Understanding the safety performance of commercial motorcycles in urban transport using a system dynamics approach based on qualitative data

Oluwasegun Oluyemi Aluko

Submitted in accordance with the requirement for the degree of

Doctor of Philosophy

University of Leeds

Institute for Transport Studies

November 2014

Acknowledgements

I am grateful to the Almighty God for the gift of life and the opportunity to undertake this study. I am also grateful to President Goodluck Jonathan in whose time funding is made available for me to come to the United Kingdom to pursue this research. This same appreciation goes to the management of TETFUND and Ekiti State University who nominated me for the offer. I would like to thank my supervisors – Dr Astrid Gühnemann and Dr Paul Timms for their commitment, guidance, support and patience in taking me through the course of this study.

There are many individuals who assisted me in my study and the research process. I am indebted to those who participated in my research and helped me with my field work here in Leeds and in Nigeria. I am particularly grateful to Dr Seyi Oke. I am also grateful to my guarantors Prof Ibijola and Pastor M.A. Ibikunle who signed the bonding papers required for my funding.

A big thank you to all PhD students and staff of ITS for their support and encouragement. I also thank members of my church in Leeds and Nigeria for their support and prayers. I must express my deep appreciation to my parents, siblings and in-laws for their prayers and support throughout this study. Lastly, thank you to my wife, Kemi and my children, Temi and Tofunmi for your love and support.

Thank you all, named and unnamed.

Abstract

Para-transit modes generally offer important transport service in developing countries but are poorly regulated. Commercial motorcycle transport is one such essential service provider in many places across the world. It however has some problems of which poor safety record is chief. This research addresses the safety problem of commercial motorcycles from qualitative and systems perspectives. The aim is to identify and improve the understanding on how risk-taking-behaviour – a major cause of safety problems - is developed and learnt by the drivers. Risk-taking-behaviour is used to describe behaviours that can compromise safety which drivers often manifest as a result of the transport system's characteristics. This is accomplished using two approaches: a qualitative methods and system dynamics approach, based on qualitative and quantitative data collection. The research considers the choice of a typical medium city in Nigeria, Ado Ekiti, where commercial motorcycles are a major intra-city transport mode. Qualitative data was collected from stakeholders in the operation of commercial motorcycles and was used together with findings from the literature to obtain the description of the operation of this transport mode and to extract a list of influencing factors from which safety problems result. Key factors are found to relate to drivers' characteristics, violation practices, enforcement and regulation, and training. While these factors are broad, the research is limited to how they contribute to drivers' risk-taking behaviour. Further analysis of these factors' interaction produces a set of propositions that describe the problem-causing structure within the system. These propositions deal with issues such as deterrence effect of enforcement operation, corruption in enforcement process, expensive motorcycle-acquisition problem, and drivers' strenuous working condition, amidst others. These propositions make up the dynamic hypothesis for the system and are represented by a causal loop diagram. The dynamic hypothesis is then explored by formalising it into a quantitative model. This formalised model supports the dynamic hypothesis. The results of this research show that both the stock and flow model and the causal loop diagram might offer an opportunity for policy makers and stakeholders to better understand the structure and the dynamics of the commercial motorcycle drivers' risk-taking-behaviour. Particularly, it shows that a mix of measures including improved enforcement of law is one main way by which driver behaviour can be improved.

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List of Acronyms

CLD -	Causal loop diagram
DBQ -	Driver behaviour questionnaire
EKSTMA -	Ekiti State Traffic Management Agency
FRSC -	Federal Road Safety Corps
NGN	Nigerian Naira
NPF -	Nigeria Police Force
SD -	System dynamics
SDM –	System dynamics model
SFD -	Stock and flow diagram
SFM -	Stock and flow model
VIO -	Vehicle Inspection Officer

Chapter 1 Introduction

1.1 The commercial motorcycle

Public transport operation in many developing countries is poorly organised and provides inefficient service to the largely captive users in these countries. This partly explains the reason why different para-transit modes operate in these places, and make worse the already bad transport situation rather than improve it (Sietchiping et al., 2012). However, these para-transit modes provide an indispensable service in these places (Júnior and Filho, 2002). It is against this background that commercial motorcycles emerged as a passenger transport mode. Commercial motorcycles have some peculiar characteristics which often make them a favoured transport mode both for operators (drivers) and users for relatively short distances. These include their reliability, ability to navigate more easily through congested roads/roads impassable for other vehicle types, provision of door to door service, avoidance of waiting time and many more for the user. They are also a source of employment for drivers many of who might otherwise have no alternative reliable means of livelihood.

In spite of these benefits, this mode is plagued by some problems. Some of these problems include safety, criminality, pollution, etc. (Konings, 2006b; Konings, 2006a; Menzel, 2011). Of these, safety is the most widely reported. Motorcycle safety is an issue the world over. For example, motorcyclists' fatality accounts for about 15% share of total traffic fatality in the United State (Oster and Strong, 2013). It is however worse in developing countries, particularly where they are used for both private and commercial purposes. Thus, they are described as "the most hazardous mode in Taiwan, Malaysia and Vietnam" (Tien-Pen et al., 2003, p.40). In Nigeria, motorcycle problems, particularly, the safety problems have become so intractable that commercial motorcycles have been banned in many administrative states (Ayodele, 2010).

This safety problem has made commercial motorcycle transport popular amidst scholars. Currently, studies on commercial motorcycles cover: income (Arosanyin et al., 2011; Ogunrinola, 2011; Yakubu, 2012; Fasakin, 2002); accident predisposition (Oluwadiya et al., 2009; Solagberu et al., 2006; Iribhogbe and Odai, 2009; Morenikeji and Umaru, 2012); socio-economic characteristics of drivers (Olvera et al., 2012; Mahlstein, 2009; Beekers, 2009) etc. These studies acknowledge the poor safety profile of commercial motorcycle transport and make recommendations about improving it, for example, provision of segregated lanes for commercial motorcycles (Arosanyin et al., 2011) or dealing with the repayment problem of expensive motorcycle cost for drivers (Adeniji, 1987). However, implementing some of these recommendations has not offered the desired safety outcome. Thus, as shown by Oluwadiya et al. (2009), drivers' high-risk behaviour is still notable. Arguing in this vein earlier, Fasakin (2001) note that it is possible for policies to fail when important characteristics of commercial motorcycle operation are ignored in policy formulation. He identifies drivers' operating cost as one of the important characteristics. Other important characteristics of commercial motorcycle operation have also been identified in various research (Ogunrinola, 2009; Morenikeji and Umaru, 2012). Something about these studies is that they note that commercial motorcycle operation is affected by many factors. They have also used different methods such as descriptive statistics and regression analysis in identifying these various important factors. No study, however, has been able to use a systems approach to look into the relationships between these different factors. The possible systems relationship and feedback of the consequence of interactions between these multiple factors have therefore not been identified in previous research on this transport mode. This study therefore intends to fill this gap, addressing the safety problem of commercial motorcycles by looking at drivers' (unsafe) driving behaviour as a "whole". This means providing a holistic understanding of commercial motorcycle driver behaviour and the safety problem in a manner that causes, effects, and their feedbacks can be understood.

1.2 Research aim and objectives

The aim of this research is to generate a system understanding of commercial motorcycle safety problems. Following from this aim the following objectives are pursued:

1. Identify factors that influence safety in commercial motorcycle operation and their relationship with one another.

The safety problem in commercial motorcycle operation is conceptualised as a multi-variate complex system containing economic, social, psychological problems, and more. Identifying more broadly what these factors are and how they are related is imperative in helping to understand what is important and why it is important.

Following from the suggestions of Musselwhite et al. (2012) and Tetali et al. (2013), this research adopts a qualitative study that includes primary data collection. This data collection involves conducting interviews with commercial motorcycle stakeholders in Ado Ekiti, Nigeria to identify what these factors are, how they are understood by the stakeholders and how they are related.

2. Describe how these factors generate drivers' safety characteristics using a causal loop diagram.

As suggested by Goh et al. (2010), this research goes beyond traditional causal analysis to identify key problematic causal relationships using the process of reflection in qualitative research. These key causal relationships are eventually developed into a Causal-Loop-Diagram (CLD) using the principle of system dynamics (SD). A CLD is also known as a qualitative system dynamics model. A system dynamics perspective helps to develop a map of how the components of the system interact together as a whole unified structure to determine the behaviour of the system. The CLD representation is therefore adopted to help see how the factors identified in the first objective interact with each other to generate system behaviour. The approach has been widely used in organisation setting to deal with complex, seemingly intractable situations (Shin and Konrad, 2014; Irene et al., 2012) and is believed to offer very useful insight to address this research objective.

3. Formulate a quantitative system dynamics model that can help in understanding the process of regulating commercial motorcycle operation with respect to drivers' characteristics.

The choice of concentrating on driver behaviour in the quantitative model is premised on the fact that driver behaviour is the most important contributor to safety problem in transport (Kasantikul, 2001; Mirzaei et al., 2014). It is therefore chosen to particularly focus on safety violations based on the assumption that improving it could increase safety level on the road and make the commercial motorcycle mode more useful. A quantitative model[1] of commercial motorcycle driver behaviour is therefore developed by adopting the CLD earlier developed and supporting it with the qualitative data collected and data from other sources, particularly literature. Eventually, insights for improved understanding are extracted from the model developed by exploring different

[1] A quantitative system dynamics model is also known as a stock and flow model. In this thesis both terms are used interchangeably.

parameter settings, using different tests to see how the system behaves under different conditions.

1.3 Scope of the research

Although the safety problem of commercial motorcycle transport is encountered in many countries across the world, the current research is focussed on commercial motorcycle drivers in Nigeria. The choice of Nigeria as case study is rooted on a number of reasons. First, the debate on whether commercial motorcycle service has exceeded its useful life is popular in the media in Nigeria and some authors now recommend a ban on commercial motorcycle operation (Morenikeji and Umaru, 2012). There is the general confusion about the transport mode's operation particularly due to its poor safety records. In addition, the necessity of facilitating the conceptualisation of the system structure makes the choice of Nigeria more appropriate. According to Wolstenholme (1992, p.124), model conceptualisation requires standing back from the system to "view it over a sufficient time frame…" – an exercise less easy for a stranger in the system. The researcher is from Nigeria and has observed commercial motorcycle operation for a while. This same reason applies for the choice of the city, Ado Ekiti where the bulk of the qualitative data was obtained from. Thus in the research methods, data analysis and conclusions, the focus is more on Nigeria. This notwithstanding, the review of literature relating to driver behaviour and commercial motorcycle operation covers a worldwide view.

This study focuses on drivers' risk taking behaviour rather than predicting accident occurrence. As is shown later in sections 2.3 to 2.5, driver behaviour accounts for between 50% and 85% of safety problems. Improving on driver behaviour, in particular with respect to safety violations, should therefore improve on safety condition. Thus concentration is on driver behaviour; the occurrence of crashes is not treated. This is more so as including the occurrence of crashes might require extending the research to include all road users. This will require more data than is feasible as information would be required from all classes of road users. Doing this was not feasible in the research's timescale and due to the limited funding available for this research. How accidents are related to the system is, however, mentioned in the system's causal network developed in sections 8.6 and 8.7 in this thesis.

The period covered by the data used for this research is 15 years – 1997 to 2011. This is also the period covered in the quantitative model developed. This is the period that mostly covers the history of commercial motorcycle in Ado Ekiti prior to the data collection exercise. The quantitative model tests are however further extended to show the simulated behaviour of the system for additional 10 years into the future (i.e., up to the year 2021), a period of time covering about twice the longest time period in the model.

1.4 Thesis roadmap

This thesis is divided into three segments. The first segment contains chapters 2 to 4 and provides a review of the three different topic areas relevant for this study: commercial motorcycles, qualitative analysis, and system dynamics. The second segment contains chapters 5 to 7 and outlines the research methodology, a description of the study location, and data collection process. The last segment contains chapters 8 to 10 and shows the steps through data analysis and models development. The introductory chapter (chapter 1) and conclusion (chapter 11) are however separate. The content of each chapter in these segments is introduced below. Figure 1.1 diagrammatically illustrates this roadmap.

Segment 1: Literature review (contains chapters 2 to 4)

Chapter 2 presents a review of the literature on commercial motorcycle transport mode. It discusses the use of commercial motorcycles across the world and the challenges facing this transport mode. It reinforces driver behaviour as the core concern and provides literature background about driver behaviour and safety. This review also shows the basis for the choice of a qualitative and system dynamics approaches in the current study.

Chapter 3 introduces the qualitative methods approach. It shows different views about qualitative research methods as well as how rigour, reliability, and validity can be attained using qualitative methods. It also provides an array of approaches and methods from which this research selects.

Chapter 4 introduces the systems approach to studying complex systems and proceeds to describe what system dynamics is. It shows the importance of a CLD as a qualitative system dynamics outcome which is useful for understanding the structure of a system. It also describes the quantitative system dynamics approach – the stock and flow models (SFM) – as a way of understanding the dynamics of the emergent structure from qualitative system dynamics methods. It then provides a description of the process of developing system dynamics models and emphasises data collection issues in system dynamics models. It identifies the use of qualitative analysis methods in the development of both qualitative and quantitative models.

Segment 2: Methodology development (contains chapters 5 to 7)

Chapter 5 discusses the methodology employed in this research. It highlights in brevity all the processes and steps taken in this research and the nature of outcome each process gives. The key methodological decisions are described, including the research paradigm and the rationale for using the methods adopted. This chapter also mentions how the issue of validity in the qualitative and quantitative models developed are treated, and the limitations of the methods that are adopted.

Chapter 6 deals with the study area. It starts with the description of Nigeria's transport system and the emergence of commercial motorcycle transport mode. It then goes on to describe the study area and its transport and traffic management characteristics.

Chapter 7 gives a detailed explanation on the process of data collection. It shows how respondents were determined and gives a description of the data collection process. It also provides a reflection of the researcher on data collection process.

Segment 3: Data analysis and models development (contains chapters 8 to 10)

Chapter 8 demonstrates how the qualitative data obtained was analysed through an inductive approach. It reveals how the data was synthesised and transformed into the findings, starting with the analysis guideline adopted and outlines the use of coding. It also provides a series of thematic graphs (graphical display, causal fragments and a causal network) of the relationships between codes. It describes the processes that led to the development of the causal network and explains the researcher's reflections in the processes.

Chapter 9 shows how the key causal summaries extracted from the causal network in chapter 8 are transformed into feedback loops to obtain a system understanding of the problem. It also shows how these feedback loops are combined to form a CLD. Finally, it reveals that the CLD represents the system structure for commercial motorcycle driver behaviour which should be a useful tool for understanding the system.

Chapter 10 develops a quantitative system dynamics model and tests it.

Concluding chapter

Finally, chapter 11 draws together some of the findings and themes discussed throughout the thesis. It also addresses the limitations of this research and makes suggestions for future research.

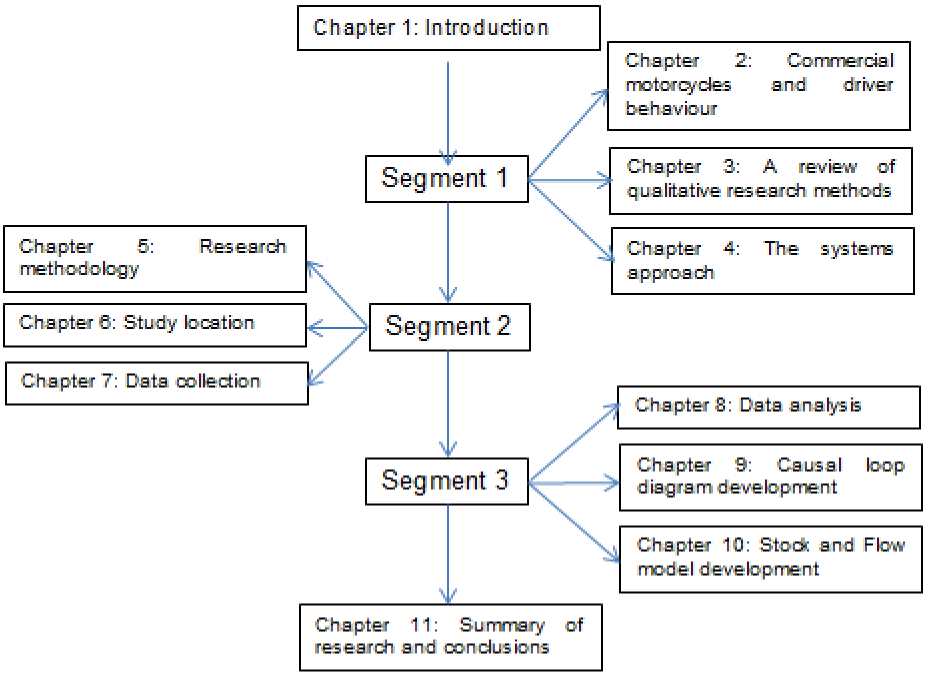

Figure 1.1: Thesis roadmap

Segment 1: Literature review

Chapter 2 Commercial Motorcycles and Driver Behaviour

2.1 Introduction

Increasing urbanisation and population growth taking place in cities of developing countries across the world has brought about increased transport needs which exceed the capacity of available services in these cities. This is more so as public transport in many of these cities is barely developed, with limited capacity for mass transit (Jones et al., 2014; Fasakin, 2001). The resulting shortfall in the provision of public transport has led to increase in the use of unconventional modes, often referred to as para-transit or informal modes (Fasakin, 2002; Guillen et al., 2013; Yakubu, 2012; Sietchiping et al., 2012). Para-transit modes are described as public transport vehicles which are usually small and majorly owned by individuals and mainly serve short haul routes (Urban Mobility for Indonesia, 2010). Common among these are pedicabs in South, Southeast and East Asia (Doucet et al., 2011), three-wheelers and minibuses in Indonesia, micro and minibuses in Mexico, Thailand, Philippines, and India, minibuses, pickups in Kenya, minibuses in South Africa, (Cervero and Gulob, 2007), three-wheeler, micro and minibuses in Nigeria, and commercial motorcycles in many of these places. These para-transit modes have not only emerged but have also grown in number to become a popular mode of transport in developing countries. In many cities of sub-Saharan Africa, the most dramatic para-transit mode emerging and growing in popularity is the commercial motorcycle (Konings, 2006a, Mahlstein, 2009).

In this chapter, the challenges of commercial motorcycles are reviewed and safety challenge is reinforced as the most serious challenge as pointed out in section 1.1. The chapter also discusses how safety and driver behaviour themes are treated in the literature, what methods are used in studying them and the limitations in the studies. It identifies driver behaviour as a main safety problem-factor. First, in section 2.2, the term commercial motorcycle is described and the uses and benefits of this mode are presented. This is followed by a description of the problems associated with commercial motorcycle operations in section 2.3. Section 2.4 discusses the subject of regulation and the limitations of some recommendations. In section 2.5, a description of commercial motorcycle operation and studies in Nigeria is provided while section 2.6 offers a review on driver behaviour research. Section 2.7 provides a description of the methodology approaches to road safety studies and driver behaviour studies. This section extends beyond studies on commercial motorcycle to vehicle drivers in general. Finally, section 2.8 gives a summary of the chapter. It is important to note that in this chapter, references are made to places where there is no distinction between motorcycles for private or commercial use. In such instance, the characteristics identified for motorcycles cover both commercial and private motorcycles.

2.2 The commercial motorcycle: meaning, uses, and benefits

Commercial motorcycle is the use of motorcycle for carrying passengers for a fare. This definition agrees with the understanding about the mode across the world (though naming varies). Junior and Filho (2002, p.1566), calling it “motortaxi”, described commercial motorcycle as “public transport services using motorcycles, operated like taxi”. Guillen and Ishida (2004, p.61) called it “habal-habal”, “a motorcycle used for hire”. Other names by which it is known include Ojek in Thailand, Bendskin in Cameroon, and motorcycle boda-boda in Uganda. Commercial motorcycles have become very popular in these places due to their perceived benefits (Junior and Filho, 2002; Konings, 2006a)

Commercial motorcycle is a mode widely acknowledged for many of its benefits. The 2010 report on Urban Mobility for Indonesia noted that commercial motorcycles have the advantage of speed, door to door service and serve narrow roads less accessible to other modes (GIZ, 2010). They play an important role in serving the transportation system as gap filler as well as a source of employment for people. Moreover problems such as poorly developed road network, narrow streets, traffic congestions, and poor standard of public transport which are characteristic of many developing countries not only contribute to the rising number of commercial motorcycles but opens up a gap they are fit to fill (Konings 2006a; Junior and Filho, 2002).

The benefits adduced to commercial motorcycles in Thailand are similar. Oshima et al. (2007) reports that commercial motorcycles satisfy users demand as a feeder in the narrow-dead-end side-streets that connect residential locations to major streets. Their role in Bangkok was recognised as a major connector in the transport network of that city. In the Philippines, the emergence of commercial motorcycle transport was adjudged a benefit as it provided employment for people as well as serve areas that are not accessible to “ordinary motor mode” (Guillen and Ishida, 2004, p.64). Because they help with the problem of infrastructural gap and serve areas where there are no alternative transport modes, they were described as “not causing any problem in the city and are actually solving mobility issues” (Guillen and Ishida, 2004, p.64). In Brazil, their emergence which dates back to around the year 1996 is described as an uncovering of a “repressed demand for this type of transportation” (Júnior and Filho, 2002, p.1567). Its spread in Brazilian cities is found to be “due to the lower cost when compared to a normal taxi and the higher average speed and route flexibility when compared to a bus system” (Júnior and Filho, 2002, p.1566).

Finally, similar use and benefits have been observed in Africa. Konings (2006a, p.36) states that the introduction of commercial motorcycles in Cameroon is of “great significance to neighbourhood development in that it offers employment and a reasonable secure income… provide a form of transport well adapted to local road condition and the people’s income level…(and) stimulate growth in other economic activities”. Bürge (2011, p.59) describes them as “nowadays enhance(ing) the physical and social mobility of others and themselves” in Sierra Leone. He reports that life in Mekeni (Sierra Leone) “came to a halt” on a day when the commercial motorcycle drivers went on strike (p.59).

The discussion above points to the social and economic contexts that make commercial motorcycles readily acceptable to users and drivers. Nevertheless, with these benefits have also come challenges to the operation of this transport mode. These problems are introduced in the following section.

2.3 Commercial motorcycle problems as a para-transit mode

As shown in section 2.1, commercial motorcycles are a para-transit mode. Para transit modes generally have some peculiar characteristics which make them less preferred by policy makers to conventional mode (Sietchiping et al., 2012). They are associated with “collectively damaging behaviour” which is reflected in poorly qualified driver, poor vehicle condition, and poor operating characteristics (Cervero and Golub, 2007, p.445). Drivers are often low skilled people who find a poorly regulated transport system as a ready source of livelihood. In many occasions, they are poorly trained, and have to work several strenuous hours, with some hired operators having to pay as much as “half or more of their daily in-take” to vehicle owners (Cervero 2000, p.47). This spurs competition amidst operators, forcing them to live on the margin of profit with the resulting inability to maintain their vehicles in good condition. This same view is advanced by Kubota and Joewono (2005) who state that para-transit forms of public transport are poorly regulated, controlled, and some operate illegally in developing countries. They further note that para-transit modes have the reputation of being dangerous and have frequently been accused as the main cause of traffic disturbance. The commercial motorcycle mode particularly exhibits these characteristics (Cervero, 2000) and some of the manifestations in its operation are described below:

2.3.1 Congestion

Motorcycles have carved a role for themselves in commercial passenger transport services complementing and competing with more conventional public transport forms (Sietchiping et al., 2012; Cervero and Golub, 2007). This competition has led to the view that commercial motorcycles are contributing to congestion problems in developing countries' traffic (Kumar, 2011). For example, Junior and Filho (2002, p.1566) notes that commercial motorcycles use is spreading in Brazil due to the perceived "higher average speed and route flexibility when compared to a bus system", thus taking passengers away from the buses. Similarly, Odumosu and Yaro (undated) in a study in Abuja, Nigeria, finds that more people changed from more capacity- efficient shared-taxi and mini-bus modes to commercial motorcycle mode than those from private cars to commercial motorcycle mode. In Asian cities too, (though available information does not put a distinction between motorcycles for private or commercial use with regards to congestion impact) motorcycles are generally regarded as contributing to congestion than bringing about a saving in it in these cities (Iyer and Badami, 2007; Pucher et al., 2007). These evidences suggest that the increasing use of commercial motorcycles might be increasing the number of vehicles on the road and can make congestion worse, thus explaining why the commercial motorcycle is often viewed as contributing to congestion.

However, this view about motorcycle and its congestion effect is not a consensus in motorcycle research. Some researchers are of the view that policies against the use of motorcycles have a way of increasing car use or at least a desire for a car, especially in the long run. In addition, lane- splitting is believed to bring about some savings in congestion through a more efficient use of road space (Sperley and Pietz, 2010). This view is however not supported by studies in high motorcycle population countries. Countries with high motorcycle population (such as Asian countries having up to 60%) adduce to congestion effect of motorcycles. It is therefore possible that the congestion effect in these countries is due to the high motorcycle population. However, in developed economies where motorcycle share is very low, e.g., in UK where it is less than 5% of vehicle population, it is possible that this congestion saving applies in traffic, as implied in Sperley and Pietz (2010). The implication is that the benefit from a motorcycle's small size may not always translate into congestion savings and perhaps congestion saving is only possible where car owners change to a more space efficient mode (in this case, motorcycles mode) in preference to their vehicles.

Finally, should it be the case that commercial motorcycles are contributing to congestions, the size of their contribution would likely vary from place to place depending on their share of traffic and the proportion between motorcycles for private use and those for commercial use. It may not be significant for places such as Brazil where they are less than 2% of the total traffic (Júnior and Filho, 2002) or Nigeria where they are less than 20% of registered vehicles (Oni et al., 2011) but might be important in Thailand where motorcycles are six times the number of cars (Tien-Pen et al., 2003) and commercial motorcycles are in this number.

2.3.2 Affordability

Accessibility is described as the ease of reaching a destination or having more choices in both destinations and modes of travel (Handy, 2002). As cities develop, motorised form of mobility is often required. This is more so with increasing socio-economic activities that characterise developing countries (Jacobs and Greaves, 2003). Commercial motorcycle meets this need particularly in remote settlements and locations with poor access roads and/ or poor/ inadequate public transport supply (Júnior and Filho, 2002; OSHIMA et al., 2007). But Kumar (2011) finds that the fare for commercial motorcycles is usually between 40% and 60% more expensive than conventional buses for some sub-Saharan African countries. Affordability might therefore be a barrier to the level of accessibility this mode is able to offer to poor dwellers in remote areas. While the extent of the seriousness of this is not known, any planning involving integrating commercial motorcycles into public transport may find this issue interesting.

2.3.3 Pollution

Available information does not always put a distinction between motorcycles for private or commercial use with regards to pollution impact. But, generally, mobility and low operating cost advantages of the motorcycles are seriously diminished by their pollution disadvantages (Saleh et al., 2009; TranSafety, 1998). Nduka and Orisakwe (2010) find ambient level of lead mainly from exhaust fume of vehicles to be above the health standard in some Nigerian cities. While this is not only from commercial motorcycle, their contribution can be significant as their number in traffic increases. In addition, motorcycle generates more of most pollutants than other transport modes (Saleh et al., 2009; Dutta and Bhattacharya, 2009); motorcycles generate between 8 and 48 times the pollution levels of shared taxi and mini-bus respectively per person kilometre travelled. With commercial motorcycles, it is more serious as it was found, in India for example, that large number of old motorcycles (and three wheelers) still rely on highly inefficient, poorly maintained, and very polluting two-stroke engines. These motorcycles are mainly commercial. Many drivers further increase pollution by illegally adulterating their gasoline fuel with up to 30% kerosene and 10% lubricating oil (Pucher et al., 2005; Pucher et al., 2007; Iyer and Badami, 2007). The situation in India is corroborated by TranSafety (1998) which finds traffic to be responsible for over 90 per cent of the ambient carbon monoxide levels, and between 80 to 90 per cent of nitrogen oxides and hydrocarbons, in city centres, where traffic congestion levels are high. In addition, lead emission from the combustion of leaded gasoline also was found to be responsible for "an estimated 80 to 90 per cent of lead in ambient air." (TranSafety, 1998). Although the use of leaded gasoline is reducing due to the awareness on its health effect, "ambient lead levels (still) greatly exceed the health standard" in most developing countries (TranSafety, 1998). Bearing in mind the higher polluting characteristics of motorcycles used for commercial purpose, its effect on human health and natural resources makes this transport mode challenging.

2.3.4 Crime

Crime is yet another challenge which is often attributed to rising use of commercial motorcycles. A number of recent bans on commercial motorcycle operation in Nigeria put crime as one of the reasons for the ban (Nwadiaro et al., 2011). Similar instance was reported in China (Xu, 2012). Generally, criminals are found to use motorcycle as a getaway vehicle after perpetrating their vices (Kumar, 2011; Xu, 2012) and usually commercial motorcycles are blamed for it. In many places, it is difficult to distinguish between motorcycles for private use and those for commercial use (Xu, 2012). Thus, with the growing population of commercial motorcycles, it is possible to blame all crime-related motorcycle problems on commercial motorcycles. For example, it was only on one occasion that a ban on commercial motorcycles operation was extended to privately owned motorcycles in Nigeria[2]. This bias may not ultimately address the problem of criminality. This is more so as

[2] This information can be confirmed online from http://africanurbanism.net/2011/07/08/city-wide-motorbike-ban-in-maiduguri-nigeria-aims-to-halt-boko-haram-violence/. It was accessed on October 10, 2014.

Xu shows that a ban is inadequate to address the problem of crime (Xu, 2012). He studied Tianzhi in China where there were no distinctions between motorcycles for private and commercial use. In this location, a ban was imposed on both commercial and private motorcycles to deal with crime. It, however, turn out to be a short-term solution to crime prevention as criminals found alternative media to perpetrate their criminality (Xu, 2012). This method of crime prevention known as situational crime prevention theory (Hayward, 2007) has been found to only remove the problem in time and space and often brings it back after some time. In summary, while crime and commercial motorcycles have often been viewed as related, it is not known if they actually are. At least, China instance tend to query this view.

2.3.5 Accident

Accident is the most commonly reported challenge faced by motorcycle transport in general and commercial motorcycles in particular (Tien-Pen et al., 2003). The initial suspension of the attempt to regulate commercial motorcycles in Bangkok was premised on the fears about their safe operation (OSHIMA et al., 2007). The share of motorcycle accident in Asian road traffic has been found to be as much as 60% of total road traffic accident (though this includes both private and commercial motorcycles). Commercial motorcycles were regarded as “necessary evil” in Cameroon where drivers were perceived to be notorious for their reckless and dangerous driving that often results in “numerous accident” (Konings, 2006a, p.43). Commercial motorcycle drivers are viewed as usually engaging in high-risk behaviours, unsafe lane-splitting and weave in and out of traffic with little caution, putting passengers and other road users at great risk (Kumar, 2011). They dominate the road space, overtake along the wrong side of traffic, and drive against traffic. This high-risk behaviour largely contributes to the safety problem this mode faces. This has also been found in other studies (Verma et al., 2011).

2.3.5.1 Seriousness of commercial motorcycle safety across the world

In this section, the variation across the world in the distinction between private and commercial motorcycles in the literature is first introduced. This is followed by a review of motorcycle safety in Asia. The section ends with the description of commercial motorcycle driver behaviour.

Commercial motorcycles’ occurrence has been reported in more Asian countries than other parts of the world (Xu, 2009; Guillen and Ishida, 2004; GIZ, 2010).

However, while commercial motorcycle use is reported in many places across Asia, it does not seem to attract such special attention as it does in some other parts of the world, particularly, Africa. This is more so as there are more literature on motorcycle mode in Asia (usually without distinction between private and commercial use) than there are on commercial motorcycles. One possible explanation for this is that commercial motorcycles are less in number compared to private motorcycles in Asia. This is more so as motorcycles are more in traffic than private cars in most of these Asian countries, being 2.43, 1.23, 15.76, 4.27, 5.54, 4.46, and 6.24 times more for Taiwan, Malaysia, Vietnam, China, India, Indonesia, and Thailand respectively (Tien-Pen et al., 2003). Alternatively, it is possible that the behaviour/characteristics of commercial motorcycle drivers in Asia do not differ substantially from private motorcycle drivers there - and so they do not warrant any special/separate study. This second possibility however, does not agree with findings that show that work-related drivers engage in a variety of less safe driving behaviours than the general driving population (Newnam et al., 2014). Whatever the case, commercial motorcycles in Asia do not have problems peculiar enough to warrant special studies as much as is the case in Africa. Notwithstanding, motorcycle mode (which includes commercial and private motorcycles) still have safety problems in these places.

