions are not significant.

Step 6, we can notice that S*T*M interaction is removed from the model as it has likely hood ratio statistics 1.027 and highest P-Value of 0.311.new generating class is

P*S*T*W, P*T*M*W, S*M*W and reevaluated the model. Only P*T*M*W interaction is significant as likely hood ratio is 6.247 and P-Value is .012. Rest of the all interactions are not significant.

Step 7, we can notice that S*M*W interaction is removed from the model as it has likely hood ratio statistics 1.847 and highest P-Value is.174. New generating class is P*S*T*W, P*T*M*W, S*M. Here new two-way interaction S*M added to the model and model has reevaluated. Also, we can notice here that two interactions are significant as P*T*M*W likely hood ratio is 6.257 and P-Value is .012, S*M likely hood ratio is 201.846 and P-Value is .000.

Step 8, we can notice that P*S*T*W interaction is removed from the model as it has likely hood ratio statistics 2.649 and highest P-value is .104. New generating class is P*T*M*W, S*M, P*S*T, P*S*W, S*T*W. It was newly added three of three-way interactions to the model as P*S*T, P*S*W, S*T*W and reevaluated the model. We can notice here that three interactions are significant as P*T*M*W likely hood ratio is 4.817 and P-Value is .028, S*M likely hood ratio is 200.422 and P-Value is .000, S*T*W likely hood ratio is 6.167 and P-Value is .013.

Step 9, we can notice that P*S*W interaction is removed from the model as it has likely hood ratio statistics 0.075 and highest P-value .784. New generating class is P*T*M*W, S*M, P*S*T, S*T*W and reevaluated the model. We can notice here that three interactions are significant as P*T*M*W likely hood ratio is 4.771 and P-Value is .029, S*M likely hood ratio is 200.507 and P-Value .000, S*T*W likely hood ratio is 6.094 and P-Value .014.

Step 10, in our final model P*S*T this tree way interaction removed from the model as it has likely hood ratio statistics 1.235and highest P- Value is 0.266. New generating class is P*T*M*W, S*M, S*T*W, P*S and it is the final model itself. Therefore, our final model is remained all main effects with these four interactions. Our main effects are not examined because we found that those main effects are remain in the interactions.

5.6 Final Model

SPSS evaluate the final model with the likely hood ratio statistics. The results of the final model and test statistics are shown in Table 5.8 and Table 5.9.

Table 5.8 Results of the goodness of fit test of the final model

Test	Chi-Square	df	Sig.
Likelihood Ratio	9.206	10	0.513
Pearson	9.434	10	0.492

According to the results in Table 5.8 the null hypothesis of the fitted log linear model is adequate (Chi-Square=9.206, p=0.513) is not rejected and thus it can be concluded with 95% confidence that the fitted model is significantly better to explain observed variability of the data. The final model is

$$log\left(e_{ijklm}\right) = \mu + \lambda_i^P + \lambda_j^S + \lambda_k^T + \lambda_l^M + \lambda_m^W + \lambda_{jl}^{SM} + \lambda_{ij}^{PS} + \lambda_{jkm}^{STW} + \lambda_{iklm}^{PTMW}$$