Motorcycle mode is a subject of research in Asia and the literature points to this. For example, in a study conducted in India, Dandona et al. (2006) observes the prevalence of unlicensed drivers amidst motorcycle drivers. In addition, drivers often violate traffic laws, failed to maintain their motorcycles as well as ignore the use of helmet. In the study, half of the drivers acknowledged committing at least one violation within the previous quarter of a year, a situation which might be worse since people tend to under-report their bad behaviours. Similarly, (Verma et al., 2011, p.1373) notes that “inappropriate driving behaviour is considered as one of the major causes of accident in India”, citing lack of lane discipline, disregard for traffic laws, and frequent traffic violations amidst others as causal factors. Pucher et al. (2007, p.392) corroborates this saying that the “combination of speed, open exposure and dangerous driving make motorcycle the most dangerous way of getting around” in India and China, with fatalities being about 20% for India and China (Pucher et al., 2007; Pucher et al., 2005). Similar situation about drivers’ attitude to traffic law was observed in the Philippines by Guillen and Ishida (2004) who finds that commercial motorcycle drivers ignored the use of helmet and overloaded their vehicles. This disregard for traffic safety might be responsible for the response of users in a study, half of which expressed worries about commercial motorcycle safe operation. In Malaysia and Vietnam, motorcycle accident accounts for 49% and 68% respectively of traffic accident (Tien-Pen et al., 2003). Most of these studies do not make any distinction between commercial and private motorcycles. They are however both present in these countries as shown by Guillen and Ishida (2004).

The situation is a bit different in other parts of the world where motorcycle studies have been conducted with specific attention on commercial motorcycle transport mode. In Brazil, where the rise in the fleet of motorcycle coincided with a "boom in the number of motorboys (a courier commercial motorcycle)" (Breitenbach et al., 2012, p.205), 38.9% of accident victims reported being under the influence of some substance in a previous traffic accident. Konings' (2006a, p.43) study of commercial motorcycle drivers in Cameroon found that young drivers were "renown for driving recklessly; they tend to drive at high speed, ignore traffic lights…exposing themselves and their passengers to untold dangers". They were therefore described as necessary evil by users as they cause numerous accidents so much that a ward in one of the local hospitals in Douala is named after commercial motorcycle accident victims (Konings' 2006a). The distinction in these other studies between commercial and private motorcycles indicates that the safety characteristics of both are different in these places. In addition, the problem across the world is more with driver behaviour as chorused in all the references. This view of driver behaviour as the major problem is noted by Mirzaei et al. (2014, p.37) when they note that "Recent researches highlight the need to modify driver behaviour as a major target for traffic safety interventions".

This safety challenge is as important as the benefits of the transport mode, thus the view of Júnior and Filho (2002). Junior and Filho (2002, p.1571) remarked that "The national expansion of the (commercial motorcycles) phenomenon should be analysed with…more…studies. The transport specialists should study, analyse and present solutions instead of ignoring the mode". The following section addresses how this mode is being treated and what solutions are being adopted.

2.4 Commercial motorcycle regulation

2.4.1 Attitude to commercial motorcycle regulation

Following from the numerous benefits of commercial motorcycles and their problems, there have been attempts to develop policies that can put this mode within an efficient regulatory framework – a framework that sustains its benefits while minimising the problems. Oshima et al. (2007) show that Thailand was the first country to come up with such attempt. In Thailand, three areas of motorcycle operations were addressed in regulation. These included formalising the operation, improving vehicles' safe operations, and controlling driver behaviour. Specifically, Oshima et al. (2007) note that regulations included setting fares, adopting additional safety equipment for passengers, and setting penalties for traffic violations and other inappropriate behaviours. This example acknowledged the necessity to deal with driver behaviour. However, the study did not show how the regulation improved driver behaviour. Nevertheless, it notes that the regulation "has noticeably influenced service level" (Oshima et al., 2007, [no pagination]) and so was adjudged successful. But this is not the case for most other places.

In Brazil, Júnior and Filho (2002, p.1569) quotes the national lawmakers that "The Council decides, with majority of votes that the present traffic legislation does not contemplate the motorcycle as an appropriate vehicle for passengers transportation". Notwithstanding this resolution, commercial motorcycles' regulation was left to cities administration's volition: as at 1998, as many as 10% of cities where commercial motorcycles were in use have adopted one form of regulation or the other. But the majority still ignored this mode, preferring to keep "the service in an informal way" (Júnior and Filho, 2002, p.1567). The situation reported by Guillen and Ishida for the city of Davao in the Philippines was not so different. They note that enforcers applied "maximum tolerance" (Guillen and Ishida, 2004, p.63) to the presence of commercial motorcycles even when provisions for motorcycles "such as use of helmet and restrictions on overloading is not strictly followed" (Guillen and Ishida, 2004, p.65). Similarly, the report of Urban Mobility for Indonesia (GIZ, 2010) observes that while commercial motorcycles are growing in number in Indonesia, they do not have any legal permission for operation, indicating that definite regulatory effort has not been undertaken. It therefore proposes a form of regulation that will reduce them by the provision of alternative service for users. Generally, in these places, commercial motorcycle operation does not have any formal regulation yet. Some of these instances also point out that the operation of commercial motorcycles has not been observed to cause any significant problem (as Guillen and Ishida (2004) write). This is not the case in some other places where the problems of commercial motorcycle safety have caused serious worries. Douala (Cameroon) is one of such places.

(Konings, 2006b) notes the repeated clashes between the police and commercial motorcycle drivers, and even revenue collectors in Douala, in the bid to enforce law. This which is related to the flagrant violation by the drivers has come to give the drivers the name “master of the road” and “master of the city” (Konings, 2006a, pp.37, 43). The repeated effort of the police to subject the drivers to traffic law is always resisted by the drivers who feel the police always want to extort them or cheat them in some other forms. Thus the attempt to provide some form of regulation in Douala has not been successful in spite of the reported need for one. In China, the problem was not as serious as Cameron before commercial motorcycle was ban (Xu, 2012). China’s case was however related to crime management.

The above discussion shows three different attitudes to commercial motorcycle operation: in some places, their benefits are acknowledged and some form of regulatory framework is designed to put the problems under control (Oshima et al., 2007; Sietchiping et al., 2012); in some others, policy makers and enforcers behave as if they are not aware (Guillen and Ishida, 2004; Júnior and Filho, 2002); and in the third group, it has been difficult to control commercial motorcycle operation despite repeated attempts. Some places have therefore ignored their benefits and a ban is implemented in response to their problems (Ayodele, 2010; Xu, 2009; Odumosu and Yaro, [undated]). These differences point to the poor performance in regulating the operation of commercial motorcycles. This is despite various studies that have been conducted about commercial motorcycle operation. In the next section, some recommended regulatory measures are reviewed.

2.4.2 Regulatory measures in commercial motorcycle operation

Studies on commercial motorcycle transport mode often make recommendations on what can improve its safety. Some other specific recommendations include the compulsory use of crash helmet, improved licensing scheme, provision of motorcycle lane, and in the extreme, a ban of commercial motorcycles. As is shown below, these recommendations are not always effective for this type of problem.

Provision of motorcycle lane: Provision of motorcycle lane has often been advocated for in research looking at ways to improve commercial motorcycle operation (Arosanyin et al., 2011). This is based on the premise that an opportunity to separate motorcycle traffic from other traffic can substantially reduce traffic incidences involving motorcycles. This was found to have limited impact however in

Malaysia where motorcycle accident still accounts for about 49% of total accident despite separate motorcycle lane (Tien-Pen et al., 2003).

The use of crash helmet has been shown to substantially reduce fatality resulting from motorcycles accident as well as the treatment cost. Hyder et al. (2007, p.19) show that treatment cost for motorcycle victims without helmet crash could be as much as three time those with helmet. The use of crash helmet also has the capacity to reduce serious and fatal head injury (Dandona et al., 2006). Nevertheless, crash helmet use does not prevent or reduce the incidence of accident. Tien-Pen et al. (2003) finds that accident number fell in the year crash helmet was introduced to Thailand but picked up again the following year. Thus while helmet use is an important policy, more is required of the policy makers to reduce the scale of commercial motorcycle safety problem.

Another recommendation Verma et al. (2011) shows is that driving test should be enforced before licensing as an important part of the selection process for issuance of driver license. He advocates pre-license training as an effective countermeasure for road safety problems. But Nantulya and Reich (2002) observes that vehicle and driver licensing issues are usually undermined by corruption. As Anbarci et al. (2006) notes corruption is a major problem in developing countries' transport system which also has a relationship with accidents. Enforcing this test would therefore be difficult under a corrupt enforcement system as is the case in many places (Anbarci et al. (2006) lists some examples and illustrations in the study).

Owing to the complexity involved in identifying a suitable measure to reduce commercial motorcycle incidence, a number of studies have either called for a ban or even reported one (Ayodele, 2010; Morenikeji and Umaru, 2012; Xu, 2012). These have often been hinged on the seemingly intractable problem of this mode. This however is at variance with the identified role of this mode as gap filler in many developing country cities. A better understanding of the difficulty with improving the operation of this mode as well as tackling the safety problem is therefore required. Thus, a more detailed review of a single country, Nigeria, is conducted to grasp a clearer understanding of this problem.

2.5 Commercial motorcycles in Nigeria

The safety problem of commercial motorcycle transport mode has come to make its study topical in transport research particularly in some part of Africa where it is the most common informal transport mode (Sietchiping et al., 2012). It is in this group of countries that Nigeria belongs. Commercial motorcycle transport is an important mode in Nigeria. It goes by names such as “okada”, “alalok” etc. in Nigeria (Iribhogbe and Odai, 2009; Mahlstein, 2009). Arosanyin et al. (2012) in Nigeria described it as the use of motorcycle for passenger transport while Iribhogbe and Odai (2009, p.359) describe it as “transport(ing) passengers and goods from one location to another for a fee”. The discussion below provides an historic view of commercial motorcycle operation in Nigeria, the problem with its regulation, as well as the characteristics of studies on commercial motorcycle safety problem.

2.5.1 Commercial motorcycles’ operation in Nigeria

The emergence of commercial motorcycle service today is largely attributed to the mobility challenges of the late eighties. The huge transport need and the difficult economic terrain of the late eighties in Nigeria naturally made motorcycle owners to offer their vehicle for hire, initially on a part-time basis before it eventually became a trade (Ogunbodede, 2008). As found by Ogunbodede (2008, p.12), “one way by which the public responded in beefing up the supply of public transport was the use of motorcycle as means of urban transport”. It has now spread from the big cities to medium and small cities across Nigeria. But it has been widely acknowledged that this transport mode predates this time (Gbadamosi, 2006; Olubomehin, 2012). Previously, commercial motorcycles served the riverine areas of the south where roads were sparse as well as the dispersed settlement of eastern Nigeria; they were exclusive to these locations until they finally emerged in cities. They were therefore novel when they eventually emerged as intra-urban transport mode.

Commercial motorcycles are an important transport in many towns and cities in Nigeria. This is corroborated by Oyesiku and Odufuwa (2002) who finds that as much as 80% of the commuters use commercial motorcycles on a daily basis. Cerevo (2000) reports that as much as 70% of Nigerian cities with population of 250,000 inhabitants rely on motorcycle for intra-city public transport services. Commercial motorcycles offer immeasurable benefit in Nigerian cities and towns. They serve various uses to their patrons: in some instances, they are the only means of transport available to some passengers. In some others they are required to complete a trip. Yet, others need it to beat regular traffic jam in their commute trips. The growth in the number of registered motorcycles is an indication of the importance of this mode. Arosanyin et al. (2011) reports that motorcycle registration in Nigeria grew from 19,589 in 1995 to 35,788 in 1997, to 344,215 in 2000, to 617,739 in 2001 before slightly falling and to 501,809 in 2003 falling further to 439,536 in 2005.

Commercial motorcycles' operation however, started to become knotty soon after it emerged as a transport mode in Nigeria. For example, Olubomehin (2012) shows that the number of motorcycle accident in Lagos, Nigeria, rose from 144 in 1989 to 699 in 1999. Similarly, the share of motorcycle accident in traffic accident rose from about 11-14% in the pre- commercial motorcycle days to as much as 21-26% in recent times (Solagberu et al., 2006; Gbadamosi, 2006; Olubomehin, 2012). In addition, other problems such as mob action, motorcycle related crimes were linked to them. Oyesiku and Odufuwa (2002) noted that these problems are widespread but were initially ignored by the government and policy makers. However, this neglect was not to be for long, especially as the problem grew in intensity. Nevertheless, while government/ policy makers' attitude has now changed, and policies are regularly coming up on measures to improve this mode's operation, there is still no record of successful regulation of commercial motorcycles in Nigeria today (Ayodele, 2010; Mahlstein, 2009).

In Nigeria, accident is the most commonly reported challenge faced by motorcycles in general and commercial motorcycles in particular (see table 2.1). Thus most commercial motorcycle related studies in Nigeria usually treat safety as a core part of their interest and make recommendations for safety improvements. This safety concern is so important that even studies whose core interest is not safety still do make safety related recommendations (Fasakin, 2002; Arosanyin et al., 2011; Ogunrinola, 2011 are examples of non-core safety studies). One of the reasons for these safety related recommendations is the attribution of driver behaviour to safety incidences (Oluwadiya et al., 2009). This attribution is also widely acknowledged in literature on driver behaviour (Cheng et al., 2011; Stanojević et al., 2013). Problems such as vehicle overloading, lack of pre-license test, unlicensed drivers, disregard for the use of crash helmet and other protective clothing, alcohol use amidst others have been observed among commercial motorcycle drivers in Nigeria (Ehikhamenor and Agwubike, 2004; Iribhogbe and Odai, 2009). Thus accident share of motorcycles in Nigeria has been as high as between 19% and 27% (Oluwadiya et al., 2004; Solagberu et al., 2006) while fatality has been shown to be as much as 33% (Eze et al., 2012). These values are high. This high accident share is substantiated by Ogunrinola (2011) who found the scale of accident frequency to be such that 56% of 642 commercial motorcycle drivers randomly selected from two cities have had accident at least once while 27% have had accident three times or more. Similarly, Oluwadiya et al. show that while only about 42% of motorcycles involved in crash were being used as commercial motorcycles at the time of the incident, they were responsible for 63.9% of motorcycle accident victims (Oluwadiya et al., 2009). These studies emphasise risk taking behaviour of drivers which reflects in violations of traffic laws and are similar to what is obtainable in other places as described in section 2.3.5.

In Nigeria, an important feature of this transport mode is the fact that the operating characteristics are similar across many cities and towns where it operates with only small variations. Olawole et al. (2010) show this in their comparison of commercial motorcycle risk perception across three administrative states in Nigeria. Policy direction across various locations in Nigeria also attest to this feature. For example, the ban of commercial motorcycle in Abuja (central Nigeria) was premised on safety and criminality associated with the mode. Similar reasons were given in Imo State, Rivers State and Cross Rivers State (south-eastern part of Nigeria). The current attempt to curtail their operation in Lagos is premised on the same reasons. In Ado Ekiti, legislation on commercial motorcycle operation was undertaken with similar concern in mind (fieldwork interview). With respect to safety, Morenikeji and Umaru (2012) in a north-western city and Ogunrinola (2011) in a south-western city observe that as many as 54.2% and 56% respectively of drivers had previously been involved in accident. Similarly, Solagberu et al. (2006) in a north central city in Nigeria finds the share of motorcycle accident to be 27% while Arosanyin et al. (2011) finds the national average between year 2000 and 2009 to be 26%. These similarities across many regions and cities in Nigeria show that commercial motorcycle operations are similar in their characteristics. As a result, most studies on this mode in Nigeria provide recommendations of national dimensions rather than local/regional control measures (Solagberu et al., 2006; Oluwadiya et al., 2009). This review on Nigeria therefore treats operation of commercial motorcycle with the intention to reflect what these characteristics are as shown in previous studies.

2.5.2 Commercial motorcycle regulation in Nigeria

As mentioned in section 2.5.1, a number of attempts have been made in Nigeria, like other places, to combat commercial motorcycle safety problem. Mahlstein (2009) and Ayodele (2010) both show that several attempts have been made by various administrative state governments in Nigeria to regulate the operation of commercial motorcycles. But these have not been successful. Ayodele (2010) observes that some of the regulatory frameworks developed were eventually relaxed due to agitation from the public while some were abandoned due to both enforcement and non-compliance problems. He identifies five administrative states in Nigeria that have resorted to banning commercial motorcycle operation in their capital cities. Mahlstein's (2009) work is from an anthropological perspective. He studied the regulatory attempt by an administrative state (Cross Rivers State) in Nigeria. The study observes that the lack of trust between the regulators and the drivers and the lack of sincerity on the part of enforcement agencies in pursuing the provisions of the regulation eventually caused the seemingly well-conceived regulatory design to fail. These problems of trust and sincerity were probably not previously envisaged. It however happened. These situations emphasise the seriousness of the problem with commercial motorcycle regulation and the inadequacy of the policies being adopted.

The trend in Nigeria has therefore been to impose a ban of commercial motorcycle operation[3]. Similar outcome resulted in a ban on commercial motorcycles in other places (Xu, 2009; 2012). While the researcher could not identify any study on the impact of the ban, this impact would affect both the drivers who might become jobless and many of the users who might have increased accessibility problem. This situation points to the fact that more knowledge is required on commercial motorcycle operation to address its problems. In the following section, studies on commercial motorcycles in Nigeria are further reviewed.

2.5.3 Commercial motorcycle safety and safety research in Nigeria

Table 2.1 on page 25 is a summary of some papers dealing with commercial motorcycles and making reference to their use in Nigeria. This table is intended to reflect how commercial motorcycle research is conducted in Nigeria. This table is particularly used to show what themes are researched about commercial motorcycles, how these studies are conducted and what their recommendations are. The table provides a summary of the understanding about commercial motorcycle operation in the literature in Nigeria. It shows that almost all the literature tabulated refer to safety in one way or the other and recommend measures that can improve driver behaviour so as to improve safety. They also identify different factors that affect commercial motorcycle operation. For example, Cervero (2000, p.38) noted that commercial motorcycle drivers in sub-Saharan Africa have higher accident rate "because many drivers take drugs to immunize

[3] The news media and online news show increasing spate of commercial motorcycle ban in Nigeria. While Ayodele (2010) identified five administrative states that have implemented a ban, the number is now well over 10.

themselves from the hot sun and rigours of work”. Similarly, (Fasakin, 2000) observed that regulatory effort might fail when it has not taken cognizance of the operating cost of operators. In addition, Mahlstein (2009) observes the problem of trust between drivers and enforcement agencies, which often affect behaviour and compliance. These findings point to the complex, interlinked relationships between regulations and safe driver behaviour: they show that there are multiple factors interacting together to shape the ultimate characteristics of commercial motorcycle drivers (e.g., working condition, enforcement process, income structure, etc.).

Furthermore, these studies generate various recommendations. For example, Odumosu and Yaro (undated) conducted a study on commercial motorcycle operation after its ban in Abuja, Nigeria. The study was intended to find out about the issues of commercial motorcycle acceptability amidst the populace. It finds amidst other things that majority of the respondents needed commercial motorcycle service for their everyday life despite its risky nature. It also finds that over-speeding was the most serious complaint about commercial motorcycles, voted by 55% of respondents ahead of accident which got 18% of the vote as the most serious problem. It concludes that the ban is not acceptable to the people since “majority of users (80% of respondents) prefer the continuous operation of commercial motorcycles in Abuja city”. It recommends infrastructural provision through public-private partnership (PPP) arrangement and the integration of commercial motorcycle into the National Transport System. To the study making the mode safer (rather than outright ban) is what is required. Thus it suggests other things such as the provision of motorcycle lanes and a list of other regulatory measures. The study suggests improved understanding of the operation of commercial motorcycle as a necessary tool for appropriate regulation.

Table 2.1: Tabular review of literature on commercial motorcycles in Nigeria

		Odumosu & Yaro [undated]	Adisa, 2010	Olowokudejo& Aduloju, 2010	Iribhogbe & Odai, 2009	Solagberu et al., 2006	Alti Muazu & Aliyu, 2008	Fasankin, 2000	Fasakin, 2001	Fasakin, 2002	Ogunrinola, 2011	Oluwadiya et al., 2009	Olubomehin, 2012	Arosanyin et al., 2011	Arosanyin et al., 2012	Arosanyin et al., 2013	Morenikeji and Umaru, 2012	Salako et al., 2013	Ukwayi, 2013
	Purpose of study																		
1	Safety and driver behaviour		X	X	X	X	X				X	X			X		X	X	
2	User satisfaction	X																	
3	Driver's Income							X	X	X	X			X		X			
4	Historical context of mode												X						
5	Crime																		X
	Method applied																		
1	Descriptive statistics	X			X	X	X					X						X	X
2	Econometric models		X	X				X	X	X	X			X	X	X	X		
3	Other methods												X						
	Findings																		
1	High-risk behaviour	X	X	X	X	X	X				X	X	X		X			X	
2	Poor regulation and weak enforcement					X						X	X					X	
3	High profit in the trade							X	X	X	X		X	X		X			

	Recommendations																		
1	Stricter enforcement		**X**		**X**	**X**	**X**				**X**						**X**	**X**	
2	Ban (phasing out mode)																**X**		
3	Education		**X**				**X**				**X**				**X**		**X**	**X**	
4	Regulation and mode integration	**X**		**X**	**X**							**X**	**X**	**X**	**X**	**X**			
5	Provision of supporting infrastructure	**X**						**X**	**X**	**X**									

X shows that the corresponding theme on a row in the second column applies to the publication named in the column where **X** appears

Similarly, Oluwadiya et al. (2009) in their study on motorcycle safety factors obtained information from accident victims and their relations/ eye witnesses. This study differentiated between private motorcycles and commercial motorcycles. They find that 63.9% of motorcycle crashed victims were using motorcycle for commercial purpose at the time of crash. They also show that many of the drivers exhibited risk taking behaviours with 17% being lone crashes, more than 90% not using crash helmet, over 60% being without drivers' licence, 17.5% moving against traffic. They point out the risk taking behaviour of drivers and suggest that policies should address the behaviour. Iribhogbe and Odai, (2009, p.356) in their study, find that commercial motorcycle drivers were "ill-prepared and ill-equipped for the road (and that this) is a recipe for traffic crash-related injuries and fatal motorcycle crashes". They see improved training as essential for improved driving safety and recommend improved enforcement, improved licensing, and better road safety education as ways of achieving it. Their study, like many others, pointed out the risky nature of commercial motorcycle trade and the drivers' awareness of it. Other studies follow similar path of identifying the problems with commercial motorcycle operation and making recommendations about them. These include Morenikeji and Umaru (2012), who recommend the gradual phasing out of commercial motorcycles and Etukumana et al. (2010), who recommend improved road safety education. Others are Alti-Muazu and Aliyu (2008) and Salako et al. (2013) who propose improved enforcement.

It is obvious from these studies that there are more than enough policy recommendations available for improving commercial motorcycle safety. But as shown in section 2.4.2, these recommendations do not always yield desired results. For example, while drivers' training has been shown to be effective in improving safety in some instances, it has been shown to be of little benefits in some others. Similarly, while increased monitoring has been shown to improve safety substantially in the literature, the actual effect has often been found to be less (Stanojević et al., 2013). It might be imagined that the extent of safety improvement is context dependent and that understanding the local conditions is important in determining what can be successful (Shams et al., 2011). Moreover, providing a method that provides insights about the strength of different alternative recommendations in improving safety can help in policy implementation. This is more so as studies from elsewhere show that policy makers might be more interested in what policies have been/ can be successful and how the success has been/ can be achieved (Marsden et al., 2011).

Furthermore, the studies reported in table 2.1 use different methods ranging from historic review to statistical methods. In many of these instances, the recommendations are outcomes of authors' opinion or generated from a descriptive analysis of the problem devoid of a systems understanding of the characteristics of the transport mode's operation. These particularly include Olubomehin, 2012; Odumosu and Yaro (undated); Oluwadiya, et al., 2009. Some others however, adopt the use of statistical models to identify the nature of relationships between variables within commercial motorcycle safety system. These models have better capacity to show the significance of factors (or recommendations) included in the model. Some of these studies include those relating to safety and those not directly relating to safety. Those not directly relating to safety include Ogunrinola (2011), Arosanyin et al. (2011), Arosanyin et al. (2012) and Fasakin, (2000, 2001, 2002), which all treat drivers' income mainly but add some other characteristics, including safety issues. They make recommendations including not banning commercial motorcycle (Fasakin, 2000), more safety education and improved licensing enforcement (Arosanyin et al., 2012; Ogunrinola, 2011), and the regulation of mode, including provision of motorcycle lanes (Arosanyin et al, 2011). Others that are safety related include the work of Adisa (2010) who studied substance abuse and its effect on drivers and Oni et al. (2011) who developed a statistical model for predicting accident involvement. Adisa finds that commercial motorcycle ownership and alcohol use index were related and that educational level, experience, income, and working period per day correlate with alcohol index. He then recommends reducing expensive ownership options amidst drivers and improvement on strict enforcement. Similarly, Oni et al. (2011) develop a regression model to determine the probability a driver or a passenger getting involved in an accident. As noted earlier, these statistical models are able to evaluate the significance of recommendations when included in the model. One main problem with these types of models, however, is that their explanatory powers of the variation in model output is usually low: being between 0.13 and 0.23 in Arosanyin et al.'s (2011) models; 0.308 in Oni et al.'s (2011) model, for example. Particularly, these explanatory powers reduce as the number of variables included in the models increases.

Thus, while these studies are rich in their findings, their recommendations might not be reflecting adequately the required understanding for commercial motorcycle safety improvement. This probably explains why some attempts to regulate this transport mode in Nigeria have failed. With particular reference to the foiled regulatory attempt reported by Mahlstein (2009), the policy failure resulted from some aspects of the system that were ignored or not adequately provided for in the regulatory attempt – a reflection of inadequate understanding. This inadequate understanding might be due to the complexity of the problems, or to method limitations, or even to other important factors not considered. Capturing the complexity of the problem better, improving on study method, and more wholly covering the problem concept are avenues to explore the possibility of increased confidence in and improved quality of research recommendations. Since the subject of interest is driver behaviour in commercial motorcycle safety, a review of the understanding about human factor/ driver behaviour in safety literature is first presented in the next section. This is followed by a broader review of methods in safety studies in section 2.7.

2.6 Road safety and the human factor

The three broad factors of accident causation are the human, road environment, and the vehicle. Of all these three, human factor is known to be the most significant contributor to accident causation (Davey et al., 2007; Özkan et al., 2006; West et al., 1993). Specifically, Davey et al (2007) note that the link between, for example, aggressive driving violations and increased risk of crashes has been growing of late. This has, however, been found in some developing countries much earlier (Abane, 1994). To deal with this human factor, several studies are being conducted to identify what constitute human factor and how its negative effect can be reduced in the driving task. West et al., (1993) identify two approaches to dealing with human factor: studying of accident report to determine causation; and evaluation of driver "performance" to find out features which may be risky in certain circumstances (p.557). The study of accident report can take a qualitative or statistical method. The second approach (which deals with evaluating drivers' performance) is reflected in the concept of driving skills and driving style (driver performance and behaviour respectively) as the two main components of human factor in road safety (Qzkan, et al, 2006). The basis for this is the expectation that it should be possible to improve understanding about human causes of accidents by investigating the variations in driver performance and behaviour and judging what may be related to accident rates (West et al., 1993). Ozkan et al. note that driving style is influenced by motives, attitudes and personality traits while driving skills are related to information processing and motor skills: skills concern the ability the driver has to control the car; style reflects the habitual modes of operating the car on the road. The variation in these characteristics between drivers has therefore become an important study object.

2.6.1 Driver Behaviour

The study of individual differences in accident involvement assumes that different degrees of accident involvement are in part a product of differences in driving style or driving skills as opposed to chance factors (West et al., 1993). Both style and skills are empirically related to each other and interact together to influence crash risk. While it is not clear the extent to which accident liability results from defects in skill or style or some interaction between them, (Summala, 1996), more recent findings led to a view that driving style may be more important than skills for an average driver (West et al, 1993). This has led to more concentration on driving style (driver behaviour) rather than skills (driver performance). Driver behaviour which reflects driving habit can be used, for example, to estimate the amount of risk a driver accommodates as he uses the roadway.

The focus of driver behaviour theories is on the concept of risk with risk measures viewed as a major control variable in driver behaviour (Summala, 1996). There is the concept of zero-risk theory: which suggests that drivers adopt a dynamic safety margin below which they operate in comfort. This concept of dynamic safety margin leads to the concept of behaviour adaptation which indicates that the "risk of collision is generally not relevant in the decision-making" (Fuller, 2005, p.461) process of the driver. He drives with learnt habitual patterns and without the thought of risk but based on the developed safety margins. This dynamics occurs such that with experience, drivers adapt to situations which at first provoked a risk response, changing this margin from time to time. Thus, Summala (1996, p.103) pointing out that: "in introducing safety counter-measures, it should always be recognised that the driver is inclined to react to changes in the traffic system, whether they be in the vehicle, in the road environment, or in his or her own skills or states, and that this reaction occurs in accordance with his or her own motives"..

The principle of behavioural adaptation (also known as risk compensation) acknowledges that the driver tends to react to changes in his environment and that, for example, the speed chosen by a driver is more important than his skill level in safety outcome. Following this understanding about driving style, the motivation module is used to explain the tendency to approach the risk threshold. This module includes motives from outside traffic, motives relating to the trip, and those inherent in the behaviour of human beings. These characteristics are different for different classes of individuals and this difference is what makes the relationship between accident and driver behaviour possible to identify. In addition, studies on driver aberrant behaviour are based on these differences and have been described "as a possible turning point for a comprehensive model of everyday driving behaviours" (Ozkan et al., 2006, p.386). These studies are conducted using various methods such as interviews, observation, and questionnaire surveys. These are then statistically analysed to generate results (Shams et al., 2011). For example, Abane (1994) used interview and observation methods to identify deviant behaviours amidst drivers in Accra. The most commonly used method is however questionnaire survey - Driver Behaviour Questionnaire (DBQ) (Stanojević et al., 2013; Özkan et al., 2012; Chorlton et al., 2012).

2.6.2 Safety culture and climate

In addition to looking at individual driver's behaviour, organisational safety culture and climate is another way of assessing safety and driver behaviour relationship, especially when it is considered that the vehicle is a work place. Safety culture and climate started with organisations but has now been extended to road safety. Culture and climate in this context have close meaning. This is particularly because organisational climate is not different from the manifestations and reflections of cultural assumptions (Öz et al., 2014). Notwithstanding, climate is a temporary state of an organisation and is being affected by changes within the organisation. Culture, on the other hand, is the structure in place that makes everyone feel responsible for safety and pursue it. Culture is more qualitative while climate is quantitative and can be measured with dimensions such as management, risk, work pressure, and competence (Öz et al., 2013). These measures have been found to affect both the violation tendency of drivers and the safety climate within which they work (Öz et al., 2014). Looking at these themes and how they relate to one another can improve the understanding about safety.

2.7 Methods in transport safety studies (all road modes)

Usually, accident studies contribute to improving understanding about crashes by extracting causation information from accident victims and/ or at risk persons to identify these factors, or by the analysis of hospital and police accident data. These causes are most usually statistically analysed to attach degree of importance to identified factors. This can be through the use of simple percentages or more rigorous statistical tests and the use of econometric models. For these methods of analysis, the quality of findings depends on the quality of data (Mannering and Bhat, 2014). But reliable data is often not available in sufficient amount for many developing countries. A more serious challenge is cost (in terms of time and fund) required for collecting fresh data for detailed analysis. For example, the Hurt's report and MAIDS report which studied motorcycle accidents between the year 1975 and the year 1980 in the US and between the year 1999 and the year 2000 in Europe respectively cost hundreds of thousands of dollars and huge time investment. This time and financial cost is usually a barrier to conducting such data collection exercise whenever reliable data is not available. So there are usually very few of large and detailed studies.

Perhaps one of the most detailed accident studies conducted on motorcycle accident which might be related to commercial motorcycles was the one conducted in Thailand (Kasantikul, 2001). Unfortunately, this study did not differentiate between commercial motorcycles and motorcycles for private use like most other studies on motorcycles in Asia. In the study, data was gathered at the accident spot at the time or immediately after the incidence – and on many occasions, while the victim was still at the accident scene. More than 1000 cases were considered. This study was conducted to identify causation factors of motorcycle accident in Thailand. It found that riders' error contributed to more than 85% of accident with alcohol intake responsible for as much as 35%. This is similar to what other researchers find out about road safety (as discussed in section 2.5). Environmental and vehicle conditions contributed less than 15% to accident in the study.

Because these studies are large scale, they cannot always be repeated. In addition, they do not tell everything: they do not tell how well policies will be effective. Thus, there are other methods in use in road safety studies. In this section, the review is extended to what methods have been used in research to treat the themes of behaviour and safety. Starting with a reflection on statistical methods, this section offers four methods in all which are in use across the world for safety systems. The other three methods are qualitative method, driver behaviour survey and systems approach. These methods are described below.

2.7.1 Statistical models of accident data

Statistical analysis of highway accident data has been in use to provide guidance for policy decisions targeted at reducing crashes over the time (Milton et al., 2008). This analysis method has been recognised to bring much success to road safety (Mannering and Bhat, 2014; Milton et al., 2008). This is more so as statistical methods have been undergoing improvement within the research community to provide better methodological approaches from time to time (Abdullah and Zamri, 2012; Milton et al., 2008). For example, Poisson regression approach gave way to negative binomial models to overcome over-dispersion problem associated with

Poisson regression. Still further, some forms of generalised ordered-response approach are now being studied for their potential to accommodate both spatial and temporal variations which some previous methods have limited capacity for (Mannering and Bhat, 2014). Even now, there are methods that are able to deal with correlation problems (Lord and Mannering, 2010). Moreover, these methods have come with huge success. Milton et al. (2008, p.261) note that Washington State adopted an enhanced "safety-programming approach" which was based on statistical model and this led to over 50% decline in fatalities. Nevertheless, while improvement in the statistical models is being addressed through methodological advances in the field, there are still many challenges to tackle (Lord and Mannering, 2010). In particular, statistical models require more accurate and detailed data than what is usually available (RIPCORD-ISEREST, 2008; Lord and Mannering, 2010). They rely on quantitative data and are of little use where reliable data cannot be obtained. They are therefore of limited use for accident studies in poor developing countries where reliable accident statistics are non-existent. This notwithstanding, they remain the most widely used method in these countries, a situation that calls for caution in the use of many studies from these places.

2.7.2 Qualitative methods

Golafshani (2003), alluding to Patton (2001) and Strauss and Corbin (1990) describes qualitative research as any research that uses naturalistic approach to understand phenomenon in context specific settings without any attempt to manipulate the phenomenon of interest. It is any kind of research that produces findings not derived by means of statistical procedures or any other means of quantification. He note that qualitative researchers seek illumination, understanding, and extrapolation to situations. This position is alluded to by Malterud (2001, p.483) who describes qualitative research methods as methods for exploring meanings of "social phenomena as experienced by individuals themselves in their natural context". This broader understanding provided by qualitative research is also mentioned by Barbour (2001). Barbour notes that qualitative research acknowledges the existence of multiple views of equal validity with each affording only a partial view of the whole picture. Thus there have been a number of applications of qualitative method in safety studies. For example Huth et al. (2014) conducted a qualitative research using focus group discussions on motorcycle safety with the goal of better understanding the nature of riding, the risk factors that underlie this activity, and the strategic and tactical issues involved. They find that this method helps to identify where interventions might be required as well as identify areas that might require further research. Similarly Musselwhite et al. (2012) conducted a qualitative research to identify the perception of motorcyclists and non-motorcyclists about safety issues. They also indicate that this method is able to provide a broader understanding about motorcyclists' safety. They particularly state that a quantitative approach is unhelpful and unnecessarily reductive in the pursuit of understanding about a wide variety of relevant factors and their effect on a phenomenon in a social context. Other who adopted the use of qualitative research in safety include Tetali et al. (2013, p.s17) who used focus group discussion to obtain a "better understanding of areas for improving road safety". As is shown, there is this general agreement that qualitative method is appropriate for improving understanding about a phenomenon in a way probably better than quantitative methods. None of these authors indicated the capacity of qualitative methods for predicting events. However, Miles et al. (2014) show that qualitative methods can be used to predict events in a manner similar to quantitative methods. They demonstrate this with examples that are not related to transport. At the least, this method might be able to improve understanding about commercial motorcycle safety.

Nevertheless, qualitative methods are often described as unscientific, fluid, lacking in repeatability and subjective. There have therefore been authors recommending methods to make qualitative research scientific (Mays and Pope, 2000; Malterud, 2001; Barbour, 2001, Miles et al., 2014). This will therefore be further reviewed.

2.7.3 Driver Behaviour Questionnaire (DBQ)

The Driver Behaviour Questionnaire (DBQ) is the use of questionnaire survey to elicit information about the behaviour of drivers in traffic based on self-report. DBQ which originally was designed to make a distinction between different types of aberrant driving behaviours has been used extensively to reflect differences in driving conditions, driving population, and many other different factors (Warner and Åberg, 2014). This method has been shown to be consistently reliable in spite of social desirable responding bias (Lajunen and Summala, 2003; Parker et al. 1995b in Ozkan et al., 2006). The method has several advantages: large amount of data can be collected and analysed in a short time with low cost; it provides a means for studying driving behaviours which can be difficult or even impossible to study by using observation method or even national accident statistics (Lajunen and Summala, 2003). Through the use of this questionnaire, several taxonomy of aberrant driver behaviours have been identified from the two basic ones: error and violation. Errors are the outcome of the failure of planned actions to achieve their intended consequences, whereas violations "are deliberate deviations from those practices believed necessary to maintain the safe operation of a potentially hazardous system" (Ozkan et al., 2006, p.386). Slips and lapses are attention and memory failure and may not have an impact on driving safety (Öz et al., 2014). The taxonomy ranges from two factor structure to six-factor structure. The three and four factor structures are however more commonly reported (Ozkan et al., 2006). With driver error and violations being the two distinct classes of behaviour, the three-factor structure divides these two into: deliberate violations, dangerous errors and silly errors. These have also been called violations, errors, and lapses respectively. The four factor structure on the other hand has one additional factor obtained by dividing violation into aggressive and ordinary violations.

The DBQ offers very useful information. It has also been possible to develop modified versions of DBQ to address problems such as incompleteness, over-inclusiveness, and category overlap (McNally and Bradley, 2014) though these problems are still often noticed (Cordazzo et al., 2014). Based on this instrument, it has been possible to discover that men and young drivers tend to commit violations more frequently than women and older drivers and that those who drive more frequently violate traffic rules more than those who drive less frequently. It was also found that competitiveness in traffic seemed to reduce with age and experience while concerns for rules decreased at the same time (Winter and Dodou, 2010; Özkan et al., 2006). Unfortunately, this tool was found to show low test-retest factor stability raising the question of suitability for longitudinal studies (Ozkan et al., 2006).

2.7.4 Systems approach

Systems approach is an approach that shows the connections between the elements of a system. As noted by Conroy and Allen (2010), systems approach helps to see the bigger picture of challenging situations so as to be able to develop solutions that are more reliable. In this way, it can help to understand a challenging problem better. This approach has been used in transportation field to address safety problem in many studies. Examples include (Leveson, 2004; Leveson, 2011; Underwood and Waterson, 2013; Rasmussen, 1997). Rasmussen for example, asked the rhetorical question: "Do we actually have adequate models of accident causation in the present dynamic society?" He went further to note that the "socio-technical system involved in risk management includes several levels ranging from legislators, over managers and work planners, to system operators. This system is presently stresses by a fast pace of technology, and changing regulatory practices and public pressure". (p.183). Rasmussen indicates by this that the characteristic of drivers, for example, is caused by the pressures they are subjected to. Defining system characteristics based on drivers' characteristics alone without considering the interaction with other system components might make the solution proffered less effective. Speaking in this vein, Leverson (2004) argued that models should not treat just safety events and conditions; rather, the process involved should be treated. This process, according to him, controls a sequence of events and describes system and human behaviour over time. He concluded that safety in a system can be maintained when the process leading to safety compromise is constrained to operate within safety limits. Thus it is not about preventing an event from occurring in the system; it is about maintaining the characteristics of the system. Following from this wider analytical opportunity provided by systems approach, Underwood (2014) notes that systems thinking approach to understanding safety problems in socio-technical systems provides a deeper understanding of how dynamic, complex system behaviour affect safety.

A good example of the use of systems approach in safety analysis was presented by Goh et al. (2010). Using a case study of Bellevue hazardous waste fire that occurred in Western Australia in 2001, they show how linear causal methods may not be effective. They show that safety culture in Bellevue fire was a by-product of the system structure put in place unknowingly by the joint actions of the different parties in the system. They note that the reaction of each party appeared necessary from each party's point of view. But the combined actions from these parties were detrimental to the overall safety of the system. They used a tool called causal loop diagram and show that it can help to understand systemic structure that contribute to incidence more readily than traditional causal analysis tools. Earlier, Cooke (2003) developed a SDM to analyse Westray mine disaster, in Canada. This model was developed based on the causal relationships established by a public enquiry (the Westray Mine Public Inquiry) and standard system archetypes. He notes that despite the lack of validity about the nature of the functions that are most suitable to model human behaviour, the stock and flow model he developed is better than the more traditional root-cause analysis methods available for understanding organisational accidents. Other safety models developed based on systems approach includes: the use of causal loop diagram (Goh et al., 2012); the use of SDM (Mehmood, 2010); the development of AcciMap (Rasmussen, 1997); the development of System Theoretical Accident Modelling and Processes model (STAMP) (Leverson, 2004), and others. All these models demonstrate the superior capacity of systems approach over most conventional methods. These models are however more common in non-road safety applications.

2.8 Conclusion

In this chapter, the use, benefits and problems of commercial motorcycle transport have been discussed. It has been shown that commercial motorcycles manifest high-risk behaviour which impact on their safe operation. Section 2.4.2 identifies a number of policy actions that have not been successful as would be expected. It further shows that the problem with regulating the operation of commercial motorcycles may not be the identification of measures that might be adopted: there are many recommendations already. It rather posits that the context in which these recommendations are implemented might not be well understood. This is particularly as these recommendations are targeted at solving specific “visible” problem without identifying the structure that drives the problems in this system (Conroy and Allen, 2010). Driver behaviour which has been identified as a major factor in safety is influenced by several factors: these factors are however often treated separately and not as a whole. Moreover some analysis methods in use cannot justify the appropriateness of recommended policies. Furthermore, statistical models in use suffer from reliability problems in their data and are usually unable to accommodate all important variables; particularly, the need to improve the explanatory power of these models often makes it necessary to limit the number of factors to be included. This chapter therefore argues that the failure of regulatory policies observed in the system might be a reflection of the inadequate understanding about commercial motorcycles’ safe operation. As a result, it remains to be found how to extend understanding about commercial motorcycle operation as well as identify why some previous measures have not been successful. Specifically some questions require to be addressed and these include:

1. What are the underlying factors in commercial motorcycle safety system and how are they related?
2. How do the factors that relate to driver behaviour interact with one another to form the structure observable within the system?
3. What is the behaviour of this underlying structure and how is it changing?

These questions form the basis for generating the objectives of this research and the rest of the thesis deals with how these questions are answered. First, two of the four methods described in section 2.7 are further treated. This is because they look more appropriate to deal with these questions as described in section 2.7. These two methods are: qualitative methods and system dynamics approach.

Chapter 3 A Review of Qualitative Research Methods

3.1 Introduction

Chapter 2 identified the use of qualitative research as one of the options for improving the understanding about commercial motorcycle safety operation. It particularly showed the strength of qualitative research in being able to broadly capture and explain social phenomenon based on the different views of different players. However, qualitative research has a lot of fuzzy and fluid nature which often results in methodological misconception. This has particularly been noted in studies that use qualitative methods in health sciences (Malterud, 2001; Coyne, 1997). This risk of misconception provides a basis for a review of qualitative research methods. This chapter therefore attempts to provide some general information about guiding principles in qualitative research. The chapter is divided into five sections. The next section (section 3.2) provides information about the use of qualitative data and approaches to research in qualitative studies. This is followed in section 3.3 by a review of data collection methods. The fourth section (section 3.4) discusses data analysis and section 3.5 provides information about validation process in qualitative research. Section 3.6 gives a brief summary of the section. What this chapter offers is a general frame for conducting qualitative research. The final choice of qualitative research method adopted for this research is made and justified in section 5.4.

3.2 Data use and approaches in qualitative research

Qualitative data appear in different forms and are therefore analysed using different methods. These methods are not only qualitative in nature; there are quantitative analysis methods too (Barbour, 2001). The use of qualitative data for quantitative studies is well cited in the literature (GAO, 1989; Graneheim and Lundman, 2004; Hsieh and Shannon, 2005; Mays and Pope, 2000; Thorne, 2000). When this is done, the goal of such analysis is to find out how something operates in the manner it does. In this sense, it provides a description for the object of analysis. The analysis may involve determining the frequencies of variables or the differences between them and statistical tests are usually conducted on the outcome. Generally, a form of counting and comparison is done in quantitative research (University of Surrey, [no date]). Qualitative analysis, on the other hand, goes beyond description to generate explanation for the object of analysis. It involves exploring data in a manner that can generate analytical concepts or categories that can be used to both describe and explain social phenomena. This exploratory process can be deductive or inductive in nature.

Generally, deductive and inductive approaches are the two basic approaches to data analysis. They are the fundamental tools for generating meaning in qualitative research regardless of the philosophical position a researcher is adopting. However, the word “approach” is fuzzy[4] in qualitative research and methods such as grounded theory, ethno-methodology, etc., are often called “approaches”. This is due to their philosophical underpinnings (theoretical assumptions) which reflect in how data is collected and analysed. In this thesis, these methods will therefore be called approaches. First the two analytical approaches are described. Then the methodological approaches are described in section 3.2.2.

3.2.1 Analytical approaches in qualitative research

3.2.1.1 Deductive approach

Deductive approach involves testing a priori hypotheses which often requires the use of a structured format for obtaining information as well as standardised procedure for analysis (Dicicco-Bloom and Crabtree, 2006). It first identifies some a priori issues which provide guidance for searching the data during the analysis. It is very useful in studies where the data collection is more structured and the required analytical process is expected to be more explicit and strongly informed by a priori themes, such as in the case of framework approach[5].

3.2.1.2 Inductive analysis

Inductive analysis, on the other hand, means to explore meaning and perceptions to gain a better understanding. It involves identifying themes analytically as they emerge from the data. It does not assume any a priori but allows the data to provide explanation for itself. Inductive process is thus hypothesis generating unlike deductive process which tests a priori (tests hypotheses) (Thorne, 2000). Notwithstanding, inductive analysis often incorporates deductive approach in the course of exploring data.

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[4] For example, ethnology is regarded either as an approach or a method in the literature (Luna-Reyes & Anderson, 2003; Thorne, 2000).

[5] More on framework approach is provided later

3.2.2 Methodological approaches in qualitative research

3.2.2.1 Grounded theory

Grounded theory is a term used to describe the use of inductive analysis to identify analytical categories as they emerge from the data (Pope et al., 2000). Its underlying basis assumes that fundamental social processes explain something about human behaviour and experience (Thorne, 2000). Grounded theory searches to detect commonalities and variations among and between datasets and provides interpretation and structure for the meaning of data (Thorne, 2000). It uses a series of cumulative coding cycle and reflective analytical memo-ing to develop major categories for theory generalisation (Miles et al., 2014). This comparative approach involves taking one piece of data and comparing it with another to identify themes and patterns that may be similar or different in order to obtain both the relationships and differences between them (Barbour, 2001). This comparison usually results in multiple themes that may require some sort of indexing so as to provide a good organisation for data. This process is a sort of content analysis[6] (Burnard, 1991).

Grounded theory is not without its criticism. While its popularity comes from its approach of simply making sense from raw data, Barbour notes the criticism of its use as "'an approving bumper sticker' invoked to confer academic respectability" on a research work even when such work actually does not qualify (2001, p.1116). She supported other critics that the potentials to better illuminate a study topic are usually replaced with the declaration of the use of grounded theory approach and called for a more auditable reporting of process.

While grounded theory is a well-used theoretical assumption about research approaches, there are many other research theories in place. As Miles et al. (2014) observed, many interpretations are possible, it is just that some are more compelling for theoretical reasons of credibility/ trustworthiness than others. Some of these other approaches include phenomenological approach, ethnographic method, hermeneutics, and framework analysis, to mention a few. A few of these are described below.

3.2.2.2 Phenomenological approach

Phenomenological approaches are used when the research is intended to discover underlying structure or essence (University of Surrey, [no date]) of an experience by

[6] More information is provided about content analysis later

using individual cases[7]. In this case, patterns and commonalities between cases are not important to the research. This is similar to grounded theory in that it is a purely inductive analysis process but different in the sense that it seeks to make sense of a specific and particular phenomenon. It is a reductionist perspective that explains the phenomenon as free and as unprejudiced as possible (Dowling, 2007; Thorne, 2000). As a result, phenomenological approach, in its traditional orientation, does not make generalisation about the structure of a phenomenon. This is because of its underlying assumption that humans make sense of the world by imposing their own unique and individual meaning (University of Surrey, [no date]). Thus it is criticised for what McNamara (2005) called “intentionality and bracketing” (p.695)which relates to the extended subjectivity analysis using this approach accommodates.

However, while traditional phenomenology does not attempt to generate theories, there are variants of it (e.g. continental phenomenology , van Manen’s phenomenology, etc., – a situation called “crisis of representation” (Dowling, 2007, p.139)) with possibility for theory generation. Thus, phenomenology is described “as a moving philosophy with many parallel currents” (Dowling, 2007, p.139).

3.2.2.3 Ethnomethodology

Ethnomethodology (or ethnology) is another approach. This approach goes beyond the meaning and descriptions an individual gives to a social phenomenon. It rather looks into the culture within a society to determine actual, concrete setting and not hypothetical or theoretically depicted setting (Maynard and Kardash, 2007). Studies using this approach engage with the culture in a participatory manner (Thorne, 2000), a process which usually takes some time. Nevertheless, it offers a very rich result.

3.2.2.4 Framework approach

Framework approach is a research approach that adopts deductive analysis. This relatively young approach attempts to provide evidence for a priori issues previously determined before the data collection process by searching data to identify key ideas and recurrent themes. While themes outside the a priori might emerge, its goal is to provide explanation for the findings in a validating manner rather than explaining the data. It thus develops some sort of systematic indexing and thematic frames that gather related concepts together to provide for data interpretation based on initial a priori (Pope et al., 2000). While this approach is rapidly spreading, it is criticised for

[7] A case is described as a phenomenon occurring within a bounded framework which can be an event, a person, a culture etc. (Miles et al, 2014). Another word for it is “phenomenon”.

its focus on the achievement of intended effect using intended routes which might make learning through this method less realistic (Gasper, 2000).

All these approaches have one thing in common: they all attempt to uncover knowledge hidden behind the case (phenomenon) under study. In addition, they all adopt inductive, deductive or both techniques in their analysis. What is different is the type of case (phenomenon) each approach is better able to treat. Moreover, some have clear definition of process, others are shifting. Nevertheless, they are all used in qualitative research. In fact, (Miles et al., 2014) note that there is relatively little standardised instrumentation in use in qualitative research as the researcher is the main instrument and he often employs "a little bit of this and a little bit of that, used on an as needed basis" (p.9). Finally, the type of approach chosen for any research is usually a major determinant of the data collection method that is adopted. In the following section, some of the general methods used in data collection are identified.

3.3 Qualitative data collection

The previous section ended with a description of some methodological (or theoretical) approaches to conducting qualitative research. In this section, methods again are discussed. But these are data collection methods, not theoretical methods. There are three major ways through which qualitative data can be collected. These are interviews, observations, and document reviews. These three do take different forms and can be combined in different ways. Some of these forms include individual or group interviews, focus groups, Delphi method, case studies, participant observation, review of previous research, and historic data and information, amidst others (Dicicco-Bloom and Crabtree, 2006; Luna-Reyes and Andersen, 2003; University of Surrey, [no date]). Some of these are described below:

3.3.1 Interviews

Interview method is one of the main methods for collecting qualitative data (Curry et al., 2009; Dicicco-Bloom and Crabtree, 2006). Interview can be structured with the use of questions that require well defined answers, unstructured such that a respondent may be able to provide a lot of details in his answer or semi-structured which is a mid-point between the two (Luna-Reyes and Andersen, 2003). Structured interview is generally accepted as useful in quantitative research while semi-structured and unstructured interview methods are employed in qualitative research. But as Dicicco-Bloom and Crabtree (2006, p.315) note, the differentiation between unstructured and semi-structured is "artificial". They went further to say that unstructured interview actually have some sort of structure but are better described as “guided conversations” than interview. Interview allows for elaboration of topics (Luna-Reyes and Andersen, 2003). It is usually made fairly informal and participants are made to feel that they are participating in a conversation rather than a formal question and answer (University of Surrey, [no date]). Usually, the interviewer is expected to remain neutral so as to avoid influencing the respondent.

However, interview method like any other qualitative research tool is biased to a degree. Questions asked are usually influenced by the conceptual framework of the researcher. In addition, interview is often chosen without sufficient skills to effectively use and benefit from it (Broom, 2005). Moreover, (Myers and Newman, 2007) note some problems with qualitative interviews including what they call elite bias, lack of trust, and artificiality of the interview. Nevertheless, these challenges can be overcome through learning by doing (Myers and Newman, 2007).

3.3.2 Focus group

The use of focus group when obtaining information from a group rather than an individual might be more rewarding (University of Surrey, [no date]). It can be used when the phenomena being investigated require a collective discussion in order to understand the circumstance or behaviour, or where greater insight might be obtained through group dynamics. Dicicco-Bloom and Crabtree (2006) note that focus group can also be used as group interview where the entire group is taken as a single entity and no information is required from particular individual member. It is also good where resources for the research are limited. Usually, more than one focus group is required when this method is adopted with each group being around the range of 6 – 10 participants. As in interviews, the role of the researcher is to guide and keep the discussion focussed. This method rely upon respondents complementing each other’s’ experience and remark (Luna-Reyes and Andersen, 2003). The challenge with this method for the researcher is usually the need to prevent a member from dominating the discussion and ensuring all participants have equal opportunity to respond.

3.3.3 Delphi group

This method entails reaching consensus through a group of respondents. Individuals within the group can be asked to, for example, create a list of important factors in about a phenomenon. The outcome of this exercise is collated and returned to the group members to rank. This process can continue until a near-consensus is reached (Luna-Reyes and Andersen, 2003). One of the challenges with this method is that a fair consensus may not be attained where individuals in the group seek to preserve their vested interest (Okoli and Pawlowski, 2004).

3.3.4 Case study approach

Complex problems can be studied with case study approach. It is a combination of all the three basic data collection methods. It is a good tool for developing theories, evaluating a system, and developing intervention (Baxter and Jack, 2008). Case study can take qualitative or quantitative research approach which can involve in-depth analysis of a single or small number of units. It can be a study of a single event or a complex social situation over a period of time. It tries to obtain rich information about how as many as possible variables interact together in a complex situation to produce a particular behaviour/manifestation. It usually follows phenomenology approach and is more particular about the case unit. It uses many methods to gather information. There are however criticism that the case under study may not be representative and so cannot be used for generalisation (University of Surrey, [no date])

3.3.5 Secondary data sources

Data from secondary sources provide the benefit of time saving as well as provide historical data that may offer general background information and set the scene for a research and its findings. Moreover, they can be used to put a research into context and can be used to prove or disprove an argument. However, it is not always possible to authenticate the validity of these sources and that may affect the quality of research they are used for (University of Surrey, [no date]).

3.3.6 Other methods

Other methods include observation method, longitudinal study, historical method, etc. Observation method takes place in natural settings and involves the researcher taking notes of what is happening. Longitudinal research or panel studies is usually done over a long time period requiring repeated visits, say at two years interval. Historical method involves systematic data collection based on past events. Historical method can be used to test hypothesis about cause, effects or trends of events so as to be able to explain the present and anticipate the future (University of Surrey, [no date]). These methods, however, require a huge amount of time both for data collection and analysis.

What is discussed next is the analysis process when data has been collected.

3.4 Data analysis

Once data has been collected, the next stage is data analysis. Yet it must be said that data collection and analysis are usually not completely separable in qualitative research (Thorne, 2000). In what Pope et al. (2000, p.114) called “sequential or interim analysis” the analytical process starts during the data collection process as data already collected are reviewed to guide what would be subsequently collected. In a similar manner, Dicicco-Bloom and Crabtree (2006, p.317) described data collection and analysis as concurrently taking place “so that investigators can generate an emerging understanding… which in turn informs both the sampling and the questions being asked”. Nevertheless, much analytical work has to be done once the data collection exercise is completed.

Data analysis is the process of making sense of the data collected to understand the phenomenon under study. It involves using data to describe and improve understanding about the phenomenon. This process usually involves some form of coding in a manner that the differences and similarities are recognised. Usually, the initial analytical stage is coding with analysis proceeding further to develop theories that are grounded in the data. Coding stage can however be structured to what is known as content analysis.

3.4.1 Content analysis

Content analysis is a method/process of coding data. It is a method that has been in use for over two centuries (Hsieh and Shannon, 2005). Its use has metamorphosed from being used for both qualitative and quantitative research initially to primarily quantitative analysis only and now again to both qualitative and quantitative analysis (Hsieh and Shannon, 2005). Notwithstanding this length of use of content analysis, its definition and meaning is still fuzzy. For example, content analysis is implied to mean a process of iterative inductive coding such as in grounded theory by Burnard (1991). In Bos and Tarnai (1999), it is compared with other research methods (data collection methods) such as interviews, observations, and questionnaire. Some treat it as a purely deductive method (Luna-Reyes and Andersen, 2003) with GAO (1989) stating that it can only answer the questions “what?” (i.e., deductive analysis) and not “why?” (as required in inductive analysis). This confusion was recognised by Graneheim and Lundman (2004, p.105) when they wrote “A review… shows different opinions and unsolved issues regarding meaning and use of concepts, procedures and interpretation in qualitative content analysis”. While this different views look messy, they all point to the wide application of content analysis as a method of making sense out of data which can be inductive or deductive, grounded or phenomenology or even ethnography. Moreover, content analysis provides an iterative coding system that eventually facilitates grounding theories in the data through the logical sorting process of coding and identifying themes or patterns (Burnard, 1991; Hsieh and Shannon, 2005). It allows for the use of both inductive and deductive analysis to generate result. Summarily, content analysis may be described as a “research method for the subjective interpretation of the content of text data through the systematic classification process of coding and identifying themes or patterns” (Hsieh and Shannon, 2005, p.1278).

Content analysis method has been criticised as having the resemblance of grounded theory without being as deep as grounded theory (Hsieh and Shannon, 2005, p.1278). It has also been criticised for its subjectivity. This is more so with what is called “latent content” (Graneheim and Lundman, 2004, p.106) which deal with interpretation of the underlying meaning of the text. Nevertheless, (Miles et al., 2014) noted that approaches are usually combined in qualitative research such that the inadequacy in one can be made up for with the capabilities of others. Thus an analysis might start with content analysis and reach its conclusions through other methods such as grounded theory. This is more so as this method only initiates the process of generating meaning and requires other theoretical approaches to make sense of the codes generated.

While content analysis method helps with the generation of codes, the coding process often requires some form of organisation of codes. This is presented below.

3.4.2 Data organisation and the use of software

In a bid to provide a good audit trail of analysis for improved research quality, good organisation of analysis is usually required. This is more so as during coding process, several themes and sub-themes emerge that may become difficult to manage. This is where many of the qualitative software become useful. Pope et al. (2000) stressed that these software may help to show that the analytical process is systematic. They also do help with generating graphs of analysis outcome. They however do not necessarily make analysis less time consuming. The actual analysis still has to be done by the researcher. Some of the more common software includes NVivo and Atlas. The next section speaks to the how analysis outcome can be represented.

3.4.3 Representation of data analysis outcome

Not many texts offer a guide on representing analysis outcome diagrammatically. Saldana, for example, used tree and model diagrams to represent analysis method, steps in analysis as well as analysis outcome (Saldana, 2013). A model diagram is usually a combination of links or arrows and nodes/circular or oval shapes. Mason (2002) too adopt the use of tree and model diagrams for similar purpose. Miles et al. (2014), however, offered several styles for representing analysis outcome which they termed: "displaying the data" (p.105). Of particular interest is what they called methods of explaining causation. They described these methods as ways to illustrate a research story's trajectory and outcome showing interaction and interplay between multiple pairs of variables so as to explain causation. They offer three types of representations: causal chain, causal fragment, and causal network. A causal chain is a linear display of events, actions, etc., that suggest a sequence of cause and effects. When causal chains are joined together, they form a causal fragment. Causal fragments are a combination of causal chains that do not tell a complete story. When the whole picture is represented, it is called a causal network. A causal network "is a display of the most important variables (represented in boxes) in a field study and the relationships among them (represented by arrows)". (Miles et al., 2014, p.236). It is a diagrammatic representation of the emergence and consequences of codes.

3.4.3.1 Causal network representation

Causality can be represented in several ways. Perdicoúlis and Glasson (2006) list about a dozen different types including CLD, evidential causal network, Bayesian network, tree diagrams, etc., all of which may be generally called causal networks. These diagrammatic representations are used in various fields of endeavour, including transport research. However, in this research, causal network is used to mean the definition provided in section 3.4.3 above.

Miles et al. (2014) note that the use of causal network requires planning to use it from the outset of the research. They show that there are two different approaches to it: inductive and deductive approaches. In inductive approach, the causal network emerges piecemeal from the discovery of phenomena in the flow of field experiences and recurrent relations among them. It has a regularity and pattern that shows that some things happen when others do or don't.

In deductive approach, on the other hand, the researcher has some a priori causal network which he goes to the field to test or observe. Miles et al, however, advise that the "better alternative is to save full causal network drawing and analysis for later…, making it perhaps the last analytic exercise” (p.238). This, according to them, is to avoid a network vision that sets in too early. Nevertheless, inductive and deductive methods of developing a causal network are not mutually exclusive research procedures: only that deductive approach is a top-down approach while inductive approach is a built-up one.

A causal network can be generated by a combination of causal chains, the use of event-state network, or the use of causal network variable list (Miles et al., 2014). Causal Fragments are combination of causal chains in the process of generating a causal network: they are incomplete causal networks. They can be developed from a combination of causation coding. Causation coding, according to Saldana (2013) is a coding system based on attribution[8]. In the case of event-state network and causal network variable list, tables containing, for example, antecedent variable, outcomes, and mediating variable are developed. However, Miles et al. advise new qualitative researchers to use a combination of causal chains.

In addition, Miles et al. suggest that a causal network should be supported with a narrative of what the network represents. This narrative is an explanation of the relationships within the network.

Once the data is analysed and interpreted, it is important to provide a form of validation for the result. The next section provides some views about this process.

3.5 Validation in qualitative research

3.5.1 Subjectivity issues in research validity

Over time, concerns have grown on the reliability and validity of qualitative research (Barbour, 2001; Golafshani, 2003; Mays and Pope, 2000; Pope et al., 2000; Thorne, 2000). This has been in a bid to make qualitative research more scientific. While reliability and validity are rooted in positivist perspective and have been more easily adopted in quantitative research, their adoption in qualitative research is still a process. For example, Thorne (2000, p.70) notes that “systematic, rigorous and auditable analytical processes” are criteria for judging a good qualitative research. Mays and Pope (2000, p.52) use the description: “systematic self-conscious research design, data collection, interpretation, and communication” as the strategy to ensure quality in qualitative research. In similar manner, Golafshani (2003) states that repeatability, reliability and validity are more related to quantitative analysis and terms such as credibility, neutrality/ confirm-ability, consistency/ dependability, and

[8] Causation coding is described further in chapter 8

applicability/ transferability are better for assessing quality in qualitative research. These terms are however subjective and cannot be defined exactly the same way at all times. As a result, researchers in qualitative research suggest many tests for improving validity and reliability (Golafshani, 2003; Guion et al., 2011). Some of these are discussed below.

3.5.2 Triangulation and validity

Triangulation is one of the most widely recommended forms of validation in qualitative research (Guion et al., 2011; Miles et al., 2014; Golafshani, 2003). As shown in Guion et al. (2011), triangulation can be done in several ways. Data triangulation involves obtaining data from multiple sources to increase the validity of a research. Investigator triangulation requires using more than one researcher in a research to minimise individual bias. Theory triangulation adopts multiple theories (usually by different individuals) to examine the same phenomenon. Methodological triangulation uses multiple qualitative and/ or quantitative methods in the research. This is also known as methodological pluralism or mixed method (Dicicco-Bloom and Crabtree, 2006). Mixed method is particularly good for its ability to combine the strengths of different methods. It is useful in helping to provide opportunity to cross check and/ or complement/ support research conduct. Environmental triangulation uses different locations or settings or time, etc. to conduct the same study. This multiple triangulation approach is based on the constructivist notion of reality as something changing and thus requiring multiple study approaches to view, understand and interpret it.