Table 5.9 Results of parameter estimates of fitted log linear model

Parameter	Estimate	Std. Error	Z	Sig.
Constant	2.19	0.18	12.37	0.00
[P = 1]	-1.61	0.20	-8.02	0.00
[P = 2]	0a	.	.	.
[T = 1]	1.22	0.21	5.89	0.00
[T = 2]	0a	.	.	.
[M = 1]	1.26	0.14	9.04	0.00
[M = 2]	0a	.	.	.
[W = 1]	1.70	0.19	9.05	0.00
[W = 2]	0a	.	.	.
[S = 1]	2.79	0.17	16.64	0.00
[S = 2]	0a	.	.	.
[P = 1] * [T = 1] * [M = 1] * [W = 1]	-0.78	0.39	-2.00	0.05
[P = 1] * [T = 1] * [M = 1] * [W = 2]	-1.04	0.32	-3.25	0.00
[P = 1] * [T = 1] * [M = 2] * [W = 1]	0.34	0.32	1.07	0.29
[P = 1] * [T = 1] * [M = 2] * [W = 2]	0.09	0.23	0.38	0.71
[P = 1] * [T = 2] * [M = 1] * [W = 1]	0.16	0.27	0.60	0.55
[P = 1] * [T = 2] * [M = 1] * [W = 2]	0.42	0.22	1.88	0.06
[P = 1] * [T = 2] * [M = 2] * [W = 1]	0.53	0.21	2.52	0.01
[P = 1] * [T = 2] * [M = 2] * [W = 2]	0a	.	.	.
[P = 2] * [T = 1] * [M = 1] * [W = 1]	-1.13	0.30	-3.83	0.00
[P = 2] * [T = 1] * [M = 1] * [W = 2]	-0.86	0.16	-5.28	0.00
[P = 2] * [T = 1] * [M = 2] * [W = 1]	-0.02	0.23	-0.09	0.93
[P = 2] * [T = 1] * [M = 2] * [W = 2]	0a	.	.	.
[P = 2] * [T = 2] * [M = 1] * [W = 1]	-0.18	0.15	-1.27	0.20
[P = 2] * [T = 2] * [M = 1] * [W = 2]	0a	.	.	.
[P = 2] * [T = 2] * [M = 2] * [W = 1]	0a	.	.	.
[P = 2] * [T = 2] * [M = 2] * [W = 2]	0a	.	.	.
[M = 1] * [S = 1]	-1.26	0.09	-13.76	0.00
[M = 1] * [S = 2]	0a	.	.	.
[M = 2] * [S = 1]	0a	.	.	.
[M = 2] * [S = 2]	0a	.	.	.
[P = 1] * [S = 1]	0.33	0.10	3.12	0.00
[P = 1] * [S = 2]	0a	.	.	.
[P = 2] * [S = 1]	0a	.	.	.
[P = 2] * [S = 2]	0a	.	.	.
[T = 1] * [W = 1] * [S = 1]	-1.93	0.17	-11.63	0.00
[T = 1] * [W = 1] * [S = 2]	0a	.	.	.
[T = 1] * [W = 2] * [S = 1]	-1.03	0.20	-5.24	0.00
[T = 1] * [W = 2] * [S = 2]	0a	.	.	.
[T = 2] * [W = 1] * [S = 1]	-1.46	0.17	-8.51	0.00
[T = 2] * [W = 1] * [S = 2]	0a	.	.	.
[T = 2] * [W = 2] * [S = 1]	0a	.	.	.
[T = 2] * [W = 2] * [S = 2]	0a	.	.	.
a. This parameter is set to zero because it is redundant.				
b. Model: Poisson				
c. Design: Constant + P + T + M + W + S + P * T * M * W + M * S + P * S + T * W * S				

Table 5.9 presents the parameter estimates of the final model. It shows that based on backward elimination method starting from the full model, the 4-way interaction of P*T*M*W, 3-way interaction of P*T*W , 2-way interactions of M*S and P*S are also significant in addition to all four main effects. Thus in order to discuss percentage of crimes the 3-way table of P*T*W is given below.

Table 5.10 Frequency distribution of crimes between T,W & S

Single or grouped			Weapons usage		Total
			Weapon not used	Weapon used	
Grouped	Time of the day	day	711	322	1033
		night	487	392	879
	Total		1198	714	1912
Single	Time of the day	day	454	90	544
		night	250	52	302
	Total		704	142	846

The higher order interaction of order 4 is ignored due to obvious reasons. Results in Table 5.10 indicated that highest number of crimes have occurred during day time without using weapon as a group. The lowest percentage of crimes have occurred during night time, using the weapons by single persons.

5.5 Summary of the Chapter 5

Out of the 2758 total number of robberies the majority belongs to the time rang of day time. While it is considering grouped or ungrouped method the majority robberies were recorded in the method of grouping criminals and implementing the robberies. When it is concerned on usage of the weapons for the robberies, most of them are done without using weapon. When focusing on travelling methods for the robberies criminals were using travelling method of walking and using vehicles approximately equal percentages for the robbery crimes. SPSS produced two different models under general model development and model development under backward elimination method. In this case the final model obtained using backward elimination was used. The log linear model found that only one 4-way interaction and one 3-way integration are significant, but for the purpose of interpretation the four-way interaction was ignored. The 3-way integration found that that the highest percentage of crimes (25%) occurred during day time with out using as a group.