However, (Mays and Pope, 2000) note that triangulation is controversial as a test for validity while (Barbour, 2001) cautioned about the use of triangulation as a validity check in qualitative research. First, triangulation in qualitative research does not always imply a validation exercise. According to Barbour (2001) when similar findings are obtained from the use of different methods, the findings become more reassuring and increase internal validity of data. However, the absence of similar findings does not make findings inferior. This is because qualitative research acknowledges the existence of multiple views of equal validity and this is what makes it different from quantitative research that assumes a central truth against which all findings are measured. Moreover, different methods in qualitative research "furnish parallel datasets, each affording only a partial view of the whole picture"(Barbour, 2001, p.1117). Rather than attempt to valid qualitative data from triangulation, the concept of complementary perspective is suggested. This is more so as Thorne (2000, p.68) note that "qualitative researchers are often more concerned about uncovering knowledge about how people think and feel about the circumstances in which they find themselves than they are in making judgement about whether those thoughts and feelings are valid". This complementary concept, named "crystallisation" is offered as an alternative to triangulation as "comprehensiveness may be a more realistic goal for qualitative research than is internal validity *(and)* … apparent contradictions (or exceptions) do not pose a threat to researchers' explanations; they only provide further scope for refining theories" (Barbour, 2001, p.1117). It may summarily be said then that while triangulation is a complement in qualitative research, its full potential as a corroborating factor should be adopted rather than limit its use it to refinement of findings. Moreover, the five different type of triangulation tests recommended in Guion et al. (2011) are rarely practicable in a single research due to cost. Some other forms of qualitative research validity are provided by Bryman. This is discussed below.

3.5.3 Bryman's four tests of validity

To keep the interpretation of triangulation simple, the recommendation of Bryman (2001) may be considered. Bryman suggested four types of validity for qualitative research method and findings. These are measurement validity, internal validity, external validity, and ecological validity. Measurement validity (or construct validity in University of Surrey ([no date])) tries to check whether a measure being used actually measures what it claims. This is usually determined by the research approach and the method of data collection. As Malterud (2001) noted, this is influenced by the researcher's background and position. Internal validity attempts to answer the question of whether conclusion of a research or theory developed is a true image of the cause adduced to it (University of Surrey, [no date]) or whether it investigates what it is intended to (Malterud, 2001). External validity considers whether the result/ part of the result of a research work can be generalised, i.e., in what context the study can be applied (Malterud, 2001; University of Surrey, [no date]). Ecological validity checks if findings are fitting to people's everyday natural situation. While these four validity tests are subjective to an extent, it is easier to provide specific answers to them than what many other authors recommend.

While the measures discussed above are essential to validity, other issues are equally important to build reliability and trustworthiness in the research outcome. These include dealing with bilingual data, setting research boundary, and sampling techniques. These are described below.

3.5.4 Bilingual data

Qualitative research often involves collecting data in a language different from the one intended for analysis. For example, Halai (2007) noted that he and some of his respondents were switching between two languages during interview. In instances such as this, Twinn (1997, p.421) recommended using the same translator for all scripts so as to ensure consistency during analysis.

3.5.5 Research boundary

Miles et al. (2014) noted that research boundary is an important aspect as it dictates the size of sample to be collected during data collection process. To arrive at the boundary, it is necessary to identify the study case or phenomenon to be researched as this forms the focal point which the boundary surrounds. The research boundary can be by deciding on the factors that relate to the defined case based on the research aim or research objectives.

3.5.6 Sampling

Mack et al. (2005) note that it is not necessary to collect data from everyone in a community for the purpose of research even if it were possible. Only a subset is selected from a population. The process of this selection is called sampling. As (Miles et al., 2014) note, sampling is affected by the boundary set for a research as well as the conceptual frame chosen by the researcher for the study. It requires considering the research setting, the actors within the phenomenon, the phenomenon itself, and the research process. Sampling methods are therefore not the same. Some of the types of sampling identified include purposive/ purposeful sampling, quota sampling, selective sampling, theoretical sampling, and snowball sampling (Coyne, 1997; Mack et al., 2005; Miles et al., 2014). However, these sampling methods are not clearly defined in most literature. Coyne (1997) report how different publications identified different numbers in sampling methods ranging from three in some to 15 in (Patton, 1990, cited in Coyne, 1997, p.627). Going further, Coyne (1997) concludes that all sampling starts with a sort of selective sampling. Furthermore, he posit that all sampling are purposive and that it may be appropriate to divide purposive sampling into three broad categories identified by Sandelowski as: maximum variation, phenomenal variation and theoretical variation (Sandelowski, 1995, cited in Coyne, 1997, p.628).

Maximum variation of purposeful sampling is a sampling where researcher attempts to bring in the widest variation in the sample. It is the most common type in use in qualitative sampling. “Phenomenal variation is variation of the target phenomenon under study and the decision to seek phenomenal variation is ‘often made a priori in order to have representative coverage of variables likely to be important in understanding how diverse factors configure as a whole’”(Coyne, 1997, p.628). Theoretical variation is a form of sampling based on philosophical grounds as demonstrated in grounded theory studies.

Finally, snowballing sampling is a method used to find and recruit hidden populations – those who may not be easily accessible to the researcher through other sampling strategies (Mack et al., 2005). This method, though similar to theoretical variation of purposeful sampling does not seem to fall under any of the three categories. This is especially the case if the approach adopted is not grounded theory.

3.6 Conclusion

This chapter highlighted the various approaches that might be adopted for qualitative research with reference to how different approaches are useful in different contexts. The main conclusions are:

- Deductive approach to data analysis is more suited for studies that seek to test a set of hypotheses, not those that seek the understanding the unknown.
- Inductive studies are more appropriate for seeking understanding, being hypotheses-generating.
- Grounded theory seeks to identify causality better than most other approaches but requires the process of data collection and analysis to run simultaneously throughout the research process.
- A theoretical approach such as phenomenology seeks to discover the underlying essence or structure without necessarily generalising the outcome but is more subjective than grounded theory.
- Framework approach is a hypothesis-testing research approach.
- Interviewing method is the most commonly used method. Data collection methods are however commonly used in combination with one another.

Finally, this chapter has been able to show that it is possible to undertake a high quality qualitative research and conduct appropriate validity tests.

Chapter 4 The system dynamics approach

4.1 Introduction

The system dynamics approach is rooted in systems theory. The systems theory is an approach that improves the understanding of the inter-connectivity and interactions between the different components of a system. It views the behaviour of each component as determined by the interactions between components within the system and the behaviour of the system as determined by the combined effect these interactions. Illustrating this, Conroy and Allen (2010, p.195) explain that problems perceived in the outside world are simply the visible part of a much larger and mostly-hidden "iceberg". The system drivers (system structure) that generate the patterns which the problem reflects are usually not seen as they lie deep down the "iceberg". What systems approach does is to reveal this hidden iceberg by enabling the problem to be viewed as a reflection of a system and to identify the structure that drives the system.

The systems approach is a paradigm that is rooted in non-linearity and feedback concepts (Carhart and Yearworth, 2010). It has different names such as systems thinking, systems theory and systems approach. Systems approach attributes the behaviour of a system to the feedback control structure of the system itself. This view does not mean that the effect of external factors should be ignored. Rather, what it reflects is that the way the system responds to external factors depends on the dynamic structure of the system itself. This paradigm challenges conventional wisdom to view a problem from a wider perspective as against the usual narrow linear cause-and-effect perspective. Nevertheless, systems approach supplements rather than replaces analytical thinking (Schoderbek et al., 1980). Thus existing knowledge about the system under study are all still very relevant.

The systems approach finds ready applications to socio-technical systems. It is particularly a method of choice where a system comprises multiple interdependent components, multiple feedback processes and non-linear relationships. It is good for highly dynamic systems and systems that require the use of both 'hard' and 'soft' data (Kummerow, 1999; Ogunlana et al., 1998). The discussion in this chapter is committed to the description of this approach. The next section (section 4.2) provides a discussion of systems dynamics concept. In section 4.3, the steps to develop system a dynamics model is presented. This is followed by a discussion on the challenge with data in SD method in section 4.4. Section 4.5 concludes the chapter.

4.2 System dynamics concept

System dynamics (SD) is a representation of a systems approach. It reflects the fundamental principle that the structure of a system gives rise to its behaviour. It is founded in the theory of nonlinear dynamics and feedback control, but also employs psychology, economics, and other social sciences (Sterman, 2000). It is a field of application derived by Jay W. Forrester. Core SD method is concerned with the behaviour of a system over time in its quantitative form; this involves building a model that can mimic the observed patterns of behaviour important variables of a system exhibit. Generally, in real life systems, a system problem and its symptoms may be separated by time and space. It is also possible that the system behaves in a counter-intuitive manner. Moreover, real life systems have been found to demonstrate policy resistance and characteristics such as unpredictability and disequilibrium condition (Radzicki and Taylor 1997). In SD, a model is developed to understand how these situations emerge within a system which would otherwise be too difficult for the human mind to process (Kirkwood, 1998). Particularly, in its quantitative form the model can be used for testing decisions aimed at altering the system's behaviour in desired ways. SD models offer a transparent and easy to follow analysis by displaying maps that show the cause and effect relationships between individual system variables. It conceptualises the system as being controlled by a process of information, action, and consequences (meaning feedbacks) in order to maintain its purpose. As a result, SD has often shown to be superior to some analysis methods. As illustrated by Sterman (2000, p.185), a typical system is the "mass transit spiral death" whose analysis defied standard economic analysis. The MARS model of land-use and transport planning (Pfaffenbichler, 2003) is yet another application of systems approach which shows how the structure of a visible problem might be more difficult that what statistical analysis alone can treat.

System dynamics models (SDM) can be of two types: qualitative SD model and quantitative SDM (Coyle, 1996; Coyle, 2000; Wolstenholme, 1999). The qualitative SDM is usually referred to as causal loop diagrams. According to Coyle, (2000, p.233), there are situations where the quantitative demand for developing a quantified model cannot be met, "one should, perhaps, restrict the analysis to the qualitative level…rather than producing a model of no value". The use of quantitative SDM (usually referred to as stock and flow model (SFM)) is however more popular (Homer and Oliva, 2001; Sterman, 2000).

Notwithstanding the benefits of SD approach, it is criticised (particularly in its quantitative form) for the significant amount of modelling assumptions required to obtain good results (Mullai and Paulsson, 2011). This criticism particularly applies to the use of soft variables. Soft variables are those variables whose measure involves greater measurement errors due to the difficulty to observe them directly or that they are multidimensional in nature (Luna-Reyes and Andersen, 2003). However, Sterman (2000) noted that most measurement in real life (for example GDP) are a proxy of their construct and so the use of proxies that are believed to be correlated with the characteristics being observed may still be valid.

SD models adopt some basic building blocks: causal loops, arrows, accumulation (stock), rate-of-change (flow), reinforcing loops, balancing loops and delays, sub-system diagram, and model boundary charts. Many of these building blocks are in use in non-system dynamics fields too. Specifically, (Perdicoúlis and Glasson, 2006) described CLDs as a type of digraph while SFDs are examples of flow diagrams. The attention here however is on how the ones related to SD are used to represent the problem structure of a system which a modeller may want to analyse. These building blocks are broadly discussed below under the themes: causal loop diagrams, and stock and flow models. This is followed by the description of the process of developing a SFM.

4.2.1 Causal loop diagrams (CLDs)

CLDs are maps that show the relationships between the components of a system in a manner such that a cause is linked to its effect(s) in a way that (a) closed loop(s) emerge. They are unique for the ability to visually display relations in a cause and effect manner as well as reveal the feedback processes within the system being represented (Kirkwood, 1998). They help to depict the basic causal mechanisms of the system, thereby providing the opportunity to "improve the process of thinking about the structure underlying a problem" (Homer and Oliva, 2001, p.349). They are able to illustrate poorly understood systems and provide insight about the system even before any form of analysis is initiated (Smith, 2000). Smith (2000) describes influence diagram (a variant of CLD) as a "sense-making" device which helps to communicate the understanding about a system. Sterman (2000,p.137) observed that CLD has a number of important functions including eliciting and capturing the mental models of individuals or teams, showing hypothesis about the causes of dynamics, and revealing feedbacks that might be responsible for a problem within the system. He went further to note that they are flexible tool and good for diagrammatically representing the feedback structure of systems "in any domain" (Sterman, 2000, p.102).

CLDs emphasize the feedback structure of a system and represent it as a map showing the causal links among variables with arrows pointing from a cause to an effect. They help “the analysis (to focus) on diagnosing problematic behaviour (rather than) the unlimited details of a system” (Homer and Oliva, 2001, p.348). Ülengin et al. (2007, p.83) observed that they represent “domain knowledge” more descriptively than other models, such as regression models or structural equation models. They also help to improve transparency (Shepherd et al., 2009). They usually consist of names and arrows with positive and negative signs attached to the arrow heads. (Bredeweg et al. (2008) called these nodes and arcs). This is represented below.

a. Balancing feedback loop b. Reinforcing feedback loop

Figure 4.1: Illustration of feedback loops

A positive sign next to an arrow head indicates that a change in the cause results in a change in the effect in the same direction. For example, in figure 4.1a above, it is shown that if population increases, the number of death increases more than it would have been if population had not changed. Similarly, if population reduces, then the number of death would reduce more than it would have been if population had been constant. Figure 4.1a represents a balancing (negative) loop, the product of the arrow signs being negative while figure 4.1b represents a reinforcing loop. CLD is usually recommended as a precursor to developing a SDM (Homer and Oliva, 2001).

CLDss are however limited in application to what might be called “brainstorming”. They cannot be used to identify problem loop and may be delicate if used to support policy decision. This is because they only provide information about feedbacks within the system. They do not demonstrate the dynamics within the system or the strength of the feedbacks they indicate. They also do not provide information about system parameters, net rates, or the non-linear relationships within the system. A simulation is therefore usually required to make them more useful (Homer and Oliva, 2001).

Other tools used for brainstorming about the problem structure in SD include model boundary charts and sub-system diagrams. A model boundary chart summarises the scope of a model by listing the key variables related to the model as endogenous, exogenous or excluded variables. A subsystem diagram on the other hand shows the overall architecture of a model. These tools however provide less detail than what a causal loop diagram can offer.

4.2.2 Stocks and flows

As noted earlier in section 4.2.1, CLDs helps to depict the basic causal mechanisms of the system, thereby providing the opportunity to "improve the process of thinking about the structure underlying a problem" (Homer and Oliva, 2001, p.349). Obtaining more information from the identified underlying structure requires extending analysis beyond the causal loop diagraming to a SFM. By developing a SFM, it is possible to suggest the root cause of system problem from the simulated dynamics of the system. A SFM usually makes use of stocks and flows.

Stocks are accumulations. They have memory and create delay. They symbolise the state of the system and produce the information upon which decisions are based. Moreover, they influence the behaviour of the entire system components. In addition, the delay created by stocks often leads to a significant lag between cause and effect, often making it difficult to perceive a connection between the two (i.e., between cause and effect) (Radzicki and Taylor 1997). Flows on the other hand are rates. They can be inflow or outflow. They determine the strength of a stock and are often determined by the stock too. Sterman (2000) notes that the decisions that alter flow are influenced by stocks so that changes in flow eventually alter the stocks too, closing the feedback loops in the system. Stocks and flows trail accumulations as they travel through a system. They are responsible for the dynamic behaviour of systems. A representation using stock and flow diagrams (SFD) highlight the primary physical structure of a system (Sterman, 2000).

Stocks and flows often work such that a dynamic system behaves in an unexpected or counter-intuitive way. This is due to the non-linear relationships between the system variables. The behaviour shown by this dynamic interaction in a system can be represented with five typical graph patterns. These graph patterns include exponential pattern, overshoot and collapse, goal seeking, oscillatory, and S-shaped. Usually, these patterns are determined by which loop is the dominant one between the two loop types in a system. As mentioned in section 4.2.1, these two types of loops are reinforcing loop and balancing loop (Radzicki and Taylor 1997; Sterman, 2000).

Reinforcing loops (also known as positive loops) are loops that describe actions that create a result that further generates more of the action. In real life, these are usually connoted by virtuous or vicious circle. They lead to the growth or decline of systems.

They sometimes work to stabilise a system, notwithstanding. Balancing loops on the other hand are called negative loops or goal seeking loops. They generate results that move the system towards a goal or towards maintaining a desired state. They can occasionally destabilize a system and cause them to oscillate (Radzicki and Taylor 1997). Both reinforcing and balancing loops are used in CLDs and SFMs.

4.3 Developing a stock and flow model

Table 4.1: Steps to building a SDM

(Luna-Reyes and Andersen, 2003, pp.276-278)	**(Radzicki and Taylor 1997)**	**(Sterman, 2000, p.86)**	**(Harris and Williams, 2005, p.3)**	**(Hwang and Hu, 1999, [no pagination])**	**(Albin, 1997)**
Conceptualisation	Problem Identification	Problem articulation	Identity a problem/an evaluation question	Conceptualization	Conceptualisation
	Develop hypotheses	Dynamic Hypothesis formulation	Develop a dynamic hypothesis		
Formulation		Formulation of Simulation Model	Build a model of the system	Formalization	Formulation
Testing	Test hypotheses	Testing	Ensure the model reflects the behaviour as seen in the real world		Testing
			Evaluate the model to see what insight it gives		
Implementation	Test policy alternatives	Policy design and Evaluation	Draw conclusions from these insights	Building a micro-world	Implementation

(Source: author: information is extracted from the literature shown in the first row of the table)

The development of a SFM helps to identify critical feedbacks and problem causes within a system. Identifying these critical feedbacks makes it possible to depict system behaviour and check what is amenable to changes. This process involves some steps. These steps include formulation of the problem, construction of a mathematical model, derivation of solution from model, testing model and solution, establishment of control over the solution, and putting the model to work (implementation) (Shepherd et al., 2009). These steps are generally accepted in SD literature, though their description varies. For example, (Luna-Reyes and Andersen, 2003) identified four broad steps to building a SDM. These four steps are conceptualisation, formulation, testing and implementation. While these four steps provide a simple guide, several authors have come with different number of steps, each trying to emphasise one aspect or the other. Table 4.1 compares the concepts of some authors about these steps. The concept provided by Luna-Reyes and Anderson (2003) is a convenient guidance for exploring the process of developing SDM. Nevertheless, representing the conceptualisation stage by Sterman's two-steps process is useful. These steps and the understanding about them is discussed in this section.

4.3.1 The Conceptualisation stage

This is the stage at which the problem to be tackled is identified. Questions that are normally asked include "What is the problem? ... Why is the problem? … What is the historical behaviour of the key concepts and variables?" (Sterman, 2000, p.86). This stage requires accessing all manner of available information about the problem. This includes qualitative and quantitative data (Luna-Reyes and Andersen, 2003). Because all forms of available data can be useful, there are several methods of collecting these data and extracting useful information for them (Hwang and Hu, 1999; Andersen et al., 2011; Richardson and Andersen, 1995). In addition, model boundaries are identified too (Albin, 1997; Sterman, 2000). According to Sterman (2000), this stage involves clearly stating the problem and its structure as well as generating an explanation for this structure. It is usual to develop a map of this structure at this stage. The map structure should contain the hypothesis about the structure of the system and about the reference modes known to the stakeholders about the system. It is a hypothesis because it is provisional and subject to revision or abandonment as the modelling process continues. A reference mode, on the other hand, is a graphical illustration of the trend of important parameters in a system, especially, as known to stakeholders. Some modellers do suggest that developing the appropriate conceptual model for a problem (especially with the use a graph of causal representation) is often adequate in some instances for the purpose of learning (Coyle, 1998; Wolstenholme, 1999). Others however argue that the information provided by this stage is not adequate for policy decisions and insists that going further with the analysis into a quantitative model is always better (Sterman, 2000; Homer and Oliva, 2001). Notwithstanding both CLDs and SFMs are in use in SD today.

4.3.2 The Formulation stage

All models are wrong. Some are however more useful than the others (Sterman, 2000). The fact that some are not so useful was noted by (Shepherd et al., 2009) who find that policy makers often find models to be complex and view it as black box with their predictions often being unreliable and so having limited/ restrictive applicability. However, models can be enhanced when they are able to “automatically construct a form of narrative account of the policy test output based on the model mechanisms” (Shepherd et al., 2009, p.287). The formulation stage of the model building process is the stage that helps transform the conceptualised map from the first stage of this process into such model. Albin (1997) notes that this is the stage where feedback diagrams are converted to level and rate equations. Sterman (2000) described this stage as where the structure and the decision rules governing it (the structure) are specified. In addition, it is the stage where estimations are made for the parameters within the system structure, the behavioural relationships as well as the initial conditions for parameters. Feedback diagrams are also converted to level and rate equations. This stage too relies on both quantitative and qualitative data.

4.3.3 The Testing stage

At this stage, the model is now developed, though far from being complete. Measurement systems are imperfect: while hard variables would normally have little error, “soft variables usually have more. This is due to difficulty in measuring them thus requiring that such variables be measured with multiple proxies that are correlated to them (Luna-Reyes and Andersen, 2003). In SD, lots of this soft variables form part of the model developed. Testing stage is therefore always an important part of the model building process. (Diker et al., 2005) describe this “validation” process as a process of raising the confidence of users in the model relative to its intended use. The stage involves checking model behaviour against the initially identified reference modes and model assumptions. The model is also tested to assess its behaviour under extreme conditions. This stage involves testing model’s consistency with its purpose and pre-defined boundary (Sterman, 2000). Other tests that can be conducted include structural assessment, parameter assessment, boundary adequacy and sensitivity tests (Sterman, 2000; Albin, 1997; Barlas, 1989; Barlas, 1996; Qudrat-Ullah and Seong, 2010). Luna-Reyes and Andersen (2003) pointed out the importance of the use of both qualitative and quantitative data at this stage.

4.3.4 The Implementation stage

This is the last of the four stages. “Policy testing using simulation approach allows for compressing dynamics that would otherwise take place over a longer period of time, thereby overcoming some traditional barriers to successful learning in” a system (Spectora et al., 2001, p.534). The opportunity to reflect on the possible outcomes of decisions which SD offers is useful in helping stakeholders to gain practice and experience that would normally be more expensive in real life situations (Spectora et al., 2001, p.524). The implementation stage involves the use of “what if” conditions to check model behaviour under various scenarios. A scenario “puts forward a number of different alternative futures, each of which is possible and focuses less on predicting outcomes rather than understanding the forces that may eventually compel an outcome” (Ülengin et al., 2007, p.85).

However, SD is an iterative process (Graham, 2002; Andersen and Richardson, 2010). So, it is possible at this stage to identify flaws in the model which might necessitate returning to previous stages to correct the errors and improve the model. Eventually, when the model is able to offer enough confidence, insights can be translated into accessible form for learning (Albin, 1997). Nevertheless, a model is a decision support tool; it should be intended for use to support decision making process, not replace decision making process (Shepherd et al., 2009, p.293).

4.4 Data use challenge in system dynamics modelling

An important aspect of the four steps discussed above is the extraction of qualitative and quantitative information for the model building process. The model building process usually requires the complementary knowledge from various stakeholders in defining the system, identifying the problem and building a reliable and useful model. This makes both quantitative and qualitative data relevant to the process. This information elicitation process is, however, the most controversial aspect of SDM building (Coyle, 1998). While quantitative data extraction process is straight forward, it is not so with extracting qualitative data and using it in SD. Nevertheless, Luna-Reyes and Andersen (2003) show that while SDMs are mathematical representations of problems and policy alternatives, most information available to the modeller is qualitative in nature. Similarly, (Forrester, 1991) emphasise that it is not best to focus on measured data for developing a model while far richer and more informative body of information available with active players in the system are neglected. Furthermore, (Sterman, 2000, p.854) warned that “omitting structures or variables known to be important because numerical data are unavailable is actually less scientific and less accurate than using your best judgement to estimate their values”. This “judgement” are often based on qualitative information available to the modeller, including the use of proxies to measure multidimensional constructs (Luna-Reyes and Andersen, 2003). These references point to the importance of this less accessible model requirement. The case is therefore not as much as the appropriateness of qualitative data; rather, it is the appropriateness of how qualitative data is obtained and used. This fuzzy situation with qualitative data in SD might be responsible for why it is more popular to regard SD modelling process as an art more than science (Andersen and Richardson, 1997). The fuzziness also account for the reason why Luna-Reyes and Andersen (2003) observe that there is the lack of an integrated set of procedures in the modelling process, especially as it relates to using qualitative data.

However, there is now an increasing loudness in the voice of those who think SD should be scientific (Graham, 2002; Luna-Reyes and Andersen, 2003; Yearworth and White, 2013). This might be partly due to the increasing adoption of SD in research works where transparency and systematic presentation of process is required. The SD team at the University of Albany were the first to respond to this challenge. A method, typically a variation of focus group, known as group model building (GMB) was developed (Richardson and Andersen, 1995). This method is popular and widely used (Andersen and Richardson, 1997; Andersen and Richardson, 2010; Carhart and Yearworth, 2010; Luna-Reyes et al., 2006). As reported by Andersen and Richardson (2007) GMB is a developing but established problem structuring method for developing SDM with clients (or stakeholders) and using qualitative data. This method which has been experimented using many techniques has evolved an approach detailed in both the structure and the process involved. This “structure and process” is described as “Script”[9] (Andersen and Richardson, 1997). Scripts are “planned and rehearsed” routines for accomplishing set goals in the course of a group model building workshop (Richardson and Andersen, 1995, p.130). These scripts are recommended for use to help attain a standard modelling practice in SD modelling (Andersen et al., 2011). Using GMB script, however, relies on skills developed over time by the practitioner.

[9] Script as a term is not limited to GMB method. Since it is a data collection instrument, it is also in use in interviewing method (for example in Luna-Reyes et al, 2005). However, there is a more formal script for GMB than for any other method.

GMB scripts do not look suitable, however, for most research works considering the requirement of its “script”. It emphasises on the need to adopt a modelling team which requires the services of three to five skilled practitioners to perform five roles which “must be present for effective group support” (Richardson and Andersen, 1995, p.351). This is a difficult challenge in any student research. There have therefore been attempts to use other qualitative research methods in a scientific manner to develop SDMs. A review of methods in qualitative research provided in chapter 3 can be useful to guide the use of qualitative data in this research.

4.5 Conclusion

This chapter describes the system dynamics approach and how a SDM can be developed. The following are of particular importance in this chapter

- Identifying the feedback structure of a complex system helps to provide useful understanding about what is amenable to changes in the system.
- The opportunity of representing the structure of a system pictorially to provide an opportunity to thinking through the interactions within the system can be invaluable.
- The additional opportunity for different scenario testing of possible future conditions this method offers makes it suitable for adoption in this research.

In addition, this chapter has pointed out the importance of using qualitative data in developing a (SDM). While it identifies the challenge with obtaining and using qualitative data appropriately, the SDM proposed for this research will draw from the information provided in chapter 3 on collecting and analysing qualitative information. A SDM of commercial motorcycle safety system and driver behaviour should therefore give significant insight into the problem of the system, just as it has given in studies of similar social-economic systems. What follows from here is a demonstration of how chapters 3 and 4 have been embraced in developing the methodology for this research. Particularly, sections 5.5 and 5.6 show how SD approach is used in this research.

Segment 2: Methodology development

Chapter 5 Research Methodology

5.1 Introduction

This chapter explains the steps taken to collect data, analyse it and arrive at the findings for each of the objectives of this research stated in section 1.2. Earlier, section 2.8 indicated that both qualitative methods and system dynamics approach are more appropriate for the research. Qualitative research methods are methods for exploring the meaning social phenomena as experienced by individuals themselves. They offer a broad understanding in social context by acknowledging the existence of multiple views of equal validity with each affording only a partial view of the whole picture (Barbour, 2001). On the other hand, systems approach posits that the interaction between the components of a system is more important than the components themselves (Carhart and Yearworth, 2010). It challenges system stakeholders to identify and understand these interactions to be able to successfully influence a system desirably. The steps followed in the process of identifying the system structure and understanding its interactions addresses the research objectives in this study. In this chapter, a summary of the methodology adopted in following these steps is introduced. Research methodology, as distinct from method, is the strategic approach adopted, rather than the technique, to guide how a researcher goes ahead to find out knowledge and carry out research. It is the plan linking the choice of methods to the desired outcome. The following discussion thus highlights the importance of each stage of the research process and shows how these stages fit with one another to achieve research aim and objectives.

First, in section 5.2, the researcher clarifies his ontological and epistemological perspective. The essence is to provide appropriate justification for the choice of methodology. Then, in section 5.3, the research aim and objectives are stated. This is followed by a description of how each of the three research objectives is achieved in sections 5.4, 5.5, and 5.6. In section 5.7, the methodology limitations are mentioned. Section 5.8 summarises the manner ethical issues and data protection are managed in the research while section 5.9 provides a summary of the chapter.

The discussion in this chapter is not a full report of these stages of the process; it is rather intended to show how one stage leads to the other and why they are important in the research. Since this chapter only gives summary information about these stages, the details of the activities involved are presented in other chapters of the thesis and referred to as appropriate under each discussion point in this chapter. A schematic representation of the order of presentation of information in this chapter is shown in figure 5.1.

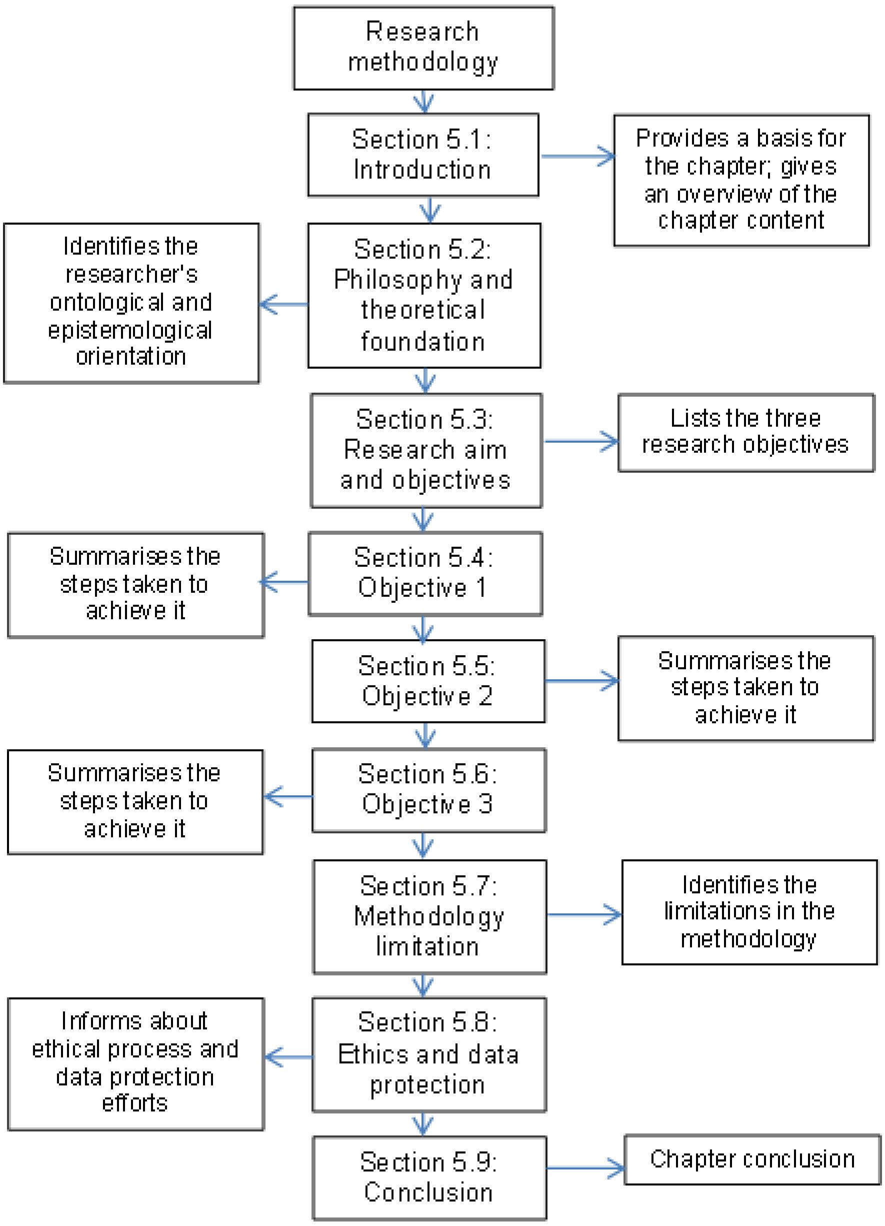

Figure 5.1: Chapter overview

5.2 Philosophy and theoretical foundation

The world is viewed differently by different people and realities are interpreted differently in different contexts. This is as a result of divergent beliefs and assumptions that human beings develop in their day to day sense-making process of the world around them. Sometimes an individual is aware of this, but in most instances, these beliefs and assumptions are hidden – they remain in the sub-conscious. Nevertheless, they are responsible for the choices, preferences and decisions an individual makes. They also affect the way of seeking to know and of knowing, and therefore the way research is conducted.

Research is a process of finding out and knowing things. It is an exercise conducted on a daily bases by man. It can be by mere sensory experience, reasoning things out or even experts' opinion. Scientific research is however more rigorous: it involves the use of scientific methods. Scientific method involves a process of testing ideas in the public arena. It provides a detailed process of investigation that can answer any question about the procedures by which conclusions are drawn. It is different from other ways of knowing which can be undependable, mistaken, based on false premises or incomplete.