CHAPTER 06

CONCLUSIONS AND RECOMMENDATIONS

Robbery crimes in Sri Lanka has been categorized under four categories namely: (i) type of robbery (single vs grouped), (ii) time of the day (day vs night), (iii) status of weapon used (yes or no) and (iv) mode of travelling (foot vs vehicle). Based on the analyses of the above crimes in western and southern provinces (Chapter 4 and Chapter 5), the following conclusions and recommendations are given.

6.1 Conclusions

- During the last five years (2013-2017) the percentage of robbery crimes is significantly much higher ($p < 0.05$) in western province (74.4%) than that in southern province (25.6%)
- During the same period, robbery crimes under all 16 categories (four factors with two levels each) are also significantly higher ($P<0.05$) in western province than that of southern province.
- Each category of crimes are significantly associated pairwise.
- The percentages of group robberies in southern province (73.9%) is significantly higher than that in western province (67.7%) irrespective of the type of robbers. In other words, the odds of group crimes in southern province is 1.35 times higher than that in western province.
- The odds of crimes without weapon in southern province (72%) is 1.21 times higher than that in western province (76%).
- Irrespective of the province, the percentage of crimes during day time by single person (64%) is significantly higher than the percentage of crimes during day by a group (54%)
- Irrespective of the province, the percentage of crimes when single person travelled by foot (62%) is significantly higher ($p < 0.05$) than the travelled by foot with a group (36%).

- Furthermore, the percentage of crimes without weapon by a single person (83%) is significantly higher than percentage of crimes without weapon by a group (63%).
- A log linear model found that in addition to main effects and 2-way effects, only the 3-way infraction between time of day, status of weapons uses and type of robbery is significant ($p < .05$).
- The majority of the robbery crimes have commissioned by groups of criminals occurred during day time without using weapon as a group followed by during day time by a single person without using weapon.
- The inferences derived from this study can be used effectively to reduce the crimes during day time.

6.2 Recommendations

While observing real data and their reflecting significant interacted behavior, we can implement much more comprehensive measures to alleviate the occurrence of robbery crime by equipping the law enforcement authorities with realistic understanding on the ground for wellbeing of the Sri Lankan society. According to the study mentioned 16 categories and their related modus operands directing us following significant and clear recommendations.

- It is obvious that western province having greater population and contain to geographically smaller potion to that of southern province. Hence it is recommended that we must focus on western province in extended level to reduce robbery crime comparatively southern province.
- Large number of robberies were done by grouped criminals, so it must be collected the information about suspicious groups and it is recommended to coordinate general public to provide ground information about the concerned groups while police updating relevant data base for better prevention methods over the data analyzing.
- Though this study there are four type of robbery patterns can be recommended to concern for Sri Lanka police while deploying robbery prevention measures as they are prominently displaying among other combinations according to prioritized descending order,

1. grouped, day time, using vehicle and without using weapons

2. single, day time, by foot and without using weapons.

3. grouped, night time, using vehicles and without using weapons.

- As most of the robberies, were done without using weapon it can be recommended that police and public should have much concerned on grouped criminal activity as mentioned above because of having organized criminals are acquired more dominating power for implementing robberies even without using weapons.
- As most of the robberies were related to the day time. It can be recommended that covering this time period police can be deployed, patrol and alert the public to be liaised with police to avoid the robbery happening while apprehending the criminals.
- when it is travelling methods for the robberies criminals were using travelling method of walking and using vehicles approximately equal percentages for the robbery crimes so it is recommended that police patrolling should be equally by foot, motorbike ,and using vehicles during the above mentioned time range and relevant areas of the organized criminals are activating. .
- Focusing on these relationships of tasking robberies law enforcement authorities likewise Sri Lanka police and public can mediate with each other to prevent, manage the security situation rendering number of robberies going down.

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Appendices

Appendix A : List of the 16 categories

Variable	Categories
Single or Grouped = S	1 = grouped 2 = single
Time range (Day or Night) = T	1 = day 2 = night
Travelling Method = M	1 = on foot 2 = on vehicle
Weapon used or not used = W	1 = weapon not used 2 = weapon used