In the world of scientific research, the way beliefs and assumptions are made about problem and their solution, known as paradigms can be broadly divided into two, joined together by a continuum. These are subjectivism/interpretivism paradigm and objectivism/positivism paradigms. The subjectivist sees reality as a projection of human imagination. He posits that knowing is personal and tacit, and is based on individual experience (Guba and Lincoln, 1994). On the other hand, the objectivist understands reality to be "concrete" (Guba and Lincoln, 1994, p.110) and asserts that knowledge is universal, independent of the observer (Hirschheim et al., 1995) and real in terms of observable similarities, laws and patterns (Lakoff and Johnson, 1980). In this way, these two paradigms are at the extremes. However, lying in between these extremes are views that have a mix of both. These include critical realist and post positivism.

In research, paradigms adopted in viewing a problem and attempting to proffer solutions are characterised in the way the following questions are answered: What is reality? (i.e., ontology) How do you know something? (i.e., epistemology) How do you go about finding out? (i.e., methodology). Ontology relates to the view that is held about the nature of reality (Uschold et al., 1995). It is the researcher's understanding of what constitutes reality and how existence can be understood. It is the articulate "nature and structure of the world" (Wand and Weber, 1993, p.220).

Epistemology, on the other hand, is the researcher's understanding of what constitutes valid knowledge and how it can be obtained. It is about the researcher's relationship with the knowledge being discovered / uncovered. It tells what the researcher's position is on whether he is part of the knowledge or external to it. This is what frames the researcher's interaction with what he is researching and is the outcome of his ontological view (Annells, 1996). So both ontological and epistemological orientation of a researcher shapes his worldview. This view (or philosophical stance) dictates the theoretical perspective of his research and informs the methodology to apply while providing the context for its logic (Annells, 1996).

The current research is an attempt to explain how and why the operation of commercial motorcycle is not safe. It is particularly interested in factors that interact with one another within the operation of this transport to shape its characteristics and generate its pattern of behaviour – a positivist view. It also believes that the required knowledge can be jointly constructed and that the mental models of stakeholders in the operation of commercial motorcycles can help to understand these factors and their relationship to one another better – a subjectivist view. As a result, the researcher's standpoint with respect to addressing these issues is that of an ontological mid-point between positivism and subjectivism/interpretivism. Annells (1996) describes it as post-positivism. According to her, the postpositivist asserts that reality exists and can be probabilistically captured. A postpositivist "pursues an accumulation of knowledge through modified experimental research and hypothesis falsification". He concedes that emic viewpoints collected through qualitative research can be valuable (Annells, 1996, p.384). This view is what is adopted in both approaches (qualitative methods and system dynamics) used in this research. This view of the world adopted by the researcher agrees that these approaches offer a more complete understanding of complex systems. This is more so as both approaches agree that mathematical methods that operate at a high level of abstraction may not be sufficiently enlightening since mathematical models may only be able to analyse a narrow portion of reality. These approaches however considers the whole picture, the emergent properties and other relationships between parts of a whole (Lane and Oliva, 1998).

The essence of this chapter is to describe how this ontological and epistemological stance is shown in the process of data collection, analysis, and generation of results for this research – i.e., the methodology.

5.3 Research objectives and expected outcome

Table 5.1 below is an overview of the expected outcome of each of the objectives.

Table 5.1: Overview of objectives and information sources

	Objective	Expected result	Information source
1	Objective 1	List of factors and how they are related	Semi structured interview; Observation; Literature review
2	Objective 2	Causal loop diagram	Outcome of first objective; Additional interviews; Literature review
3	Objective 3	Stock and flow model	Outcome of first and second objectives; Additional interviews; Literature review

The table also shows sources of information for achieving the objectives. As discussed in section 1.2, the aim of this research is to generate a system understanding of commercial motorcycle safety problems. The objectives pursued are:

1. Identify factors that influence safety in commercial motorcycle operation and their relationship with one another.
2. Describe how these factors generate drivers' safety characteristics using a causal loop diagram.
3. Formulate a quantitative system dynamics model that can help in understanding the process of regulating commercial motorcycle operation with respect to drivers' characteristics.

Sections 5.4 to 5.6 describe the technique/logic followed to achieve the objectives.

5.4 Objective 1:

<u>Identify factors that influence commercial motorcycle safe operation and their relationship with one another</u>

The first objective requires that influencing factors within commercial motorcycle operation with respect to safety are identified. The steps followed to identify these factors are presented in this section. Starting from literature review, it describes the process followed to eventually obtain a list of these factors and their relationship to one another. The results from these steps are used further in addressing the other two research objectives.

5.4.1 Literature review

This research process involved a broad literature review. According to Stake (1995) document reviews provide an opportunity for researchers to obtain clues and findings from records of activities the researcher cannot observe directly. First previous studies on commercial motorcycle operation were reviewed. This process treated more than 100 studies on commercial motorcycles. As reflected in sections 2.2 to 2.5, this step helped to gain insight into what has been studied and found about commercial motorcycle operations. These sections also provide insight into methods that have been previously used in these studies and how these methods may/ may not be useful in the current research. The review of literature extends beyond commercial motorcycle in section 2.7 to look at research methods in safety in general. The discussion in section 2.7 leads to the choice of qualitative methods and systems approach for this research. Following from this, a review is conducted on the use of qualitative research methods and system dynamics approach and reported in chapters 3 and 4 respectively. Of particular contribution were the texts by Miles et al. (2014) and Sterman (2000). While chapter 3 provides an array of choices for qualitative research, the final decision on what qualitative research method is adopted in this research is justified in the discussion below.

5.4.2 Data collection method

There are several methods that can be appropriately used for data collection in qualitative research. Section 3.3 described a number of qualitative data collection methods as found in (Curry et al., 2009; Luna-reyes et al., 2005; University of surrey, [no date]). These methods include interviews (Ree et al., 2011; Luna-Reyes et al., 2005), review of literature and documents (University of Surrey, [no date]; Struben, 2009; Liu, 2006), oral history, observations, and experimental approaches (Luna-Reyes and Andersen, 2003). In this research, interview method is chosen for extracting qualitative data and is supported with literature and document review and "hindsight observation". The basis for this choice is numerous. First, methods such as group model building (GMB) or focus group discussion is not appropriate for this research. The inappropriateness stems from its requirement of (in the case of GMB) 3 to 5 facilitators for group coordination which cannot be met in a one-man PhD research. In addition, conducting separate interviews for different groups separately is preferred to a GMB in this research that concerns different and unfriendly groups. It particularly made it possible to collect unbiased, group specific information (such as the opinion of drivers about the police) that would not be easy with a GMB or a focus group discussion. Using a focus group meeting (such as Group Model Building (GMB)) would be difficult in this instance. Furthermore, the use of interviews is considered better than focus group/ GMB process which might not have guaranteed efficient facilitation of respondents enough to prevent group anchoring[10] as Luna-Reyes and Anderson (2003) notes (described in section 3.3.2). This is more so as the researcher is new to the application of qualitative methods. Kirkebøen (2009) reveals that when group conclusions are outcome of deliberation, the quality of such conclusions is often not impressive - particularly due to the possibility of group anchoring. These reasons make focus group less appropriate.

Interview is also better than Delphi group method as it has been shown that it is not always possible to reach a fair consensus with Delphi group (Okoli and Pawlowski, 2004). In addition, it has also been shown that the result of consensus is often by

[10] Anchoring refers to a situation where one or two individuals in the group shape(s) the thoughts of the rest.

"group pressure to conformity" rather than by being objective (Woudenberg, 1991, p.131). Section 3.3.3 also noted that Delphi method can help to propagate and preserve vested interest. Lastly, participant observation method costs more and requires more time than what this research can afford. It was however used by the researcher by recalling his previous experience with commercial motorcycle operation. Interview is the main method adopted.

5.4.3 Interview method

Interviews can be structured, semi-structured, or unstructured interview. Semi-structured interview method was chosen for this research due to its numerous benefits. In the first instance, its semi structured nature gives respondents the freedom to cover broad themes within the discussion (unlike the case with structured interview) (Mason, 2002). It nevertheless confines the themes raised to relevant issues (unlike what obtains with unstructured interview). As shown in section 3.3.1, this benefit is corroborated by Luna-Reyes and Anderson (2003) who notes that this method provides a balance between structured and unstructured interviews in that the researcher starts with a set of questions and allows the respondent to offer a broad view in his response. In addition, this method is open-ended, allowing questions to come from responses and yet focussed (Barriball and While, 1994). Similarly, this method can make up for a novice. Hoffman (1987, p.55) noted "that the novice interviewer might be better able to ask questions about ideas or procedures which an expert tends to leave implicit or take for granted". A novice interviewer may therefore not be completely at a disadvantage unlike, for example, the GMB method. Following the decision on the method for data collection, the next phase was to develop the interview questions.

5.4.4 Developing interview questions

This research process involved a stage where the researcher attempted the development of causation in commercial motorcycle operation deductively. This process involved diagrammatically expressing the researcher's understanding of the causal structure in commercial motorcycle system based on the literature reviewed. This process generated different causal structures for commercial motorcycle system and led to developing some initial questions for the purpose of extending the emerging causal structure. However, it was later decided that a more appropriate approach would be to obtain the mental model of stakeholders on the operation of commercial motorcycles with respect to safety and inductively generate the causality. As noted in section 4.3, extracting sufficient qualitative data is essential to a rich outcome; extracting the mental model of stakeholders should be more appropriate than using stakeholders the complete or legitimise the researcher's mental model. This is more so as the objective here is to obtain factors of influence in commercial motorcycle safety. Very broad and varied information sources are therefore thought more appropriate for a rich outcome. The other important reason for the change to the way the interview questions were developed is the outcome of the pilot survey. This is discussed in section 5.4.6.

As a result of the above, the interview questions were developed following the research objectives. This is made convenient by the opportunity that semi-structured interview method offers – where the questions only provide a guide but allow respondents to introduce as many themes as they think are relevant. Mason (2002) recommends that it is appropriate for questions to be mapped out in this way. The interview questions are shown in appendix 1 of this thesis.

Finally, the nature of the interview questions partly influenced the decision on who respondents should be. This is more so as identifying and obtaining appropriate respondents is central to the outcome of data collection process and the research at large. The process through which this was achieved is discussed next.

5.4.5 Stakeholder choice

The research adopted maximum variation sampling techniques (Coyne, 1997) described in section 3.5.6 to select respondent groups from the stakeholder list (shown and described in section 7.2). The list of the respondent groups is divided into three divisions: the operators (drivers), enforcement agencies, and experts (academics researching on commercial motorcycle operation and health workers). Two groups: the user group and the other-road-users group were however not included as respondents. This is because respondents from the three groups identified could double as users and/ or other-road-users so that recruiting for these last two groups may not offer substantially different views. More importantly, the number of groups and of participants was chosen to balance the need to adequately represent all stakeholders as well as cater for the limited research funds and time available for fieldwork.

The identification of appropriate respondent groups from the list of stakeholders prepared the researcher for the actual data collection phase. However, prior to the data collection exercise, a pilot test of the process was conducted. This was necessary for two main reasons: to practice the art of conducting interviews and learn from the experience and; to know what can be anticipated on the field.

5.4.6 Pilot testing the interview process

Having decided to use semi- structured interview method to collect data for this research, a pilot test was conducted in Leeds in September, 2012. This was done to provide an opportunity to learn the process involved in interviewing as well as to compare the researcher's understanding of commercial motorcycle operation based on literature review with what users know. Four interview sessions were held with six Nigerian studying in University of Leeds who have previously used commercial motorcycle transport. The questions used were developed to cross-check the researcher's causal structure previously developed (mentioned section 5.4.4) and specify it for model building. The researcher found out that it was difficult for respondents to answer many of the questions simply because they have no answer to the questions. This exercise was useful; it particularly reinforced the need to allow respondents to respond freely and "flow". According to Rubin and Rubin (2005), it is important that interview questions stay as close as possible to what interviewees know and are willing to talk about to obtain a fresh and credible response. To avoid a repeat of the constrained response during the actual exercise, the researcher opted for more general questions relating to the research objectives. This contributed significantly to the need to change the original questions as discussed in section 5.4.4. Nevertheless, as insisted on by Mason (2002), a guide was prepared for the final questions.

5.4.7 Field work process

The actual survey took place between October and December, 2012. All the stakeholders groups previously identified were contacted. However, it was not possible to identify anyone in the expert group before the survey exercise began. The snowballing sampling technique described in section 3.5.6 was later employed in contacting the respondents from this group. Moreover, the availability of the respondents constrained the survey. The original survey design was to meet more than one respondent from each of the respondents' divisions (listed in section 7.2) and to meet expert and enforcer groups' respondents three times each. But it was only possible to meet most of them just once. Eventually, 16 contacts were made with the three divisions of respondents. The details of the data collection process are presented in section 7.3.

5.4.8 Secondary data use

In addition to capturing the mental model of stakeholders, a broad review of literature was done to, as much as possible, ascertain, extend, validate, or contest the concepts introduced by stakeholders in the course of the interviews. This was necessary to ascertain that the “effects” linked to a “cause” by stakeholders are founded in the literature rather than being mere speculations, thus providing an opportunity for “triangulating” data in the research. This process is reported in chapters 8 and 9. Nevertheless, the absence of an identified relationship in the literature did not invalidate such relationship as discussed in section 3.5.2 (Mays and Pope, 2000; Barbour, 2001). The actual exercise conducted was “crystallisation” rather triangulation. In addition, the review of literature also helped to fill gaps and/ or extend concepts raised by the stakeholders. In this way, both primary and secondary data were used in generating qualitative data required for the identification of factors and the subsequent development of their relationships (especially quantitative relationships) with one another.

5.4.9 Data preparation, analysis and outcome

The survey yielded large amount of qualitative data. To proceed with the research after the survey, a systematic form of analysis of collected data was required. The analysis method chosen is content analysis method described in section 3.4.1 using Burnard (1991) guideline. This choice of this guideline is based on the fact that Burnard is one of the few authors who gave a detailed step-by-step guideline for analysing interview data. Other authors often mix up the steps or describe them in a less sequential manner compared with Burnard. (For example, Miles et al., 2014 *overview of qualitative data analysis processes* on page 340 is less structured and difficult to follow). The steps were, however, modified by the researcher as shown in figure 8.1.

To follow the guideline, the data required some preparations. (These preparation stages are described in sections 8.2 to 8.4) First, the recorded interviews were transcribed. The transcription process also involved translating some of the interviews granted in the local language to English language for uniformity during analysis. Twinn (1997) recommendation as described in section 3.5.4 is followed in doing this. This preparation process made the data ready for analysis. Details of how the data analysis was done are provided in sections 8.5 to 8.7.

Usually, data analysis is informed by the approach adopted in a qualitative research. It was not possible to conduct data collection and analysis together in a manner that reflect grounded theory approach. This was due the remoteness of the study location. Thus phenomenological approach was adopted. As shown in section 3.2.2.2, this approach is similar to grounded theory in its use of inductive approach. In addition, in some way similar to grounded theory, data analysis started before the data collection process ended as some latter interviews were informed by the review of earlier interviews conducted. (Details of the data collection process are provided in section 7.3). The full data analysis was eventually conducted using content analysis method to obtain a systematic coding process.

Using content analysis approach, codes were generated from the interview data. NVivo software helped to provide a platform for arranging and storing the codes as they were generated. Saldana (2013) describe a code as a symbolically assigned word or phrase to capture (the essence, summation or attribute of) a language-based or visual data. This coding process was done to address two issues: factors affecting commercial motorcycle safety and; relationships between these factors. Both are reported separately. The coding outcome for factors affecting safety is reported in section 8.6.1. The relationships among these factors are reported in sections 8.6.2 to 8.7.2. Specifically, section 8.6.1 lists the factors identified from the data while section 8.6.2 lists all links between any two factors as identified in the data. Both sections 8.6.1 and 8.6.2 are the data analysis outcome while section 8.7 presents the researcher's interpretation of this analysis outcome. Thus section 8.7.1 presents themed reflections on the analysis based on the literature while section 8.7.2 shows how these factors are related using a causal network.

It should be noted that at the completion of the coding process for the relationships within factors, a huge number of codes were generated from the analysis. Unlike "pattern coding" described by Miles et al. (2014, p.86) where codes might be grouped into "a smaller number of categories", this analysis is not intended to reduce the number of categories. All codes were listed out. Nevertheless, some form of clustering was done and repetitions were removed. In addition, some element of "dross" appeared in the data. These are themes outside commercial motorcycle safety, such as criminality amidst commercial motorcycle drivers. These were coded but ignored in subsequent analysis and in the thesis.

5.4.10 Generation of graphical displays and a causal network

Codes related in the analysis are shown by linking them together with the thematic heading they relate to. A pictorial view of this linking is called graphical display in this research. They are however different from a causal network. As noted in section 5.4.9, the researcher's reflection on the data generated a causal network. This is shown in section 8.7.2 (while graphical displays are used in section 8.6.1). As demonstrated by Miles et al. (2014), causal networks are a good representation of the outcome of data analysis and can be useful for the generation of theories. The process of developing this diagram involved joining together all causal fragments[11] previously derived from causation codes and refining them to obtain the researcher's emerging map of what is happening in the data and why. Because this process is the researcher's understanding of the data, both the data and literature were used to develop the causal network.

Sequel to the development of the causal network, an attempt was made to generate some predictions based on the information from the data and the causal network. The process of generating predictions from the qualitative data in this research is reported in section 8.7.3.

5.4.11 Validity and reliability

Section 3.5 in this thesis describes the issue of validity and reliability in qualitative research. This research treats this issue by providing a rich description of the process through which findings are made from the qualitative data. The open nature of the interview questions allowed respondents to speak freely and credibly (Rubin and Rubin, 2005). The variation in the stakeholders groups consulted helps to extract diverse views about the study theme. The rigorous qualitative data analysis process followed and detailed out in chapter 8 helps to improve the reliability of the findings. This was further strengthened by the fact that the researcher maintained contact with some of the stakeholders (the drivers) during data analysis to confirm the emerging themes. Finally, the fact that data used in this research is compared across various sources, and shared with colleagues for review and criticism, provide a form of "triangulation" or rather crystallisation that enhances the research outcome. A brief reflection on this is presented in sections 8.8.

5.5 Objective 2:

> Describe how these factors generate drivers' safety characteristics using a causal loop diagram

By the time answers have been provided to treat the issues raised by the first research objective, the ground work was fully laid for addressing the other objectives. With respect to the second objective, the step required is a reflection on the findings for the first objective. The goal is to represent the factors identified under objective 1

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[11] Causal fragment is described in section 3.4.3.1 as a combination of causal chains. Multiple causal fragments can be brought together to form the complete picture. This complete picture is a causal network

as a CLD structure that represents the high-risk behaviour characteristics of commercial motorcycle operating system. This section provides a brief introduction into the process while chapter 9 describes the full process.

5.5.1 Developing system causal loop diagram

The causal network earlier derived does not produce any definite hypothesis about the structure of the system problem except it is further processed (for example, as is shown in section 8.7.3). This is partly because it shows everything to be important and connected to everything; it is not able to show what is more important or why it is. Moreover it does not show any dynamic characteristics (such as delays, feedbacks, etc.) for the system. The goal of the second objective is however to represent the system structure with a CLD. A CLD is a representation of dynamic hypothesis (i.e., a representation of the dynamic characteristic of the problem structure in a system). What is required then is to identify the problem structure within commercial motorcycle system. The causal network is nevertheless useful as a premise for the identification of this problem structure and its feedback loops.

The basis for using the causal network to develop a CLD is justified by Goh et al. (2010) who says that causal loop diagrams cannot work in isolation from other traditional investigation and causal analysis tools. Both causal network and CLD are similar in the use of causal links but they are different from each other: a causal network is similar to “problem articulation” in SD while a CLD represents a system problem’s dynamic hypothesis. According to section 4.3.1, the conceptualisation phase of the system dynamics method can be represented with two steps. These are problem articulation and formulation of a dynamic hypothesis. Problem articulation allows a modeller to know what to cut out of the model. It helps to understand the purpose of the model. According to Sterman (2000, p.90) this step can be realised through the development of the “initial characterisation of the problem through discussion with the client team, supplemented by archival research, data collection, interviews, and direct observation or participation.” This step can be likened to the techniques in objective 1. It included literature review, data collection, and data analysis. Goh et al. (2010, p.308) called it the process of identifying the “facts of the case and the key causal factors systematically”. It is however different from the other step - formulating a dynamic hypothesis. Therefore, while problem articulation identifies the problem and its characteristics, a dynamic hypothesis (represented by a CLD) identifies the dynamics of the problem characteristics.

By using the narrative provided for the causal network and the causal network, nine problematic relationships which are the key driver of the system behaviour were identified. These are listed in section 9.2. The identified feedback loops associated with these problematic relationships are eventually developed into a CLD to reflect the cause of risk taking behaviour in the operation of commercial motorcycles. The detail of this process is provided in section 9.3 of this thesis.

With the generation of the CLD which doubles as a representation of a dynamic hypothesis for the problem structure in the commercial motorcycle drivers' high-risk behaviour characteristics, the second objective is achieved and the stage is set to respond to the third objective.

5.6 Objective 3:

> Formulate a quantitative system dynamics model that can help in understanding the process of regulating commercial motorcycle operation with respect to drivers' characteristics

This third objective follows from the second. While a system dynamics model can be qualitative or quantitative, the requirement of this objective necessitates a quantitative system dynamics model (i.e., a stock and flow model). This is because, as shown in section 4.2.2, a qualitative system dynamics model cannot be reliably used to understand the consequence of interventions in commercial motorcycle safety system; it can only give the structure and not the behaviour of the system. As noted by Homer and Oliva (2001) a CLD helps in the process of thinking through a problem structure. But the actual system behaviour can only be known through a simulated quantitative model.

Developing a quantitative system dynamics model in this research necessitated turning the CLD obtained in the second objective to a quantitative model that can promote learning about the system. This section summarises the process through which the CLD is transformed into a stock and flow model in the course of the research. It should be noted, however, that the intention of this research is to offer an architecture that can be further developed, calibrated, and implemented for policy evaluation. This further work is a huge exercise that require more time and resources than is available in this research. What this model is expected to do, therefore, is to offer a tested structure for full development in future. Starting with a reminder on the justification for the choice of a system dynamics model, it summarises the step by step process to model development.

5.6.1 Stock and flow modelling choice

Section 4.2 gives the description of system dynamics approach. Its choice as one of the approaches for undertaking this research is justified in sections 2.7.4, 2.8 and 4.2. As noted by Pfaffenbichler (2011), the transport system is characterised by hidden feedbacks with time lags which can be better treated using the system dynamics approach. Other reasons include the limitation in the availability of data in the study location and; the need to use both qualitative and quantitative data, particularly in a manner that makes up for inadequate quantitative data. These reasons and those given in earlier sections make a stock and flow model a good choice for realising this third objective.

5.6.2 Model conceptualisation and generation of dynamic hypothesis

This objective of the research leans on the other two. The steps followed in achieving the first objective of this research helped to conceptualise the system dynamics model. As is shown in section 5.4, the problem definition was defined through the identification of the factors of importance in the system. Section 5.5 indicates that the identification of feedback loops within the system through a process of reflection helped to define the system boundaries for the problem context. The resulting CLD provides an understanding of what stakeholders need to know about the system as well as a basis for a stock and flow model to be developed in the research.

It must however be noted that because the identification of these problem structure took place during data analysis (after data collection), it was not possible to obtain appropriate reference modes for all parts of the dynamic hypothesis. The reference modes that were eventually used and how they were obtained is presented in section 10.9.2.

5.6.3 Data collection for stock and flow model

Both qualitative and quantitative data was required for this model building. The qualitative aspect has been treated under the first objective. Quantitative data, on the other hand, was more difficult to obtain. This is because commercial motorcycle operation is informal and there were no reliable official statistical data available: some offices were consulted to request available information about this mode. Some of the information obtained included report of previous regulation laws, data on the trend of motorcycle accident and new motorcycle registration trend. But these data are too inconsistent or too short for use. For example, accident statistics from the hospital record and traffic department shows different trends. Also motorcycle registration trend was available for about four year, with different conditions of registration within the four years period. Thus, measurements of variables were taken from different sources including literature, interview data, and best guess/estimates. The use of literature is considered appropriate for this research in the chosen study location based on the previous findings of other researchers. For example, Olawole et al. (2010) finds that motorcycle characteristics are similar across the Nigerian administrative states he selected in his study (which included the study location). Similarly, the use of qualitative data and informed guesses is not unusual in system dynamics approach. According to Ford and Sterman (1998, p.313), as good as quantitative data is, it does not tell everything. It further notes that even where numerical data is available it is usually seen as the "narrowest" form of knowledge in scope when compared with mental and written knowledge sources[12]. This, according to them is because numerical data often is "lacking in supporting contextual information about the structure that generated the numerical data" (Ford and Sterman, 1998, p.313). Finally, in supporting the use of informed guesses, Luna-Reyes et al. (2005) noted that system dynamics not only requires the intense use of qualitative data but also human judgement. The measurement for the variables therefore varied from factual to subjective quantities. Extensive model testing was therefore carried out to assess model usefulness.

5.6.4 Development of stock and flow model

This phase leads to the development of the stock and flow model based on the dynamic hypothesis previously generated. The development of the stock and flow model for this system is an extended form of analysis of the research data. In this research, formal models of generic archetypes[13] are not used for translating the CLD into a SFM. This is particularly due to the acknowledged difficulty and ambiguity in translating archetypes to SFM[14] (Lane, 1998; Dowling et al., 1995). As a result, a more common method is adopted (Ventana, 2007). This is an iterative approach

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[12] This is not intended to undermine the added benefit obtaining good quantitative data would offer. It simply implies that other data types can be useful too.

[13] This research does not describe system archetypes. For additional information about archetypes, see Senge (1990) who describes nine generic system archetypes and Wolstenholme and Corben (1993) who describe how Senge's nine archetypes can be reduced to a set of four. Also see the following for more: Rehak et al. (2006), Wolstenholme, 2004

[14] Lane (1998, p.944) notes that there are effects/behaviours archetypes are not able to represent because of "the loss of the distinction between stocks and flows". Similarly Dowling et al. (1995, pp.454, 461) acknowledge the difficulty in identifying stocks and flows in their bid to convert archetypes to a SFM. Furthermore, Richardson (1996, p.8) says "…many practitioners would find it difficult to build formal models of the archetypes".)

which involves progressively developing the SFM in small incremental bits and testing and verifying the behaviour of the emerging model to identify potential gaps. This explains why some variables which do not appear in the CLD are added to the SFM. The use of unit checks also assisted in this process as a failure in unit check often indicates a missing part or a wrong combination of variables.

Specifically, this process involves representing the relationships between system parameters with equations and specifying their initial conditions. Some reference modes are used to provide a guide for expected system behaviour. The details of this process are presented in sections 10.6 to 10.8. Finally, Vensim modelling software is used in the process. This choice is premised on the fact that Vensim is readily available and provides user-friendly support when learning to build a model with it. The software is also useful for its ability to represent and formalise complex systems explicitly in a manner they can be easily communicated to laymen as well as experts. Some basic modelling rules are followed. These rules are listed below.

5.6.5 Model Control Statements

The following rules were followed in the development of the model equations and control, based on the basic requirements of a good model (Ventana Systems, 2007):

1. Dimensional consistency is one of the basic validation tests required in model building. This helps to ensure that the left and right sides of all equations have the same units. The built-in feature of Vensim software was used to conduct this test and it shows that the model passes the test.

2. Stocks cannot be negative. The only model elements that can affect a stock are the flows; no constants or any other auxiliary variables can directly lead into a stock, except for the initial value of the stock.

3. Constants are explicitly modelled as individual elements of the model; they are not embedded in the equations. This is to facilitate sensitivity tests as well as future changes without having to change the model equations

4. The choice of appropriate time step is essential to improve model accuracy. It is important that the time step is not greater than the minimum time constant in the model. In this model, the minimum time constant is 1 week and this condition is satisfied by testing for time step as low as 0.125 of a week. However, due to computation storage burden as warned in Vensim Reference Manual (2010), the results are reported with 1 (one) time step.

How model formalisation is done is reported in sections 10.6 to 10.8. The development of this model helped to realise the third objective. But this did not end the process; some verification tests are done.

5.6.6 Model testing

As noted by Sterman (2000, p.846), no model can be verified or validated because "all models are wrong". However, it is good to ask the questions: Is the model useful? Do its shortcomings matter? Answering these questions can be done by conducting some checks on the model. As noted in section 4.3.3, the usually recommended tests on system dynamics models are model structure and behaviour tests. In this research, the following tests are conducted on the quantitative model developed: structural assessment, parameter assessment, boundary adequacy, sensitivity, behaviour replication, and extreme condition tests. As noted by Diker et al. (2005), successfully passing these tests helps to see the usefulness and limitations of the model as well as build confidence in the same. The manner in which these tests are conducted is reported in sections 10.9 and 10.10.

5.7 Methodology limitation:

As previously mentioned in section 5.4.9, grounded theory approach which allows data collection and analysis to run simultaneously could not be adopted in this research. This is due to the remoteness of the study area. Nevertheless, a rigorous and clearly detailed out analysis method is used to optimise the outcome of the qualitative data obtained.

Another limitation of this research is the unavailability of quantitative data for model specification. This means that a good part of the model involves making informed and enlightened judgement. In addition, there was no active engagement with stakeholders to further test the model. While the model is found useful as shown in the tests in sections 10.9 and 10.10, the availability of more reliable quantitative data and engagement with stakeholders is necessary for a better calibration and will improve its usefulness.

5.8 Ethics and data protection in the process

Due to the high premium placed on ethical issues in qualitative data analysis, the survey was conducted under strict ethical guidance. First an application was made to the Research Ethics Committee of the University of Leeds. The application contained the research protocol (research script) which detailed all the steps that would be taken in the survey process as well as data protection issues. An approval was obtained for this ethical application before the survey was conducted. Some of the specifics of the ethical provision included ensuring informed consents and the use of pseudonyms on Consent forms by respondents. Details of these are provided in chapter 7.

Data protection is another important part of research ethics. As a result, serious care was taken in preserving the integrity and confidentiality of survey data. Since this research involved travelling outside the UK to collect data, some measures were put in place to secure the data. First, an encryption program was installed on the researcher's laptop to secure data stored on it (though this program eventually did not work). The computer was also pass-worded. Eventually, the original digital recording and transcripts were moved from the researcher's laptop to the University's secure M drive.

5.9 Conclusion

The main contribution of this chapter is the presentation and justification of the methodological approach that has been utilised in this research. Table 5.1 summarises the research objectives, expected outcome, and data sources for the research. In addition, following from the reviews undertaken in chapters 2 to 4, the basis for the choice of methods adopted is discussed. It is shown that the first research question would be answered using a qualitative approach that adopts semi-structured interview with support from literature review as data sources. It is also shown that the remaining two objectives would adopt a system dynamics approach to build on the results of the first objective and develop a causal loop diagram and a stock and flow model. The rest of the thesis (excluding chapter 6 which introduces the study location) provides a full detail of the steps taken in executing the methods adopted. In the next chapter, the background about the study location is provided. This is followed by the data collection process in chapter 7. Chapter 8 analyses the qualitative data obtained and generates a causal network while chapters 9 and 10 build on chapter 8 to develop a CLD and a SFM respectively.

Chapter 6 Study location

6.1 Introduction

As pointed out in section 5.4.5, the characteristics of the study location contributed to the choice of methodology adopted in this research. This chapter provides an overview of the study location characteristics. In addition to this role, this chapter also provides a justification for the selection of the study location. In section 2.4.1, it was shown that while commercial motorcycles operate in various parts of the world, the challenge with their management varies from place to place. It was argued that commercial motorcycle safety problem in Africa is more infamous. It was also indicated that while each of these locations would offer interesting research discoveries on commercial motorcycle operation, this study is interested in its operation in Africa with Nigeria as a case location. In this chapter, the historic perspective of Nigeria transport system is presented in section 6.2. Section 6.3 describes the selection process for the study location, while section 6.4 describes the study location: Ado Ekiti. In sections 6.5 and 6.6, the transport characteristics and transport management issues of the study location are described respectively.

6.2 Nigeria's transport system

Road transport is the main mode of transport in Nigeria today. But it did not start that way. The colonial masters in the pre-independence period who were more interested in exploitation concentrated on developing the rail system[15]. Thus, while rail lines started in 1895 and has connected the northern and southern part of Nigeria by 1927, a trunk road policy was not in place in Nigeria until 1927. However, in the post-independence period, investment in the rail sector declined and so was its share of passenger travel such that it fell from 11,288,000 passenger/annum in 1964 to about 3,000,000 passenger/annum in 2003, even though Nigeria's population more than doubled within this period. In addition, while rail network was already about 1120km in 1912, the total length has not risen beyond 3557km in 2013, 3505km of which is still on narrow gauge. On the other hand, road network which was about 45,000km in 1953 is at over 190,000km in 2013. As a result, road dominate the transport system and account for more than 90% of both passenger and freight movement. This over-concentration of transport on road is made worse by the high ratio of vehicle growth to road development and high population growth rate. For example, motorisation

[15] Nigeria became an independent state in 1960

increased at a rate about 14 times the rate at which road was developing (Akinbami and Fadare, 1997; Ogunbodede, 2008). As motorisation increased, so did congestion, especially in the big cities. Similarly, the high population growth rate meant that travel needs were increasing. Those who could not afford a car depended on public transport. Unfortunately, at this time in the late eighties/early nineties when transportation need increased most was the time government's capacity to fund public mass transit was also at its lowest due the economic down turn. The rising population, attendant increasing mobility need, rising road congestion, and collapsing government public transit system in big cities led to the emergence of various para-transit modes (Gbadamosi, 2006; Olubomehin, 2012). One of these which is relevant to the current research is the commercial motorcycle mode (Fasakin, 2001). Figure 6.1 shows the map of Nigeria and the 37 administrative divisions (36 states and a federal capital).

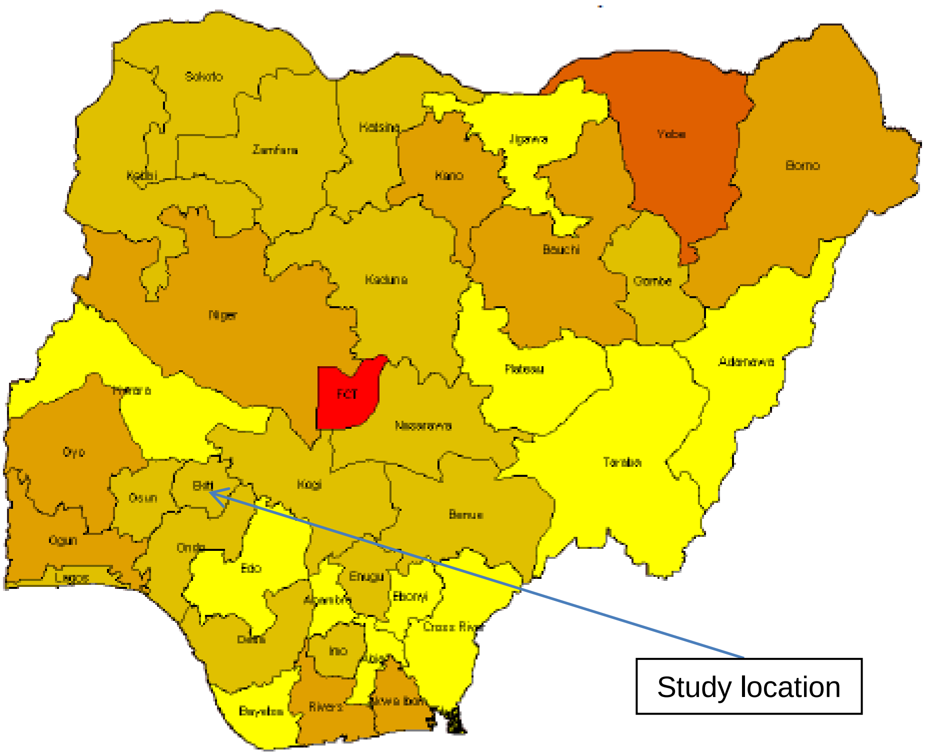

Figure 6.1: Map of Nigeria showing her 36 administrative states

(Source: FRN, 2010)

6.3 Study site selection

Usually, a case study involves in-depth analysis of a single or small number of units. It can be a study of a single event or a complex social situation (University of Surrey, [undated]). This understanding about what a case study is differentiates the study location from the case study. It is important to note that the **case** at hand is the commercial-motorcycle-safe-operation. Nevertheless, Ado Ekiti is chosen to enable a deeper study of this **case**. Some characteristics make Ado Ekiti very suitable. As shown in table 6.1, Ado Ekiti is a medium sized Nigerian city with some characteristics that are desirable for the data collection process: it is a single local-government city unlike many other cities of similar status in Nigeria. Thus administrative coordination of relevant data sources such as the drivers' union, the hospital management, and enforcement agencies is not split. Moreover, it allowed for coverage of the entire city rather than a part which could be the case in multi-administrative structured cities. In addition, Ado Ekiti was easier to access prospective respondents due to the researcher's established base there: the researcher has lived there for more than a decade. For example, an attempt to compare the data collection process to Osogbo, a neighbouring city, during the fieldwork did not succeed as good contacts to potential respondents were difficult to secure. On the other hand, the city of Enugu has banned commercial motorcycle while Owerri could not be attempted due to its remoteness to locations familiar to the researcher and the cost of establishing a field work base there. Richards and Morse (2007) point out that this familiarity is important to asking the right questions during the interview process. These reasons therefore make collecting rich information about the **case** easier with Ado Ekiti as the study location.

Table 6.1: List of alternative study location

	City	**Population characteristic** (2006 census)	**Administrative characteristic (# of LGAs[16])**	**City status**	**Commercial motorcycle operation**
1	Ado Ekiti	313, 690	Single	State capital	Applicable
2	Osogbo	155, 507	Single	State capital	Applicable
3	Enugu	717,291	Multi (3 LGA)	State capital	Banned
4	Owerri	403,425	Multi (3 LGA)	State capital	Applicable
5	Akure	360, 268	Single	State capital	Applicable

(Source: author, with extract from FRN, 2010)

6.4 The city: Ado-Ekiti

Ado Ekiti is the capital city of Ekiti-State, one of the 36 administrative states in Nigeria located in the south-western part of the country. Ekiti State is one of the smallest and youngest states in Nigeria, created in 1996 and with a population of about 2.4 million in 2006 census (FRN, 2010). Ekiti State is largely an agrarian state with the state government being the major employer of labour. Ado Ekiti, being the seat of the State

[16] LGA – local government area

government, accommodates the larger percentage of the state workforce. In addition, the presence of service industries, especially banks, and three higher institutions of learning make Ado Ekiti the economic nerve centre of the state. As a result, the population of Ado Ekiti grew from about 150,000 in 1991 to about 313,000 within a space of 15 years as shown in 2006 census result. Subsequently, Ado Ekiti will be called Ado.

Ado witnessed a dramatic change in economic fortune within the 20 years period ranging from 1991 to 2011. Prior to democratic government that was restored to Nigeria in the year 1999, road infrastructure in Ado was in a deplorable condition. This dilapidation which started during the 1980s period due to the economic programme of the federal government of Nigeria and the fall in revenue from oil sector reached its peak about the middle of the 1990s when all road pavements within the city have practically failed. The continuously worsening condition of road infrastructure in Ado was eventually halted in 1996 when Ado acquired a new status as a State capital. While this new status halted infrastructure collapse, much development did not start up until the end of that decade when oil prices in the international market started to rise. This led to increased funding support from the federal government of Nigeria and the development of road infrastructure in Ado. Thus, Ado now has over 75 kilometres[17] of road in good asphaltic condition in 2014 compared to none about two decades earlier.

The two factors that brought about road infrastructure development in Ado also led to increased migration into the city as well as increased economic prosperity for residents. The service industry grew; government establishments expanded in size leading to increase in the working population in Ado. Similarly, minimum wage for workers was raised twice between 1998 and 2000. The result was a rapid population growth, haphazard/ unplanned city expansion (just as in other Nigerian cities), increased vehicle ownership as well as increased demand for transport due to city expansion. Oriye (2013) showed that developed area in Ado tripled between 1996 and 2006. These events brought about the demand for mobility beyond what could be readily supported by the developing road infrastructure. The rapid growth in the number of commercial motorcycle in the city followed this pattern. Figure 6.2 below shows the map of Ado.

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[17] This is approximate. It has been calculated by the researcher based on the road project documentation of Ekiti State government

Figure 6.2: Map of Ado Ekiti, the study location

(Source: Google map)

6.5 Transport characteristics of Ado

Ado has a radial road structure that manifests a mono-centric central business district with four major links leading to it (as shown in figure 6.2). At the centre are the main city market and the king's palace. The four links leading to this centre are important for the locations they provide access to. The north link provides access to the State Specialist hospital (now a teaching hospital) and the State University. The east link provides access to a federal Polytechnic and a private University located at the east end of the city. The south link connects the city with the capital city of a neighbouring State, Ondo State (prior to Ado becoming a state capital itself this south link connected Ado to the then state capital). The west link (faintly shown on the map in figure 6.2) connects the city to the rest of the south-western part of Nigeria (except Ondo State). Though there are two other less important ones, these four links are the more prominent links. They were therefore the routes served by the main public transport system - shared taxis - in the days preceding the advent of commercial motorcycles. Of these four, two were more prominent: the link leading to the hospital and the State University, and the link that lead down south. These two had more regular shared taxi than the others. Development was also more rapid along these links prior to Ado becoming a state capital, a situation that further promoted availability of shared taxi. Nevertheless, other parts of the city were growing too, though with increasing limited accessibility. Eventually the city acquired the status of a state capital in 1996. This came with mass influx of people, including civil servants redeployed from neighbouring states, staff of service industries establishing new offices in the new seat of government and other explorers looking for opportunities. This sudden population growth extended the city beyond the previous limited shared taxi routes. More public transport service was required. Unfortunately, road condition was too poor for most part of the city to extend shared taxi service to their streets. These were the early days of commercial motorcycles. The combined effect of huge demand for public transport and lack of accessible roads for shared taxi service created an opportunity for commercial motorcycles to thrive. Thus the number of commercial motorcycles which was barely about a hundred in 1996 grew to about 2000 by the turn of the year 2000.

Commercial motorcycle is now a dominant mode of transportation for many urban trips within Ado. This is different from what Hathaway (1993) found in a study conducted in Ado around 1988. In 1988, there was no single commercial motorcycle in Ado. In addition, motorcycles were used in only 12% of non-walking commute trips in Ado. However, the current number of commercial motorcycle drivers is put at about 5000 people in Ado who carry more than 100,000 trips per day[18]. Oyesiku and Odufuwa (2002) find that as much as 80% of commute trips involved the use of commercial motorcycle, a situation which is not likely to have improved today.

6.6 Traffic management agencies and roles

The number of agencies of government whose responsibilities relate to traffic has been increasing. Until the year 1988, there were only two agencies of government involved with traffic. These were the police and the Vehicle Inspection Officers (VIO). The police have general responsibility of maintaining law and order, whether on the road or anywhere, and also a dedicated Motor Traffic division whose duties were essentially traffic management. It is also in charge of accident recording, investigations and prosecution through its Motor Traffic division. The VIO deal with issues such as drivers training and testing and vehicle check for “road worthiness”. Moreover, in the event of accident, the unit has the responsibility to assess the vehicles involved in the accident to ascertain whether vehicular factors contributed to such incidence or not. But in 1988, the federal government of Nigeria established an arm of the police whose duties were essentially to improve road safety[19]. This agency is called Federal Road Safety Commission (FRSC). Today, FRSC has the responsibility of formulating and implementing policies to enhance road safety in

[18] Estimated based on average income of drivers

[19] Ever since, the FRSC has been merged and demerged from the police time and again.

Nigeria. It is responsible for producing drivers' licence, and vehicle registration plate number, for arresting and prosecuting traffic offenders, and providing rescue service for accident victims. Its duties are however limited to federal roads which make up less than a quarter of Nigeria road network. Unfortunately, the effort of these three agencies has not been able to keep up with the challenges on the road. As a result a number of states (e.g., Lagos, Oyo, Osun states in south-western Nigeria) have now set up state traffic management agencies. Ekiti State inaugurated this agency in the year 2012 and called it Ekiti State Traffic Management Agency (EKSTMA). This State traffic management agency is charged with the responsibility of maintaining smooth traffic flow particularly at intersections. They are particularly responsible for arresting traffic violators and making them to pay fines.

Chapter 7 Data Collection

7.1 Introduction

The information provided in chapter 6 on the study location offers a background for the process and manner of data collection exercise discussed in this chapter. Both qualitative and qualitative data is required for the two approaches (qualitative methods and system dynamics) adopted in this research. But system dynamics approach particularly requires quantitative data as described in section 4.3.2. In addition, because the two approaches seek an understanding within a social context, it is necessary to obtain data from multiple sources. Thus while interview was the main source of data, other sources such as official documents and literature were explored. Documents including official reports, quantitative data generated by government establishments, and newspaper reports were reviewed. The literature was also widely reviewed. This review was done on a continuous process from the start of the research to the end. Thus data collection process was an extended process which ran throughout the period of the research. The review, however, did not follow any process; thus, document review is not described separately – the outcome is however reported in various sections across the thesis (particularly the tables in chapters 9 and 10). The interview data collection on the other hand followed a more structured process. This interview data was obtained from semi-structured interviews conducted as a dedicated fieldwork[20] exercise between October 2012 and December, 2012. This process of conducting the semi-structured interviews undertaken during the dedicated fieldwork exercise is presented in this chapter. The rest of the chapter follows this sequence. Section 7.2 describes the process of identifying respondents. In section 7.3, the semi-structured interview process is described. Section 7.4 gives a reflection on the fieldwork experience. It also shows the limitation of the secondary data sources obtained.

7.2 Respondents' identification

In this research, it was necessary to recruit respondents for the purpose of obtaining their mental concept of the system characteristics. Using the principle of purposeful sampling, respondents for the data collection exercise were identified. Respondents' identification is an important step as this is a factor in determining whether the research objectives would be fully achieved, and whether the validity and reliability of

[20] There were some informal post field work data collection too

the research would be attained (Mason, 2002). To address this, respondents in this research was broadened to include both internal and external stakeholders in commercial motorcycle operation. External stakeholders are those regarded as enlightened observers the system and possess information about its operation. These included academics who study the system as researchers, and medical personnel who attended to accident victims and asked questions about accident incidents. Others such as users who patronise commercial motorcycle service and other road users, such as pedestrians, motor vehicle drivers can be categorised as external stakeholders. Internal stakeholders on the other hand are the commercial motorcycle drivers and the enforcement and regulatory agencies. These latter two stakeholder groups form players within the system and interact with one another in such a manner as to determine/ influence the safe characteristics of the system. The process of listing all external and internal stakeholders identified ten different groups who were regarded as relevant stakeholders and were proposed to take part in the survey. These ten are listed below.

1. Commercial motorcycle drivers;
2. Commercial motorcycle union leaders;
3. Nigeria Police Force;
4. Federal Road Safety Commission;
5. Academics;
6. Medical personnel;
7. Vehicle Inspection Officer (Ministry of Works/ Transport);
8. Transport Safety related NGOs/government agencies;
9. Other road users;
10. Commercial motorcycle passengers

But when eventually it became obvious that funding for the research might constraint extensive data collection process, eight of the groups were selected. These eight were chosen because they were considered as active players within the system. The two excluded are other roads users and passengers of commercial motorcycle service (being external stakeholders). These two were also regarded as less definite groups when compared with other groups in that everyone in the eight groups chosen do belong to (at least one of) these last two groups from time to time. In addition, they are large groups and sampling would be more difficult for these groups due to paucity of funds for the research. Having resolved on these eight groups, it was decided to classify them based on the characteristics the groups share with one another. The three divisions arrived at are enforcers, operators, and experts and table 7.1 below provides a list of the groups and divisions.

Table 7.1: Group list and data collection method

	Stakeholder Group	Number of contacts	Number recorded	Respondent number	Stakeholder classification	Data Collection Method
1	Federal Road Safety Commission	3	-	5	enforcer	Interview
2	Nigeria Police Force	2	-	1	enforcer	Interview
3	Vehicle Inspection Officer (Ministry of Works/ Transport)	3	2	1	enforcer	Interview
4	Medical personnel	1	1	1	expert	Interview
5	Academics	3	2	2	expert	Interview
6	Transport Safety related NGOs/government agencies	1	1	3	enforcer	Interview
7	Commercial motorcycle drivers	2	2	12 in two groups of 6	driver	Interview
8	Commercial motorcycle union officers	1	1	7	driver	Interview

As shown in table 7.1 above, the eight respondent groups selected were classified into three divisions. These are enforcers, experts and operators. The enforcer division contained all respondent groups whose duties were related to traffic management and control. These include the police (also known as the Nigeria Police Force (NPF)), the Federal Road Safety Corps officers (FRSC), the Vehicle Inspection officers (VIO), and a traffic management unit of the State Ministry of Works (EKSTMA). EKSTMA is a new agency that just came up in the study area (in the years 2012). The expert division has the academics and the medical personnel groups while the operators' division has the motorcycle drivers under it. In the case of the motorcycle drivers, two groups were identified: the leaders of the organised group of drivers, and individual commercial motorcycle drivers who did not belong to the leaders' group. This group was divided into two to enable coverage of views of both the personal views of individual drivers who worked daily and their leaders who were more experienced and had more broad and corporate view of the system. Both groups were included in the fieldwork.

To select potential participants within each group, the offices of these groups were contacted. This contact was made in person by the researcher who visited the various offices to deliver “invitation to participate” letters by hand. Because of poor internet connectivity, most offices do not have websites or use emails; so it was not possible to contact respondents ahead of the fieldwork period. The letters delivered to the offices also included the research script. The research script is the pack of document that contained all the information about the research aims, objectives, and methodology.

The enforcer division had more spread of relevant organisations. There were The Nigerian Police Force, the Federal Road Safety Commission, Ekiti State Traffic Management Agency, and the Vehicle Inspection Office. All these agencies were contacted through letters delivered by the researcher to their offices within the study area[21]. Nevertheless, the respondents for this division were not directly selected by the researcher; since letters were written to their offices, to seek approval for their participation, the final selection of participants from these groups was done by their heads (usually an administrative helmsman).

In the case of the medical personnel group, visits were made to two major hospitals in the neighbourhood, one within the study area, and the other outside the study area. A respondent was recruited through the visit. This respondent was the head of one hospital's Accident and Emergency unit. The choice of this unit is premised on the fact that it is the first point of call for any accident victim.

It was however not possible to deliver letters to offices of respondents within the academics group. This is because they were not known at the start of the fieldwork exercise. Thus the recruitment process for relevant academics was different: using snowball method (Atkinson and Flint, 2001; Coyne, 1997), they were recruited through personal contact/recommendation. This process involved visiting three universities and one research institute in the neighbourhood of the study area. Two respondents were got from these visits and both participated in the interviews.

7.3 Interview structure: main survey

As mentioned in section 5.4.7, the survey exercise was conducted in Nigeria between October and December, 2012 by the researcher. The "invitation to participate" letters together with the research script was designed to intimate respondents about the aim of the research, the nature of the interview, the questions to be asked and other information about the research. Some respondent (groups) who initially could not be reached with letters were introduced to the purpose of the research and the design of the survey through phone calls before eventually meeting them. Their right to participate/ withdraw at any time and without notice was also emphasised. This was

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[21] An attempt was made to extend the invitation to participate to some neighbouring cities, but the cost of transportation and the difficulty in arranging meetings ahead frustrated this attempt. One was however successful and is included as part of the data for the research.

also repeated before the interviews were eventually conducted and consent forms were offered to document respondents' consent.

The use of semi-structured interview was adopted in this research for the purpose of obtaining stakeholders' mental concept of commercial motorcycle safety system characteristics. All the respondent groups contacted gave approval to participate in the research. It is not known if this is an indication to the seriousness of the problem with commercial motorcycle safe operations. The actual interview exercise demonstrated respondents interest in commercial motorcycle issues as they all participated with excitement – though this was only in the first arranged meeting. Some of the groups in enforcer's division were the first to be met. EKSTMA nominated three respondents to participate in the interview. These respondents indicated intention to participate as a team rather than individually as intended in the interview script. They also gave their consent for the interview to be recorded. However, in the course of the interview, they acknowledged that they were new on their job as the agency was less than a year old at the time of the researcher's visit. They nevertheless expressed their views which were more or less those of an observer of the system. The FRSC offered five officers in all who were experienced in regular highway patrol. These five were met in three groups. With the exception of one person who responded lone, the other four preferred to respond as a team of two. But these interviews were not recorded as the researcher was told that only very senior administrative heads could be allowed to grant recorded interviews. The researcher resorted to taking notes which formed part of the data analysed in the research. The interview was not very smooth as the officers were frequently invited to attend to some other official matters during the interview. A second appointment was however arranged with one of the groups to consummate the first meeting. At this appointment the researcher was offered some quantitative data. Available quantitative data was however too inadequate to generate any trend, covering less than three years.

The VIO and NPF were interviewed later. In both cases, the heads of the relevant units undertook to participate in the interview. The immediate implication was that these would be the only respondents from their groups as their participation meant junior officers would not be able to participate. For both officers, more than one interview meetings were held. In the case of NPF, the subsequent contact was however a continuation of the previous meeting as the officer was busy and the interview sessions were stopped abruptly to attend to emergencies on two occasions. Permission was not granted to record the interview sessions with the NPF. The second meeting with the VIO on the other hand enabled a review of the issues raised in the first interview session. The interviews with the VIO were recorded.

Commercial motorcycle drivers were contacted as two different groups: the union leaders were met for an interview at the union's office while two groups of drivers were met at a commercial motorcycle stop/ park around the city centre. Both interviews were recorded.

A recorded interview session was also granted by a medical staff in one of the two hospitals visited. This personnel who was in the Accident and Emergency unit of the hospital provided evidence of the use of hard drugs by commercial motorcycle accident victims in the course of the interview in addition to granting interview.

Interview sessions with the two academics contacted took the researcher outside the study area as there were no academics whose works relate to commercial motorcycle within the study area. These interviews came up well into the fieldwork and by the time they were being held, the researcher has had an initial peripheral review of data collected. As a result, the structure of the interviews with these experts was slightly different. They were required to review the interview question in the light of the views previously collected interview data during the fieldwork. While similar questions were raised with these respondents as others, they were able to review the outcome of previous interview process. This was made possible through a causal diagram developed from a reflection on the interview sessions held with the enforcer and the operator's groups. This was an important process in the fieldwork. As noted by Pope et al. (2000), the researcher is actively involved in the data collection process, so it is impossible not to start thinking about what is being heard and seen. Interviews with respondents in this group (expert group) were recorded.

Quantitative data collection, on the other hand, entailed visiting all offices that had a link with transport in the study area. These offices included those who were dealing with revenue collection, licensing office, enforcement agency's offices, and hospital. However, the secondary data is of poor quality.

7.4 Reflections

In this research, the script designed for the fieldwork process is in line with the suggestion of Mason (2002) about preparation for data collection. This script included the list of respondents to be contacted, the number of respondents required for each group, and the number of visits to be made. Because this script was designed to obtain data for the two approaches, it also included likely sources of quantitative data and methods by which they might be extracted. This script was developed in conjunction with the researcher's supervisors and approved by them. It also went through the University of Leeds' Ethics Committee for approval after it was developed. This is in line with what Zucker (2009) referred to as part of the quality control process in qualitative research.

The fieldwork exercise ran according to the research design. Experience with qualitative data collection was smooth once an appointment was granted. The script designed for the interviews were used to elicit information from the various stakeholders' groups. A total of 16 contacts were made with the 8 stakeholders groups. For 9 of these contacts permission to audio record the interview sessions was granted. In all cases, handwritten notes were taken to complement audio recordings. Nevertheless, while the script provided substantial guide during the fieldwork, it was not possible to follow it through during the exercise. Specifically, it was not possible to conduct the number of sessions intended for each of the respondents. In addition, while group interview was only intended for the drivers, this was the method that was adopted for most respondent groups as they indicated preference for it. Furthermore, it was not always possible to meet more than one representative per group. This was especially the case when the most senior officer in the group volunteered to participate. Finally, quantitative data was less available than anticipated.

Quantitative data was found to be generally non-existent. Some establishments did not have records of what they were doing at all. Some others discarded their records as government/record keeping mechanism changed and a particular establishment suggested making up data. When asked the reason why those records were not available, "administrative changes" (i.e., transfer or relocation of) to officers in charge and "directive from above" on what to collect were the major excuses for data unavailability. In addition, where data was available, data from different sources exhibited different (usually conflicting) trends. This was particularly the case with accident data from the hospital and the police.

The interview exercise was successful for the first meeting with most groups. Respondents showed interest in participating in the exercise and wanted to express their opinion about the system (only one respondent from the operators' division refused to participate). As mentioned in section 5.4.6, the questions were designed in a manner anyone could answer them. This gave respondents the freedom to start from what they knew. Further questions were based on responses to these general questions (questions are attached in appendix 1). But the interest of most respondents was not sustained beyond the first meetings. For most groups, subsequent meetings were unsuccessful: it was not possible to fix a suitable appointment for some; in other cases, appointment fixed could not be honoured. This is probably due to the busy schedules of the respondents.

For most groups, ranging from the enforcer division to the operator division, there were breaks during the session. For example, the delegates from FRSC took time off during the session repeatedly to attend to some official assignments. The drivers' union took time off to attend a meeting in between the session and so was one of the experts. This experience was witnessed in about half of the interview sessions. For the drivers, it was more of the challenge of impatient. For them, respondents kept changing: as some were leaving, some others were joining, though some stayed throughout. The researcher was specifically told he would need to pay the drivers if he wanted everyone to stay through. This attitude may not be too strange for people who are daily income earners in a developing country context. These observations might also explain why a repeat session could not be held for most of the groups. This however could not be interpreted to mean lack of interest in the research since the researcher observed that the respondents generally showed concern about commercial motorcycle safety and were eager to say what their views of the problem were and how it could be combated.

The field work yielded mainly qualitative data. This qualitative data is taken to the next chapter for analysis.

Segment 3: Data analysis and models development

Chapter 8 Data Analysis

8.1 Introduction

In chapter 7, the process of data collection was presented together with a summative outcome of the data collection process. In this chapter, the process of data analysis is described and this is followed by the presentation of the outcome of data analysis. This chapter also explains the analytical steps taken to probe the data and generate the findings reported. Previously in section 5.2, the researcher noted that this research adopts a post-positivist paradigm which supports the use of qualitative data to identify structures and behaviours within the commercial motorcycle's operating system which are concrete and recurrent (Annells, 1996). Moreover, for the reasons described in section 5.4.9, content analysis is used in the analysis described here. In addition, the approach used in content analysis process follows the logic of thematic content analysis described in Burnard (1991) with some adjustments introduced by the researcher. The logic of the amended Burnard's (1991) analytical approach is shown in figure 8.1 on the following page. This figure shows the summary of the stages followed in this analysis and points out the sections that show how they have been followed in this research. Sections 8.2 to 8.4 describe the process followed for the preparation of data for analysis. Section 8.5 describes the analysis process while section 8.6 reports the outcome of the analysis. Section 8.7 reports the researcher's interpretation of the analysed data and section 8.8 reflects on validity issues. In section 8.9 is the researcher's note on reflexivity while 8.10 provides a brief conclusion for the chapter.

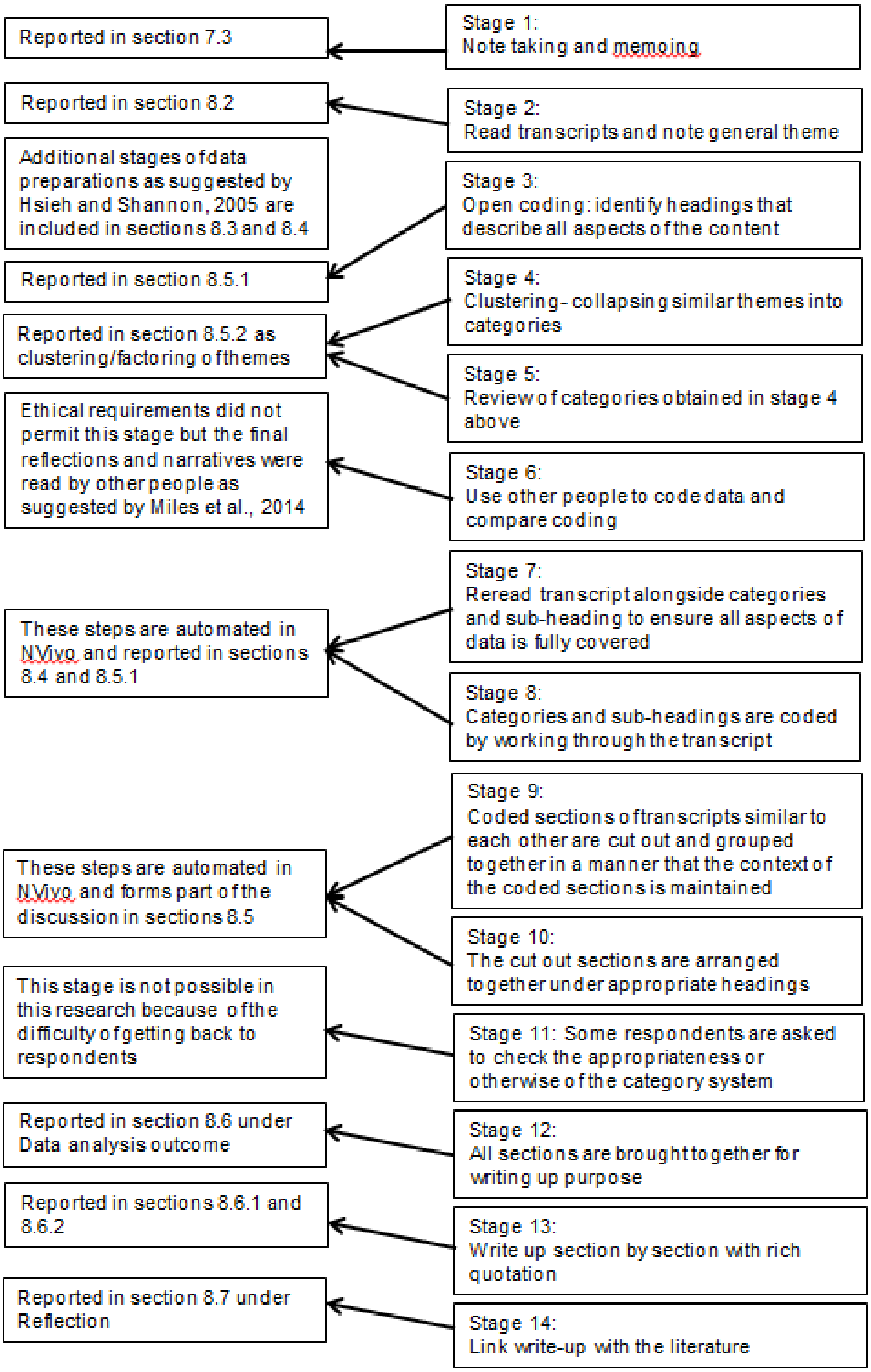

Figure 8.1: How Burnard (1991) stages for data analysis are adapted for this research

8.2 Initial data review

Qualitative research usually produces a large amount of data. This includes items such as jotted notes and transcribed recordings. As noted by Pope et al. (2000) this data provides a descriptive record of research which requires a researcher to analytically make sense out of them. The process of analysing the primary data collected for this research started with listening to the recorded interviews and reading through field notes taken during the survey. This is similar to the second stage in figure 8.1 as found in Burnard (1991). As demonstrated in section 5.4.9, this process helps to achieve “immersion and obtain a sense of the whole” (Hsieh and Shannon, 2005, p.1279) and to enter the respondents’ “frame of reference” (Burnard, 1991, p.462). This step revealed some general broad themes that were noted in the survey. These themes are listed in table 8.1 below.

Table 8.1: Emergent themes from initial data preview

	Emergent themes
1	Accident occurrence
2	Alcohol use as a concern in commercial motorcycle operation
3	Drivers’ earning as an important factor for driving attitude
4	Enforcement’s inadequacy affects deterrence
5	Other external factors that contribute to accident
6	Motorcycle ownership structure amidst drivers
7	Post-crash management of accident victims
8	Regulatory challenges as part of the system’s problem
9	Training deficiency rampant amidst drivers
10	Violations as the greatest precursor to safety problem

Hsieh and Shannon described this step as highlighting words “from the text that appears to capture key thoughts or concepts” (Hsieh and Shannon, 2005, p.1279). After this stage, the process of methodically analysing the data was initiated. Since the object of analysis is "words", it was necessary to transcribe the interview files.

8.3 Interview transcription

While this was an important phase of the analysis, it does not appear on the 14-stage guide in figure 8.1. This is because Burnard did not include it as one of the stages. Nevertheless, he noted this phase indicating that it is assumed the data has been prepared. His words: "the method described here assumes that semi-structured, open-ended interviews have been carried out...that the whole of each recording has been transcribed" (Burnard, 1991, p.461). Thus while it is not in the 14 stages, it is still part of the process.

Qualitative data usually generate a vast amount of data. Pope et al. (2000) notes that a typical single interview could take several hours to transcribe and can generate 20 – 40 pages of single spaced text. It was therefore not unusual that the transcription process was a challenging one more so as it was the first time the researcher would be involved in transcribing. Every 10 minutes recording took over an hour to transcribe. The fact that many of the respondents used two languages (both local language (Yoruba) and the official Nigerian language, English) added to the difficulty. Halai (2007) reported having similar experience which did not compromise the quality of his research. (He, together with the respondents was switching between two languages during interview sessions). Thus while the multi-lingual nature did not constitute a problem to the fieldwork, it added to the challenge of transcribing. Moreover, the transcription process involved listening to the recorded interviews, interpreting it as well as typing out what is said. The entire translation was done by the researcher. This follows the suggestion of Twinn (1997) who recommended using the same translator for all script recorded so as to ensure consistency. This also has the added advantage of enabling the researcher become more accustomed with the data content.

All the interviews conducted were transcribed with the exception one. This was the interview conducted with the staff of Ekiti State Traffic Management Agency (EKSTMA). The reason for eventually leaving this interview out was that the agency was new. The respondents from this agency noted that they were newly recruited as the agency had just started (created in the year 2012). Moreover, the staff noted that they were not dealing with traffic safety issue; they were more concerned with smooth traffic flow and removal of parked vehicles causing obstructions. Since they had no information about commercial motorcycle safety, their interview is not used.

8.4 Data organisation using NVivo

Following from transcription phase, the transcriptions were imported into the computer assisted qualitative analysis software, NVivo 9, for a formal analysis. The need to organise the data and keep track of the analysis process necessitated the use of this software. The software also enhanced the process of coding as it readily allowed for multiple coding and re-coding which were necessary in the course of the analysis. This software was also used for generating output such as framework matrices which provide a tabular view of what respondents said about a code, who the respondent is and what code it is that he spoke about. Manually presenting an analysis like this would be time consuming. While this software could have been used to generate graphs of codes to obtain a map of patterns, a different software, Vensim DSS, was used for this purpose as the researcher finds it easier to use.

It must be noted that NVivo software use provided support for sorting and organising analysis rather than helping to do the actual data analysis. This is in line with the view of literature about software use (Saldana, 2013; Thorne, 2000). As mentioned in section 3.4.2, Pope et al. (2000) note that as good as software may be, they cannot perform the actual analysis. The use of NVivo was therefore limited to organizing codes to match with the quotes they represent in an orderly (and tabular) manner as the analysis proceeded.

Finally, while NVivo software made the initial coding very easy, final re-aggregation were done manually by copying out the codes and quotes and re-tabulating them as presented in this report. This is particularly important as it would be impossible to import all the quotations coded in NVivo software into this thesis.

8.5 Analysis of Qualitative Data

8.5.1 Open coding stage

The analysis process followed content analysis method described in section 3.4.1 and it fulfils the third stage in figure 8.1 where Burnard recommended "open coding" (1991, p.462). It started with reading the transcript data “word by word to derive codes” (Hsieh and Shannon 2005, p.1279). As noted in section 5.4.9, the approach to analysis was broadly inductive. The coding was done manually on the transcripts uploaded into NVivo 9 software with the software serving as a platform to organise codes and provide an audit trail.

This coding process entailed assigning a word or a short phrase to summarise the meaning of a portion of the qualitative data. As recommended by Miles et al. (2014, p.84) it is good to have what he calls "definition of code". This is used to mean the clear operational guide to searching and coding data. Saldana (2013) noted that this guide can be informed by research paradigm, theoretical approach, emergent conceptual framework or methodological needs. In this research, the guide is informed by the research paradigm which is that of a post-positivist. The “definition of code” used in this analysis have these questions:

1. What are the themes mentioned in the data?
2. How are these themes related to one another?
3. What is said about these themes?

To operationalise this guide, two main coding methods were adopted for this process with both being used together. These are causation codes and descriptive coding (Miles at al., 2014; Saldana, 2013). Because the questions respondents answered were causal in design, responses were causal. Thus it was possible to identify causal relationships in what respondents said.

Using the coding system in NVivo 9, the data was read and the initial coding was done. In the first run of coding, themes mentioned by respondents were coded and supported with quotations from respondents' words. Hsieh and Shannon (2005) describe the step as a process in which researcher makes "notes of his or her first impressions, thoughts and initial analysis" (p.1279). Burnard (1991, p.462) called this process "open coding". This process was aided by NVivo 9 software which organised the codes and quotes in a tabular form. Being the first coding phases, the codes were very broad, general, and repetitious and require further analysis. As noted by Burnard (1991), the open coding process is expected to run several times until all possible themes have been coded in the data. Thus the coding process was repeated three other times before the open coding process ended.

8.5.2 Code factoring stage

At the end of the open coding stage, several descriptive codes and causation codes emerged. In many case, several codes were used to describe the same thing. It was therefore necessary to collapse similar ones into unifying codes. Examples of what was done in the analysis are presented in table 8.2 below.

Table 8.2: An example of code factoring

Codes retained	**Risky and dangerous drivers**	**Risky road environment**	**High job return**
Codes collapsed and removed	Dangerous overtaking	Road condition	Poverty
	Wrongful overtaking	Bad road	Difficult economic terrain
	Resistance to compliance/rebellion	Rainy season	Economic and employment problems
	Risk taking behaviour		
	Wrong judgement		
	Carelessness		
	Pseudo confidence		

The process of factoring reduced the number of descriptive codes to 42 and causation (or causal) code to 83. These codes are discussed in section 8.6.

8.6 Data analysis outcome

This section relates to the steps addressed in stages 12 and 13 of figure 8.1 as found in Burnard, (1991). Specifically, it provides a description of how the analysis outcome is written out and supported with quotations from data. This outcome is provided in two sections. In addition, each of these sections is sub-divided into five groups using "extended thematic statements" called “themeing the data” in Saldana (2013 p.175). The first division provides a list of all the codes identified in the data by using descriptive coding method (Miles at al., 2014; Saldana, 2013). Descriptive coding is a word or short phrase that summarises the “basic topic of a passage of qualitative data” (Saldana, 2013, p.88). These codes are arranged in a manner that similar codes are grouped together to provide an opportunity for further analysis involving generating valuable insights about striking relationships. The structure of presentation follows Saldana's (2013) recommendation that codes should be presented first before a reflection is provided on how they are related to one another. Thus in section 8.6.2, how each of the identified codes in section 8.6.1 is related to other codes as found in the data is reported. Then in section 8.7, the researcher’s interpretation is provided. The coding method adopted to arrive at sections 8.6.2 and 8.7 is what is known as causation coding (Miles at al., 2014; Saldana, 2013). According to Saldana (2013, p.163), causation coding “attempts to label the mental models participants use to uncover ‘what people believe about events and their causes’”. In these two sections, graphs are provided to link codes together. These graphs are used to show how interrelated and operative the coding process is (Miles et al., 2014). Nevertheless, while the graphs in sections 8.6.2 and 8.7 indicate causality, the graphs in section 8.6.1 only indicate that the codes surrounding the central theme are related to it.

Finally since a huge number of respondents’ comments are included to support the causation codes identified in section 8.6, attribute coding (Saldana, 2013) is adopted in naming the respondents to ensure anonymity. All names start with "R" and indicate "respondent". Names ending with FG1 indicate one group of drivers interviewed together while those ending with FG2 refer to the second drivers' group involved in the fieldwork. The first drivers' group had seven respondents in all who participated while the second had six respondents. Names for respondents in the expert division ends with "I" while names for respondents in the enforcers’ division ends with "IX". Finally, the researcher had some informal discussions with drivers at various times during and after the fieldwork. These are presented as “ID” meaning “informal discussion”.

The analysis outcome is now presented. The three "definition of codes" mentioned in section 8.5.1, are used as guide to present the result. However, only the first two are used as headings while the third of the code definition is merged to the first two. This gives the following new headings for reporting the result:

1. What are the themes mentioned by respondents and what does the data say about them?
2. How are these themes related to one another and what does the data say about them?

These are presented below starting with the first one.

8.6.1 What are the themes mentioned by respondents and what does the data say about them?

This section provides a description of the codes that emerged from the data as factors that affect accident causation in commercial motorcycle operation. These codes are grouped under five thematic statements. A table is also attached to each group of codes. The tables show the codes as "descriptive codes" and provide a description of what they mean. Because of the amount of quotations included in section 8.6.2 and the challenge of space, quotations are not provided in the tables in section 8.6.1. It is important to note that what is presented here are the codes derived from the data as said by respondents rather than the researcher's interpretation of data. The researcher's interpretation is treated in section 8.7.

8.6.1.1 The commercial motorcycle trade

The data indicates that commercial motorcycle trade offers very high returns on investment. Respondents R1I and R2FG1 showed that it was possible for a poor and unemployed individual to start the trade and attain a guaranteed livelihood after some time. Respondents R1I, R5FG1, R3FG2, and R4FG2 also indicated that more and more (mostly inappropriate) people were joining as drivers because they believed there was money in the trade. This was responsible for the rapid growth in the number of drivers. This unqualified army of drivers was risky and dangerous and largely responsible for the safety problem of this transport mode as said by R1I and R6FG2. Moreover, many of these drivers joining the trade started with rented or hire-purchased motorcycles as mentioned by R1I, R2FG1, and R1IX. In the rent arrangement, drivers took a lease of motorcycle and made daily payment to the lessor. The hire-purchase arrangement required drivers to pay up the cost of motorcycle and an interest on that cost within a specified time. These drivers who came in by obtaining rented motorcycles or motorcycles on hire-purchase were said to have repayment system that promoted working hard to quickly settle the bill (R1I, R1IX, and R2FG1). Respondents R1IX and R2FG1 indicated that this was one reason why many of them violated traffic rules. In addition, R1IX and R2IX showed that not all drivers were violators alike; some were worse violators than the others. Respondent R1I described all drivers as violators while R3I noted that drivers were generally regarded as risky and dangerous. Other issues mentioned were the unsafe location of commercial motorcycle parks and stops and the belief that experience was required to improve safe driving

Finally, respondent R1I was of the opinion that most drivers used second hand motorcycles and that this might be compromising their safety. But almost all respondents from the expert and enforcer's divisions (R1I, R3I, R1IX and R2IX) mentioned that accidents that resulted from vehicle malfunctioning (mechanical failure) were not significant and that the major problem with drivers was violation. Furthermore, the drivers revealed that most motorcycles were now acquired new in recent times unlike previously when most of them were second hand. A tabular presentation of these codes is shown in table 8.3 while a graphical display is used to show all the factors in figure 8.2.

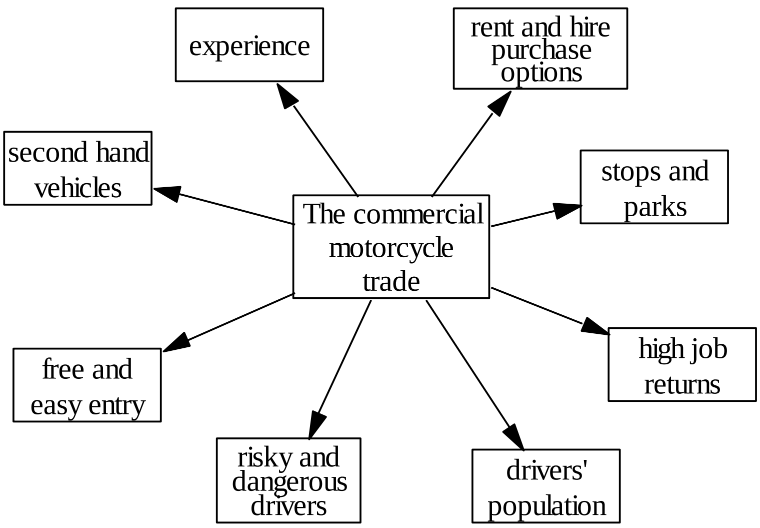

Figure 8.2: Descriptive codes under the commercial motorcycle trade

(The graphical display above indicates that the eight codes surrounding the thematic statement at the centre are classified under it)

Table 8.3: Relevant codes in the commercial motorcycle trade

Descriptive code	Meaning	Respondent
Drivers' population	Drivers' population refers to the number of drivers in the study area and its changing pattern. Safety problem is shown to have been deteriorating as the population increases.	R1I, R3I, R2FG1,
Experience	This describes how familiar a driver has become to the trade which depends on the number of years in operation. Experience is believed to improve safety. It was noted that some of those involved in accident are novice and that as years of experience increases, a driver's safety profile improves.	R2FG1, R6FG2
Free and easy entry	The process of entering into commercial motorcycle trade is not regulated or provided with any control. It is free for all and easy to join. It does not require any qualification or certification or any other thing. The data shows that this factor contributes to the high spate of violation in the system as those joining do not possess required knowledge about safety laws.	R1I, R5FG1, R3FG2, R4FG2
High job return	This means that commercial motorcycle trade is a lucrative business. This is one of the bases for the rapid growth in drivers' population. The high job return is the reason why some drivers overwork and compromise safety.	R1I, R2FG1
Rent and hire-purchase options	This is used to describe drivers whose motorcycles are not self-owned. The data shows that there are two groups of drivers in addition to owner operators: those who rent their motorcycles and have to make regular payment to the owners; and those who obtain their motorcycle through instalment payment. Both groups have the responsibility to make regular payment with almost no provision for defaulting. It also shows that this issue affect safe behaviour in commercial motorcycle operation.	R1I, R2FG1, R1IX
Risky and dangerous drivers	This term is used to describe drivers who have high tendency to violate. This can be due to inadequate training before joining commercial motorcycle trade or work pressure due to too much work or even earning pressure on the driver. The data shows how these different causes affect drivers.	R1I, R3I, R1IX, R2IX, R6FG2
Second hand vehicles	This indicates whether the motorcycles in use for commercial purpose are second hand and very old and risky.	R1I,
Stops and parks	This refers to motorcycle parks and stations where drivers usually congregate to pick passengers. These stops are in risky locations and contribute to safety problem.	R1I

8.6.1.2 Life as a commercial motorcycle driver

The data makes reference to what making money was like in commercial motorcycle operation. It gives a description of drivers' income as well as their work pattern. Respondents R2FG1 and R7FG1 both indicated that drivers' earning varied. The data also shows that drivers often did set target income and had to work more (and required more strength/ capacity called **additional work capacity requirement**) to realise this target. Some of the respondents observed that some drivers often worked harder and/or longer than the others while some others depended on some capacity enhancing drugs to be able to work (R2FG1, R4FG1). Respondents R2FG2 and R6FG2 suggested that drivers should desist from setting high target income and make reasonable targets. In addition, there were some payments drivers were making, particularly thrift savings and payment for the cost of operation. Thrift savings was mentioned as an important culture in commercial motorcycle trade (R2FG1, R2FG2).

The data also notes that some drivers were usually under a sort of **earning pressure**: these drivers were working under pressure with what to earn in view (R2FG1, R6FG2). Some drivers also complained about the cost of operation and some specific costs such as drivers' license and daily work permit tickets (R6FG1, R6FG2). Another respondent pointed out drivers' reluctance to spend when he noted that drivers would delay important expenditure at times (**spending aversion**) and would start to cut corners (R5FG1). Competition was mentioned in passing by respondents R1I and R2FG1. All these relate to the operation of a commercial motorcycle driver. These codes are presented in table 8.4 below and represented graphically in figure 8.3.

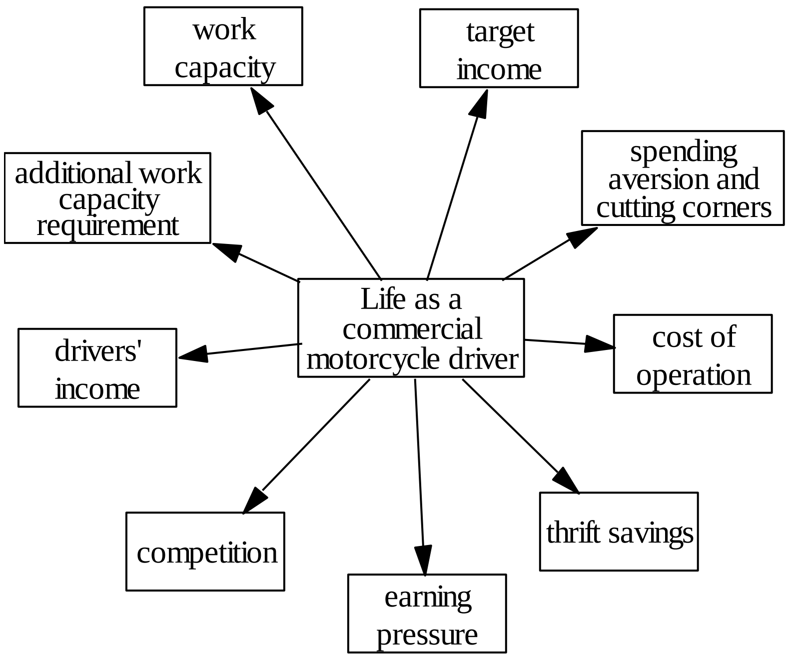

Figure 8.3: Descriptive codes in the operation of a commercial motorcycle driver

(This graphical display indicates that the nine codes surrounding the thematic statement at the centre are classified under it)

Table 8.4: Relevant codes in the operation of a commercial motorcycle driver

Descriptive code	Meaning	Respondent
Additional work capacity requirement	This describes a driver's need to work more and/ or longer than he is used to, or than the average working period of the drivers' population. This is usually reflected in the need to commit more time to working than other as well as wanting to make more trips in a day. The data notes that many drivers on rent or hire-purchase always need to work more to be able to meet up with their repayments.	R1I, R2I, R3I, R2FG1, R4FG1
Competition	Drivers compete for passengers and this do compromise safe operations.	R1I, R2FG1
Cost of operation	This theme is used to describe the cost of operation in commercial motorcycle trade. This cost which usually include cost of the motorcycle, maintenance cost, cost of licensing for the driver and the motorcycle daily taxes, etc. are important in commercial motorcycle trade. The data shows that some of these costs which should be paid to government and the union are resented by the drivers. Some drivers delay vehicle maintenance too.	R6FG1, R6FG2
Drivers' income	The term drivers' income is used to describe the average of drivers' daily earning or what a representative driver makes after a day's work. The data notes that the amount varies from driver to driver. It also shows that it is affected by the class of ownership the driver belongs to – whether self-owned or not, and that some drivers would commit violation to be able to make more money.	R2FG1, R7FG1
Earning pressure	Earning pressure captures pressure that results from the need to make payments due to thrift savings as well as the cost of the motorcycle which is usually either as rent or hire-purchase.	R2FG1, R6FG2
Spending aversion and cutting corners	This is used to capture drivers' reluctance to make some expenditure which is legally required. Such expenditure include payment for licenses, maintenance of motorcycles (e.g., replacement of broken lights), and payments of some regular taxes. Refusing to make these expenditures causes the driver to need to dodge or have to flee enforcement officers, which have safety implications.	R5FG1
Target income	This is used to describe the fact that some drivers normally set an amount they want to make in a day. The data shows that those on repayments must work to meet up with their repayments. Equally important, and may be more serious are those who make huge regular saving and do not want to fail. These have negative safety consequences.	R2FG2, R6FG2
Thrift savings	This is used to describe a savings scheme popular among the drivers where each person contributes a fixed amount regularly and the members of the thrift union collect the sum in turn. It is a way of raising funds for capital intensive projects, particularly the purchase of a new motorcycle but also other personal needs. The data shows that the scheme allows members to set any amount and individuals do not want to fail to meet up with their contribution. This thrift savings often compels drivers to work as the job is difficult and drivers can become lazy if they do not belong to a thrift scheme.	R2FG1, R2FG2
Work capacity	This theme describes the amount of work a driver is able to do. This is treated in this study as the length of time a driver is able to work for in a 24 hour period. This data shows a wide variation in work	R1I, R2I, R3I, R2FG1, R4FG1

Descriptive code	Meaning	Respondent
	capacity across the drivers' population. In addition, work capacity is related to the use of capacity enhancing drugs.	

8.6.1.3 Violations practices in commercial motorcycle operation

The theme violation is noted in the data. It was referred to by all the three respondent divisions. All respondent groups agreed that violations accounted for between 50% and 85% of all accidents occurring (R1I, R3I, R1IX, R2IX, R3IX, R4IX, R2FG1, R3FG1, R2FG2). Respondents (R1IX and R4IX) noted that drivers did not want to comply with traffic laws at all. Violations manifested in several forms and were related to some other factors too in the operation of commercial motorcycles. The two most mentioned violations in the data were speeding and the use of alcohol. Speeding was believed to have become habitual for many drivers. A similar thing applied to alcohol use. The drivers themselves in the operator's division loudly expressed their worries about hurrying and consumption of alcohol (R1FG1, R2FG1, R3FG1, R1FG2, R3FG2 and R5FG2). A respondent showed evidence of illicit drugs found with a driver. Across the length of the data, there was the repeated mention of the use of alcohol. Other violation types were mentioned too.

Notwithstanding, the operator's division blamed the government and the enforcement officers for not doing their job properly for this problem amidst the drivers (R2FG1 and R3FG2). They also agreed with the expert division that alcohol use was not the exclusive of commercial motorcycle drivers; many other road users engaged in drinking (R1I, R5FG2).

Other things mentioned were the need for drivers to boost their work ability (R1I, R2I, and R3I). Finally, some respondents from operator's division noted the challenge of inclement weather (R4FG1 and R1FG2). These violations related codes are described in table 8.5 and represented graphically in figure 8.4.

Table 8.5: Relevant codes in violation practices in commercial motorcycle operation

Descriptive code	Meaning	Respondent
Accident	Accident is used to describe any incidence on the road that results in death, bodily harm and/ or damage to properties. Such properties include motor vehicles and road furniture.	All respondents
Alcohol and drug use	This describes the habit of drink-driving and driving under the influence of drugs. The data alluded to the seriousness of this habit and the harm that results from it. An evidence of illicit drug found in the pocket of one accident victim was shown to the researcher. The data nonetheless notes that the use of these substances is not peculiar to commercial motorcycle drivers; it is a problem with many vehicle drivers too.	R1I, R3I, R1IX, R2IX, R3FG1, R1FG2
Inclement weather	This describes the harsh weather condition under which drivers work. This includes the heat of the sun, heavy down pour whenever it rains, and other similar weather effect. In the data, inclement weather is one of the main reasons given for the consumption of alcohol.	R4FG1, R1FG2, R5FG2
Licences	A form of violation mentioned in the data is not possessing drivers and/ or vehicle licence and particulars. Possession of this document is often (though wrongly) seen as an evidence of ability to drive safely on the road. While it is possible to obtain these documents without the ability to drive, the data suggests that the possession of these documents by drivers is a better indication of the driver's experience and ability to drive.	R2I, R1IX, R2FG1, R3FG2, R4FG2
Loss from accident (accident losses)	This is a measure of bodily harm, the damage to motorcycle and other losses that come with motorcycle accident. The data shows that drivers are aware of this loss and they warn themselves based on this awareness.	R3FG1, R6FG1
Maintenance	This is treated as one of the causes of accident. In Nigeria, a vehicle is required to be "roadworthy" and there are vehicle inspection officers (VIOs) who arrest drivers if their vehicles were not roadworthy. Using "unworthy" (not properly maintained) vehicle is therefore regarded as a violation. However, while this is regarded as a violation, its contribution to accident was noted to be generally small.	R1I, R3I, R5FG1
Overloading	Another violation referred to in the data is overloading. Commercial motorcycle is used to carry just anything and any size. The enforcement officers generally frown at this, particularly carrying more than one pillion passengers, a habit which is the most common form of commercial motorcycle overloading.	R3I, R1IX, R4IX
Peer influence	This theme describes the effect of drivers' interaction on one another. This sort of influence which often develops into social norm is blamed for the growing consumption of alcohol.	R1I,R3FG1, R2FG2
Over-speeding	Over-speeding connotes moving at a speed that can compromise the safety of the driver. It is a major contributor to accident occurrence. Commercial motorcycle drivers are described as being impatient. Over-speeding is a violation which attracts sanctions.	R1I, R3I, R3FG1, R4FG1, R1FG2, R2FG2, R6FG2
Violations	This is the umbrella word for all violation types. It is used to describe various unsafe and illegal habits that a driver might demonstrate while driving. These dangerous driving habits are	R1I, R3I, R1IX, R4IX, R2FG1, R3FG1, R2FG2

Descriptive code	Meaning	Respondent
	mostly treated as violations by the police who would want to arrest for any and every thing. For example, a passenger who talks to the driver while driving has committed an offence and can be prosecuted. The respondents agreed that the greater percentage of accident is caused by one variant of violation or the other.	

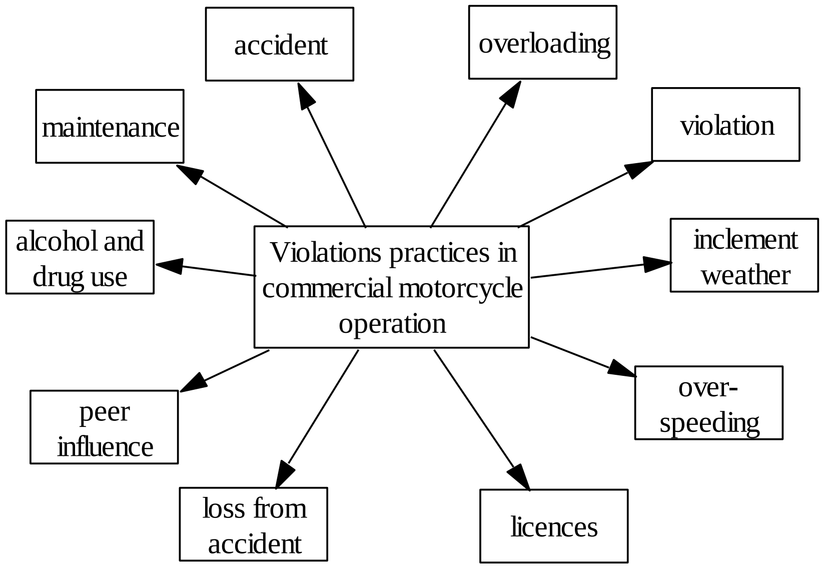

Figure 8.4: Descriptive codes under violation practices in commercial motorcycle operation

(The graphical display in figure 8.4 indicates that the ten codes surrounding the thematic statement at the centre are classified under it)

8.6.1.4 Training in commercial motorcycle operation

This theme represents one of the major issues faulted for the seriousness of the safety problem in commercial motorcycle operation. Generally, drivers were viewed as mostly untrained. The following comments from the interview data show this.

> *"No training opportunity for them oh… When there is no training opportunity, how will they know? That is why we say okada[22]; they don't know where to overtake; where not to overtake." R4IX*

> *"Someone took me out and trained me in riding on one morning. By the evening, I started to ride okada." R2FG1*

Respondents R3IX and R4FG1 noted that some drivers did not attend training/ safety orientation programmes. Respondent R2FG1 indicated that some drivers were not willing to commit time for training. Respondents R3IX, R4IX, R4FG1 and R2FG1

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[22] Okada is the local name for commercial motorcycle

indicated that there were some (but ad hoc) training opportunities which drivers could avail themselves of.

Table 8.6: Relevant codes in commercial motorcycle driver training

Descriptive code	**Meaning**	**Respondent**
Available spare time	This refers to the free time resource available to commercial motorcycle drivers. The data shows that some drivers are always working and would not have time to attend safety education orientations or drivers' union meetings where safety tips are shared. This theme therefore captures the concept that the more a driver works, the less time he has to attend to other non-work issues affecting commercial motorcycle operation.	R1I, R4FG1,
Availability of training opportunity	This issue comes up throughout the data. It shows that there is no training scheme in place for motorcycle mode. Notwithstanding, a driver is expected to master the art of driving before applying for a driver's licence. While there is no training scheme, the data shows that there are some safety education schemes available for drivers to attend and learn from. These schemes are however not usually well attended.	R3IX, R4IX, R2FG1, R4FG1
Ignorance	Another factor well mentioned is the level of ignorance of drivers about the use of roadway, the meaning of road signs and the information contained in the Highway Code. Many drivers are said to be completely ignorant of driving code.	R1I, R4IX, R2FG1
Participation in training	This represents the fraction of drivers who are actually getting trained, who have attended or are attending drivers' safety education program. Training as it appears in the data covers two schemes. The first is learning how to manoeuvre the motorcycle. The other scheme is learning about the use of roadway and the laws that guide its use. What is currently available, according to the data is the second scheme (and it is advisory, not mandatory). The data shows that many of the drivers don't turn up for safety education. It further shows that some drivers don't believe they need it. Some however want such trainings to be undertaken and believe it can reduce safety problems. Both types of training are however important as the data shows that if more of the drivers undergo training of both types, safety will improve.	R3I, R3IX, R4IX, R4FG1, R4FG2,
Willingness to give time for training	The data shows that commercial motorcycle driver's work with time and they always hurry. They are also reluctant to share their time with anything. This unwillingness to share their time with anything is what affects their willingness to give time for training. This is in spite of the fact that many of them are ignorant. The data notes that some probably do not know the importance of training. To them, they have come just to make money and do not care about safety laws.	R1I

Moreover, respondent R1I was of the opinion that drivers were not interested in training. But respondent R4FG2 called for help with respect to training drivers and requested that all drivers should be trained. Similarly, respondent R3I noted that people like to learn and would want to participate if they were aware of training. Both respondents R4IX and R2FG1 acknowledged that the level of ignorance was very high in the system and that drivers needed to train. But respondent R3I suggested that training should take minimal time and be cost friendly to the drivers. Codes around training are described in table 8.6 while a graphical display of these codes is shown in figure 8.5.

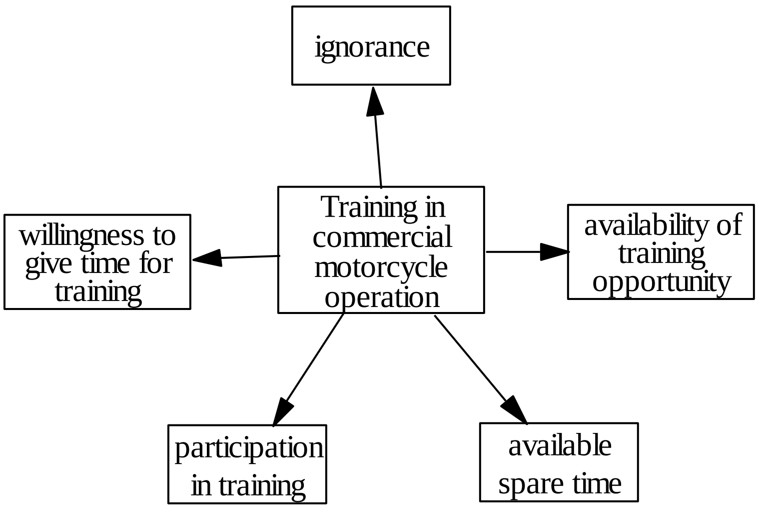

Figure 8.5: Descriptive codes in commercial motorcycle driver training

(This graphical display above indicates that the five codes surrounding the thematic statement at the centre are classified under it)

8.6.1.5 Enforcement and regulation in commercial motorcycle operation

In this section, the problem of lack of effective legal framework on the operation of commercial motorcycles is captured (R4IX). The data also notes that deterrence effect of sanction was low (R1I). Some of the respondents in the enforcer's division complained about the lack of adequate motivation and equipment for officers (R1IX and R4IX). They however noted the increasing size of enforcement workforce (R1IX, R4IX). They also complained about the interference with the course of justice by the politicians. However, other respondents complained about corruption in enforcement operations (R1I, R3I, R3IX, R2FG1, R6FG1 R2FG2 and R3FG2). Some respondents further noted that drivers always wanted to dodge arrest (R1IX and R2FG1). Some of the respondents nonetheless expressed faith in the potentials of the enforcement agencies and pleaded with them to do a good job to improve safety (R2FG1, R4FG2, R3FG2 and R4FG2). Finally, respondents R4IX, R2FG1, and R2FG2 noted that the road environment was not safe and that other road users contributed to commercial motorcycles' safety problem. These codes are shown and described in table 8.7 and represented graphically in figure 8.6.

Table 8.7: Relevant codes in enforcement and regulation of commercial motorcycle operation

Descriptive code	Meaning	Respondent
Corruption	Corruption is the undue influence on the process of enforcement that adversely affects the deterrence effect of sanctions. It includes the conduct of enforcement in a manner that reduces the seriousness of violation. Corruption mostly manifests as the enforcement officer asking a driver for money or to accept money from a driver in place of prosecuting him when alleged for a violation. It also manifests as drivers using their (political) contacts to evade prosecution. An informal discussion with a driver noted that framing also takes place where drivers are simply arrested for no offence in what is called "general raid".	R1I, R3I, R3IX, R2FG1, R6FG1, R2FG2, R3FG2
Deterrence	This theme represents the effectiveness of sanctions against violations in commercial motorcycle operation. Deterrence means the level to which drivers are discouraged from committing violations. Deterrence is the tendency to refrain from committing violations.	R1I, R3I
Dodging arrest	Refers to drivers' habit of fleeing enforcement officers. This happens in the form of not wanting to drive when/ where police posts are mounted as well as retreating when police posts are sighted ahead while on the road. The data shows this habit to be present and risky as well.	R1IX, R2FG1, R3FG2
Enforcement coverage	This is used to describe monitoring of traffic by the enforcement officers in the various enforcement agencies. The data shows how the drivers perceive enforcement process and the manner by which enforcement is conducted. It suggests that the enforcement process is not very effective and that drivers do not see officers as genuinely interested in improving deterrence. In the data, enforcement officers are pleaded with to jettison corruption and do their job well.	R1IX, R4IX,
Other road users	Are all others on the roadway except commercial motorcycle drivers. They include pedestrians and other vehicle drivers. The data points to this group of people as contributing to commercial motorcycle safety problems.	R3I, R41X, R2FG1, R2FG2
Political influence	This is used to describe the intervention of political office holders in the conduct of enforcement and prosecution. Drivers often use their political contact to evade prosecution when arrested for a violation. The data shows that this contributes to the difficulty in improving deterrence.	R1IX, R3IX, R4IX
Probability of detection	This is used to denote an encounter with an enforcement officer while driving on the road. It can take the form of being stopped for a check and found to have violated a traffic rule, and then moved to the police station. The driver might also be asked to make some payment on the spot and released to go. It can also mean an officer simply stopping and asking a driver for money, perhaps to buy potable water.	R1I, R1FG1, R4FG2
Prosecution	This is used to describe the legal form of implementing sanction on a driver caught for a violation. The data shows that the most common form of sanction is fine. It also indicates that violators can be charged to the court of law. Nothing is said about the experience of prosecution by any of the drivers in the data, suggesting that the actual experience of prosecution is rare	R1I, R1IX, R2IX

Descriptive code	Meaning	Respondent
	despite the high level of violation. But in the informal discussions held with the drivers after the fieldwork, some recalled the experience of paying fine occasionally and paying officers off in most instances.	
Regulatory issues	Refers to guiding policy on the manner of organising, integrating and managing commercial motorcycle operations as well as required monitoring operations.	R1I, R3IX, R4IX
Risky road environment	This describes the external risk drivers are subject to while driving on the road. External risk is used to denote risks that are not caused by the driver himself. Examples include poor road design, failed road portions, and risks caused by other road users.	R3I, R41X, R2FG1, R2FG2

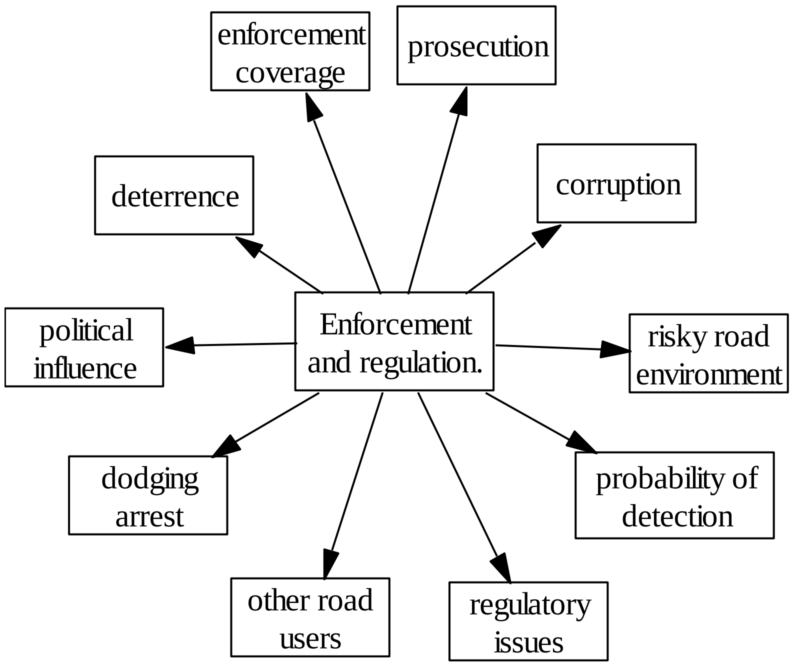

Figure 8.6: Descriptive codes in enforcement and regulation of commercial motorcycle operation

(This graphical display indicates that the ten codes surrounding the thematic statement at the centre are classified under it)

8.6.2 How are these themes related to one another and what does the data say about them?

Similar to section 8.6.1, this section deals with the demands of stages 12 and 13 of figure 8.1. It provides a description of the outcome of the analysis for the purpose of writing up the findings. The findings reported here are the causation codes that emerged from the data. They are how the descriptive codes presented in section 8.6.1 are related to one another as found in the data. These codes are grouped under five thematic statements similar to section 8.6.1. One of the themes (the third theme:

Violation practices in commercial motorcycle operation) is however broken down to two to make the themes six in all. Under each theme, two tables are presented to explain the description covered in the theme. This first table provides a matrix of respondents' who mentioned the cause-and-effect codes listed on the tables while the second table describes what these causation codes mean and provide some quotes to support the given meanings. A graph (causal fragment) that combines all the links is provided following the tables for each theme. A descriptive summary of how the causal links join together is also provided in each case. This summary is very similar to section 8.6.1 but has more emphasis on attribution.

Finally, in a manner similar to section 8.6.1, what are presented here are the codes derived from the data as said by the respondents rather than the researcher's interpretation of data. The researcher's interpretation is treated in sections 8.7.

8.6.2.1 The commercial motorcycle trade

Table 8.8 is a matrix showing causation codes obtained under this theme - **the commercial motorcycle trade**. In table 8.9, the causation codes are described and supporting quotes are included. These codes are joined together in a manner similar to causal fragments (mentioned in section 3.4.3.1). The following description explains the relationships in the graph (causal fragment).

The data shows that the unregulated nature of commercial motorcycle trade is one reason why unqualified people joined and became drivers. This view was held by both the enforcer and the expert divisions (R1I, R1IX and R4IX) while the operators' division mainly acknowledged that some drivers were not qualified (R5FG1 and R4FG2). Some of the areas where poor regulation manifested included licence acquisition (R1IX), vehicle and driver certification requirement for public service (R4IX), rules on mode of operation (R1I, R1IX and R4IX), and driver's training (R1I and R4IX). A respondent from the enforcer's division described drivers as former touts and street urchins who were now surviving by working as commercial motorcycle drivers. A respondent from the operator's division confirmed this perception and noted that it was a stigmatising perception that affected some drivers' concentration while driving and caused some to end up in an accident (R1FG2). He went further to note that some drivers were intentionally engaging in high-risk behaviour feeling they were not taken serious or treated with dignity by the society as shown in this quote

> *"…this okada job that some people do, they took it as a job of last resort; so some are not happy…some believe they may never become*

> *anything in life. So they think whatever becomes of them in the course of riding, they are less concerned. That is why some speed dangerously, hoping that something bad may happen to them" R1FG2*

This notwithstanding, the data notes that commercial motorcycle transport started well with mature adults who worked on part time basis (R2I and R2FG1). These were motorcycle owners with substantial experience in driving. The trend had however taken a different turn now: for "s*ome drivers, the first day they ever handled a motorcycle was the day they started to operate as okada drivers*" (R4FG2). This respondent said many drivers did not have any training whatsoever these days. He further noted that this was one of the reasons for the safety challenges of commercial motorcycle operation. Thus, some respondents from the operator's division mentioned that drivers usually required experience to improve their safety driving (R2FG1 and R6FG2). They acknowledged that, unfortunately, there would have been many accidents before gaining this experience (R6FG2 and R2FG1).

Moreover, the data shows that drivers were mostly from a humble background with no means to afford a motorcycle (R1I, R1IX). So they mostly started with rented motorcycles or obtained a motorcycle by hire-purchase (R1I, R2FG1). Because of "high profit, low cost" (R1I) nature of the trade, more new drivers were coming up. This rising number of drivers was raising competition for passengers amidst drivers (R1I, R2FG1). In addition, these drivers who started off with rented or hire-purchase motorcycles would want to pay up quickly for the motorcycle and become owner-operators (R1I). This often results in risky and dangerous behaviour observed within the system as drivers would then set high target income which often required working more than normal (ID, R1I, and R2FG1). The resulting working condition pushed some of them to violate laws (R1I, R1IX, and R6FG2). Respondent R2FG1 noted that these hired operators were less safe than others. Nevertheless, those joining commercial motorcycle were not only the unqualified illiterates, more educated people, including graduate and students of tertiary institutions were in the trade too (R1I, R2FG1, and R6FG1).

Finally, the data hinted that the use of old second hand motorcycles could be contributing though insignificantly to safety problem (R1I). This is because almost all respondents from the expert and enforcer's divisions (R1I, R3I, R1IX and R2IX) acknowledged that accidents that result from vehicle malfunctioning (mechanical failure) were not significant in number and that the major problem with drivers was violation. Furthermore, the drivers revealed that most motorcycles were now acquired new in recent times unlike previously when most of them were second hand. Figure 8.7 represents the description above.

Table 8.8: Matrix showing responses about commercial motorcycle trade

Cause and effect codes		Respondent divisions		
Cause	**Effect**	**Enforcer**	**Expert**	**Operator**
Experience	Risky and dangerous driver			R2FG1; R6FG2
Free and easy entry	Risky and dangerous drivers	R1IX, R2IX, R4IX	R1I; R2I	R5FG1; R2FG2; R3FG2; R5FG1; R6FG2
Free and easy entry	Accident	R4IX		
High job returns	Number of Drivers	R1IX	R1I	R2FG1
High job returns	Target income		R1I	R2FG2
High job returns	Hire-purchase/ rent	R1IX		
Hire-purchase/ rent	Risky and dangerous drivers	R1IX		
Hire-purchase/ rent	Violation	R1IX		R2FG1; R6FG2
Hire-purchase/ rent	Target income	R1IX		R2FG1; R7FG1; R6FG2
Hire-purchase/ rent	Repayment/ earning pressure	R1IX		
Hire-purchase/ rent	Number of driver		R1I	R2FG1
Hire-purchase/ rent	Accident		R1I	
Hurrying	Risky and dangerous drivers			R4FG1, R6FG2
Number of driver	Violation	R1IX,	R1I	
Number of driver	Participation in training		R1I	
Number of driver	Accident	R4IX	R2I	
Number of driver	Competition		R1I	
Number of driver	Risky and dangerous drivers		R2I	R4FG1
Number of driver	Hire-purchase/ rent			R2FG1
Motorcycle age	Accident		R1I	
Risky and dangerous driver (Hurrying)	Violations (Over-speeding, Maintenance)	R1IX, R2IX,	R1I, R2I, R3I,	R1FG2
Risky and dangerous driver (Hurrying)	Accident	R1IX, R2IX, R3IX,	R1I, R2I, R3I,	R2FG1, R3FG1, R1FG2

Table 8.9: Description of causation codes in commercial motorcycle trade

Causation code	Description	Quotes
Experience affects risky and dangerous driver	A driver is able to drive more safely as he gains more years of experience.	*"Now about the passengers, you see the passengers we refer to. They confuse us a lot. You could have been going, then the passenger, probably because his/her cap gets removed in motion, will then tell you to stop. For an okada driver who is a novice he would turn off the road immediately and there could be a problem." R2FG1*
Free and easy entry affects risky and dangerous drivers	The open, unregulated nature of commercial motorcycle trade is responsible for the way unqualified and unsafe drivers are joining and working	*"Increasing unemployment turned young male youths who were previously mainly street urchins and political thugs to okada business as a means of livelihood." R1IX*
Free and easy entry affects accident	Accidents happens often because the trade lack proper control of drivers' operations	*"Someone took me out and trained me in riding on one morning. By the evening, I started to ride okada." R2FG1*
High job returns affects number of drivers	Because working as a commercial motorcycle driver guarantees daily income and earnings above the national minimum wage, many more people are becoming drivers.	*"Okada doesn't recognise any rule, any sign, well because of ignorance you have said here. Most of them are ignorant, total illiterate: they cannot write; most of them were drivers before, farmers before in the villages. They just come to make money they believe there's money in okada. Most of them are artisans. They're ignorant, they use alcohol and they violate a lot." R1I*
High job returns (and drivers' poor economic background) affects hire-purchase/ rent	Poor background of drivers is the reason many of them start with rented motorcycles or take a motorcycle on hire-purchase.	*"It is also a means of livelihood to many. The riders are usually poor people with no other means. They are average, or low cadre people in the society. This is one of the reasons why many riders are on hire-purchase. Some others are got as political gifts, as a form of appreciation from politicians after elections" R1IX*
High job returns affects target income	Because it is possible to make so much from commercial motorcycle, drivers tend to make high target.	*"So the cost to profit margin is much: the cost so low; the profit so high. So the tendency is to want to make so much money on your own side so as to buy your own okada very soon and it causes lot of havoc: over-speeding, overloading…"R1I*
Hire-purchase/ rent affects risky and dangerous drivers	There is higher tendency that a driver who takes hire-purchase or rents his motorcycle will be more risky and dangerous.	
Hire-purchase/ rent affects accident	The more the number of motorcycles on rent and hire-purchase, the more likely the number of accidents.	
Hire-purchase/ rent affects violation	Those whose motorcycles are not self-owned are more prone to committing	*"Because they mostly obtain their motorcycles by hire-purchase. Some others obtain their motorcycles as politician gifts. Both groups violate a lot. So many*

Causation code	Description	Quotes
	violations.	*motorcycles are abandoned with the police. Those who save to own their motorcycles are more safety conscious." R1IX*
Hire-purchase/ rent affects target income	When a motorcycle is not self-owned, the driver is more likely to set (usually high) target income.	*"The reason why some over speed is because there are some people, they will project to earn N3000 and things like that, N4000 and like that or that the machine is rented from someone and the lender expect the machine at a set time, say 4pm . This driver will want to make his profit and rent charges before returning the machine. So that's the reason why they overtake like that." R6FG2* *"For those on instalment, supposing there are 5000 okada drivers, those on instalment would be about 4,500. There are actually many young school leavers migrating from the rural areas to the city. When they come, they cannot afford a machine and they need one to become a driver. There are readily available dealers. For example, if you come to me today that you need a machine, I know dealers I can take you to who would readily offer you a motorcycle at the rate of N180, 000. Repayment would now be your problem. Now you won't want to fail repayment; you'd also want to pay fees, and do many other things." R2FG1*
Hire-purchase/ rent affects earning pressure	Those who do not own their motorcycles are under constant pressure of repayment required by the motorcycle lessor or seller.	
Hire-purchase/ rent affects number of driver	The rapid growth in the number of drivers stems from the ready availability of motorcycles for rent and hire-purchase.	
Number of driver affects participation in training	As more drivers are joining, fewer of them are trained and/or participating in training.	*"Some drivers, the first day they ever handled a motorcycle was the day they started to operate as okada drivers. The first day they would ever ride motorcycle, and started to operate as okada drivers." R4FG2*
Number of driver affects violation	Violations have been increasing as the number of drivers is increasing. This also applies to the use of alcohol and it leads to other violations	*"But when government now see that people are rushing to the business, what government did was that each state, they are now accommodating it according to their own regulation according to the state. So you have states who give them a sort of bye-law, a sort of enactment to operate so and when people saw that they were causing a lot of havoc, especially accident on the road, some states withdrew from the programme: they banned them that they should not operate again in their state." R4IX*
Number of driver affects accident	Accident occurrence increases with increasing number of drivers	
Number of driver affects competition	As the number of drivers increases, there is increase in the struggle to obtain passengers	*"Sometimes, they compete in speed: "who will be number one?" - for the sake of passenger picking. They want to be there to pick passengers ahead of the other person." R1I*
Number of driver affects hire-purchase/ rent	As the number of commercial motorcycle drivers increase, so is the number of motorcycles on hire-purchase and rent.	*"In 1996 when I started okada, … Then, okada drivers were mainly matured adults and elderly people who owned machines and operated okada to fetch some additional income …* (and now) *For those on instalment, supposing there are 5000 okada drivers, those on instalment would be about 4,500. There are actually many young school leavers migrating from the rural areas to the city. When they come, they cannot afford a machine and they need*

Causation code	Description	Quotes
		one to become a driver. There are readily available dealers." R2FG1
Number of driver affects risky and dangerous drivers	As the number of commercial motorcycle drivers is growing, so is the number of unqualified and dangerous drivers.	*"Okada transportation was a very good (transport) system when (it) started. Everybody enjoy(ed) it because (okada) (could) carry you to the nooks and crannies of (the city). Then it's easily available and very fast. But as it goes on now, people abuse it because some riffraff have joined the drivers, the commercial drivers. They involve themselves in the smoking of Indian hemp which I've shown you" R2I*
Hurrying affects risky and dangerous drivers	Many of the drivers are impatient. This lack of patience is the reason why many of them are risky and dangerous.	*"The major problem of commercial motorcycle drivers is patience. They are always impatient. So they overtake dangerously and this causes a lot of accidents. They manoeuver dangerously and lack lane discipline. They are over-confident, some use drugs and alcohol and so ride dangerously." R2IX*
Risky and dangerous driver (hurrying) affects violations	Many of the violation committed are done by drivers who manifest risky and dangerous habits	
Risky and dangerous driver (hurrying) affects accident	The number of accidents occurring is influenced by the share of drivers who manifests unsafe and risky habits in the system.	*"There are instances when you drive in the night you see an okada man with torchlight he will be riding in the mouth. Is that not stupid? We have seen cases where okada had an accident and the touch-light entered his mouth. He put it in the mouth... damaged all the buccal cavity" R2I*
Second hand motorcycle use (motorcycle age) affects accident	Some of the motorcycles in use are second hand, old and poorly maintained, and this causes accident	*"Most of them, they're substandard machines. 15years "tokunbo", mention "tokunbo". "Tokunbo" means used. I've not seen any of them using anything new. 98% of okada operators use what we call used vehicles/machines, and these machines, some of them can be as old as 15, 20 years old before they're brought to Nigeria" R1I*

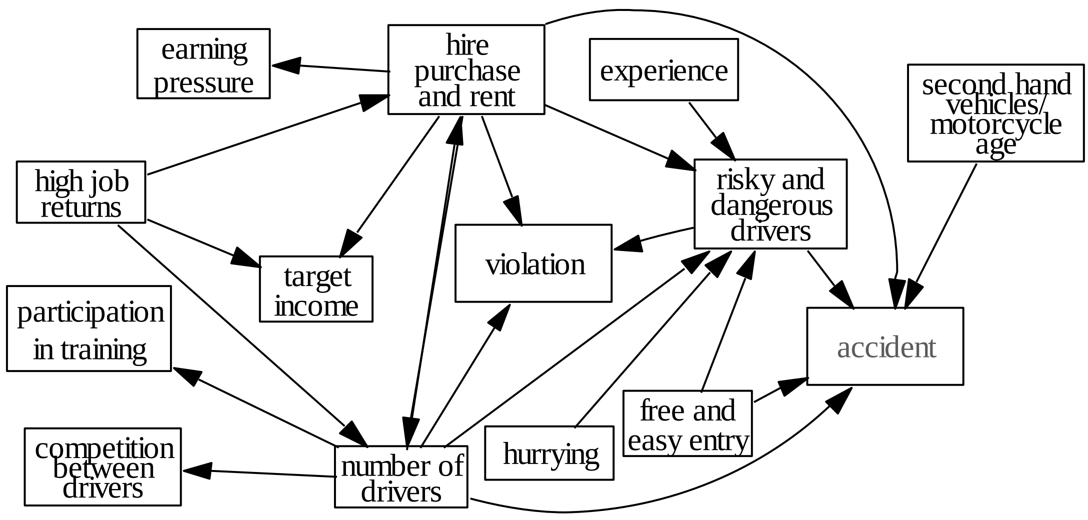

Figure 8.7: The commercial motorcycle trade causal links

(A causal fragment representing driver population characteristics)

8.6.2.2 Life as a commercial motorcycle driver

This section describes money related codes in commercial motorcycle trade. The data shows that drivers (particularly those on rent and those on hire-purchase, but also many on thrift savings) were always under intense pressure to make as much money as possible daily (R1Ia and R2FG1). An informal discussion with a driver after the fieldwork indicated that those on hire-purchase did not participate in thrift savings as their priority was to pay up their motorcycle cost first. But those on rent worked to sustain themselves, to pay their rent as well as to save to buy their own motorcycles (R1I and R2FG1). This pressure of work (earning pressure) caused some drivers to have to work more than normal (R1IX and R2FG2) and would require more strength (**additional work capacity requirement**) to work more (R1I, R3I, and R1IX). This was because drivers' income depended largely on the amount of work they did. The data shows that many drivers resorted to over-speeding to make more runs and earn more (R1FG1, R2FG1, R3FG1, R4FG1, R2FG2, R3FG2 and R6FG2). Some other drivers engaged in alcohol consumption and the use of capacity enhancing drugs to provide support for the increased strength (**additional work capacity requirement**) they required for work (R3I, R3IX, R1FG2, R3FG2). Some drivers went as far as to ignore essential things including safety education programmes and spent all their time working (R4FG1). So, some respondents noted that it was usual to conclude that the trade was strenuous and should be taken as a transitory career (ID, R4FG1).

Furthermore, respondents R1IX and R2FG1 noted that the financial burden that resulted from some payments drivers needed to make made them unwilling to meet up with some legal obligations that required spending money (**spending aversion**):

> *"For example, if I've gone to take a machine on instalment and I'm yet to pay up, do you think going for additional expenditure on plate number will be important to me? Or if I have taken a loan of N80, 000 from contribution and a machine sells for N115, 000 and what I have cannot fully pay the machine cost, will raising money for number plate be important to me? I'll be more interested in fully paying up for the machine." R2FG1*

A respondent from the enforcer's division corroborated this by saying:

> *"They don't have the money for license and would want to dodge … arrest all the time." R1IX*

In addition, drivers would fail to make their vehicles "roadworthy". A roadworthy vehicle was one that was in good working condition. But some driver would use worn tires and brakes, and would not replace broken lights (R1I, R5FG1). This was noted by one of the respondents who stated that there had been accidents where drivers had no headlamp and were using handset torch to drive motorcycle at night (R2I). This **spending aversion** was a cause of accident. The above quotations, for example, shows that when drivers did not possess a valid license or protective helmet they fled from enforcement officers. Fleeing officers (**dodging arrest**) was generally echoed to often result in accident (R2FG1, R2FG2 and R3FG3) and the accident record with one of the enforcement agencies suggests this. Table 8.10 shows the matrix of respondents and the causation codes while more quotes about these codes are provided in table 8.11. These causation codes are joined together in figure 8.8.

Table 8.10: Matrix showing responses about the commercial motorcycle driver

Cause and effect codes		**Respondent divisions**		
Cause	**Effect**	**Enforcer**	**Expert**	**Operator**
Accident	Drivers' income		R1I	
Accident	Loss from accident			R3FG1
Additional work capacity requirement	Alcohol and drug use	R3IX	R1I, R3I	R2FG1; R3FG2
Cost of operation	Spending aversion/cutting corner (violation)	R1IX	R1I, R3I	R2FG1; R6FG1
Earning pressure/ Repayment	Violation (Hurrying, Over-speeding)	R1IX, R2IX,		
Earning pressure/ Repayment	Additional work capacity requirement	R1IX		R2FG1; R4FG1
Spending aversion and cutting corner	Dodging arrest	R1IX		R5FG1, R2FG1
Target income	Spending aversion cutting corner			R5FG1
Target income	Earning pressure/ Repayment		R1I	R2FG1; R5FG1; R2FG2; R6FG2
Target income	Addition work capacity requirement		R1I	R2FG1
Target income	Violation	R3IX		R1I
Target income	Risky and dangerous driver	R3IX	R1I	R3FG1; R2FG2
Thrift savings	Target income			R2FG1; R4FG1; R2FG2
Thrift savings	Additional work capacity requirement			R2FG1; R4FG1; R2FG2
Thrift savings	Risky and dangerous driver			R2FG1; R2FG2
Work capacity	Drivers' income		R1I	R2FG1; R4FG1, R2FG2; R6FG2
Work capacity	Available spare time		R1I	

Finally, accident was costly and the commercial motorcycle union leaders normally warned drivers to remember the cost of accident and to exercise some restraints (R3FG1 and R6FG1). Moreover, the drivers' union normally levied all members and some members resented this levy and would not want to pay (R6FG2). In the attempt to dodge, there had been instances of accidents. A respondent from the expert group indicated that the levy was relatively high because the union assisted members involved in an accident from the proceeds (R1I). But respondents who were union leaders insisted that the amount was fair (R2FG2).

Table 8.11: Description of causation codes relating to the commercial motorcycle trade

Causation code	Description	Quotes
Accident affects drivers' income	Accident results in substantial monetary cost which is borne by the drivers: drivers pay union levy the amount of which is partly influenced by the number of drivers involved in an accidents in the system. This increases the cost of operation and reduces drivers' income.	*"When they are at fault, they allow whoever has collided with them to go free; they'll take care of him (their member). Is (It's) from the union purse. That's why they collect a lot of money on the road from themselves." R1I*
Accident affects loss from accident	Whenever a driver is involved in an accident, it often results in monetary losses due to bodily hurt and material damage.	
Additional work capacity requirement affects alcohol and drug use	Some drivers resort to the use of alcohol and other capacity enhancing drugs to enable them work longer	*"Yes, some of them they don't even only take alcohol. They take other drugs and make them, performance enhancing drugs, that make them to be able to work for long hours and those things also have implications on the brain system, the ability to think, and so forth which they don't know." R3I*
Thrift savings affects target income	The contribution to thrift savings drivers make is one of the reasons why they set high target income.	*"The most serious of this is that they should reduce their savings. These savings are too much. That's why some will almost kill themselves speeding. Some would even be making savings in 5 different places and will want to meet up in all the five places and not fail. So this is my thinking. If you are able to do some adjustment about the savings, then accident would reduce" R2FG2*
Thrift savings affects additional work capacity requirement	Meeting up with regular savings might require the driver to work longer/more than when not making contribution.	
Thrift savings affect risky and dangerous driver	Many of the drivers involved in thrift savings drive dangerously to meet up with what they have to pay.	
Cost of operation affects spending aversion/cutting corner (violation)	The cost of operation for a driver affects his willingness to spend on essential things. As a result, drivers would want to cut corners and look	*"If you look at my machine there, and the number plate, the number plate is about a year old. If you look at Lagos or Abuja number plates more recently collected,*

Causation code	Description	Quotes
Spending aversion affects dodging arrest	for cheap (and occasionally fake) items/ vehicle documents or even not obtain/maintain legal and necessary items. This is a form of violation; so drivers start to dodge enforcement officers.	*they're faded. Whereas, if I wash mine which is older, it would look newer. So sometimes, they fall into the hands of cheats and would have to be running from the police."R2FG1*
Earning pressure affects additional work capacity requirement	A driver who has repayments to make might be required to work longer/more than when not having repayments to make.	*"Many of okada drivers as you see us make contributions (savings). For example, my contribution on Sunday might be N5000 and I have not started to make the money. I might then wait until Friday before I start to look for N5000. Then I would be speeding (rushing), though I am not on instalment. But I have to meet up with my contribution. This can spark having to hurry and rush and speed as I must not fail my contribution. At times, these issues cause it." R2FG1*
Earning pressure/ affects violation (hurrying, over-speeding)	Drivers who have repayments to make usually over-speed and commit such other violations in the bid to meet up with the repayment	
Target income affects earning pressure	Drivers who have target to make are under pressure to make it	
Target income affects spending aversion cutting corner	Drivers often delay expenditures necessary for safe operation because of the need to meet up with a target income.	*"But because of the projected earning, he will still be managing the brake. By the time the brake is no longer working, an accident might occur. " R5FG1*
Target income affects addition work capacity requirement	Drivers who set targets on what they want to earn often have to work harder or work longer to be able to meet this target.	*"If somebody knows that, when an okada driver want to make regular contributions to the tune of N10, 000 weekly? There are some who propose N15, 000 weekly contribution just from okada trade: they still need to spend on fuel, replace worn tires, buy engine oil. So, such person is trying all means to meet the regular contribution and that's would be his goal... So an okada driver should be able to examine himself to sensibly decide what his weekly contribution should be, (based on his safe capacity) - whether it is N2000, or N1000. Something he knows he can earn without being under pressure while riding." R2FG2*
Target income affects risky and dangerous driver	Drivers often set a target on what to earn and when the target is high, it influences their driving behaviour and causes them to be less cautious on the road.	
Target income affects violation	Drivers who set (usually high) target income often violate to meet up with this target.	
Work capacity affects drivers' income	The more time a driver commits to work, the more money he earns at the end of the day	*"Whenever we call for a meeting, it's only about half of us who are able to attend. Those working/operating in Ado, only about half of them are able to come. The other half wouldn't come. They'll be away operating to raise enough money for their contributions and other financial needs... So for this reason, as they are more interested in making money, since when we call for a meeting, we would expect 5000+ in attendance but only 2000 people/drivers would come. So 3000 drivers stay away." R4FG1*
Work capacity affects available spare time	The amount of work a driver does affect how much time he has for other things	*"It's those who start early who also close late. So there's no discrimination as to whether you're coming part time or not coming part time to the business." R1I*

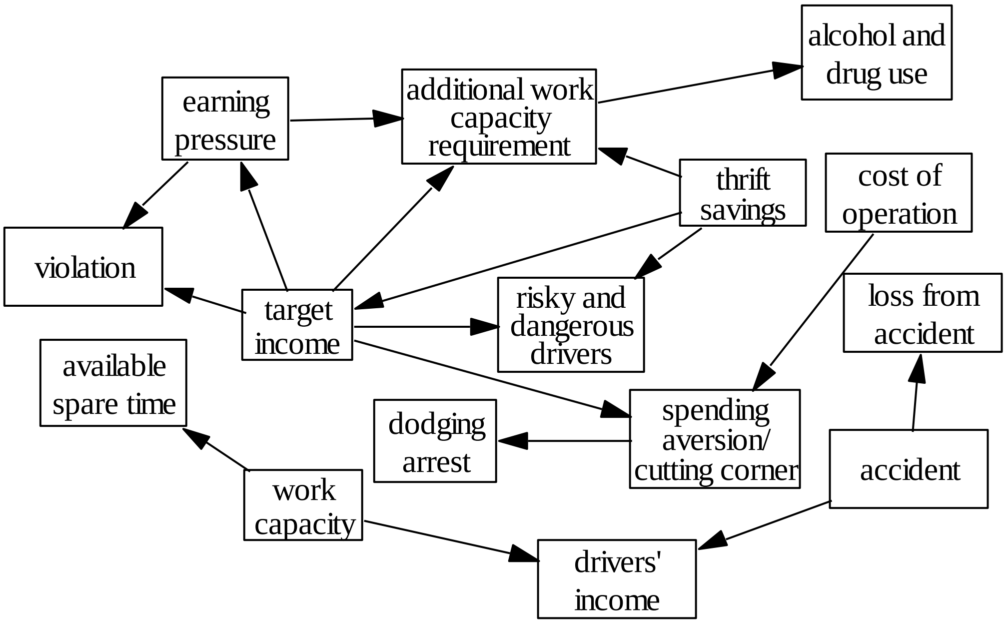

Figure 8.8: The commercial motorcycle money-related causal links

(A causal fragment representing driver population characteristics)

8.6.2.3 Violations practices in commercial motorcycle operation

This section is divided into two. The first covers general violations while the second section concentrate on alcohol and other capacity enhancing drugs. The use of alcohol and drugs is a violation which can normally be subsumed under violation theme. It is however separated to enable the researcher show that it is not just a violation, but a violation that leads to other violations as well as a norm within the system.

8.6.2.3.1 <u>Violations</u>

All respondent divisions agreed that violation was the chief cause of accident and the two most important types of violations mentioned were over-speeding and alcohol. The data also noted that it had been difficult for government/ enforcement agencies to tackle the problem of violation (R1I, R4IX). Respondent (R4IX) further noted that government had not given up and this was one of the reasons why enforcement agencies and officers were growing in number.

However, some respondents were of the opinion that there was some improvement in the system in terms of compliance to law (R1IX, R3FG1, and R6FG1). Respondent R1FG1 noted that there was a higher probability of being arrest if a driver violated. But many drivers have resorted to fleeing enforcement officers after committing a violation (R1IX, R2FG1). Thus, there was still a high level of violation in the system (R1IX, R4IX). Respondents (R1I, R2I, and R1IX) blamed the high violation rate on the fact that the system is free-for-all and all manners of people joined the trade at will. Moreover, this free-for-all system explained why the number of drivers was increasing rapidly (R2FG1).

Finally, violations were often committed out of greed to earn more (R1FG1). However, drivers were being warned regularly to remember the losses that could result from violations and desist from it (R3FG1). Tables 8.12 and 8.13 and figure 8.9 give additional support to the description above.

Table 8.12: Matrix showing responses about drivers' violations

Cause and effect codes		Respondent divisions		
Cause	**Effect**	**Enforcer**	**Expert**	**Operator**
Loss from accident	Violation			R4FG1, R6FG1
Violation	Probability of arrest/ detection		R3I	R1FG1, R6FG1
Violation	Enforcement coverage	R1IX, R4IX		
Violation	Number of drivers			R4FG2
Violation	Accident	R1IX, R2IX, R3IX, R4IX	R1I	R2FG1, R4FG1
Violation	Drivers' income	R1IX, R3IX		R1FG1
Violation	Dodging arrest	R1IX		R1FG1, R2FG1

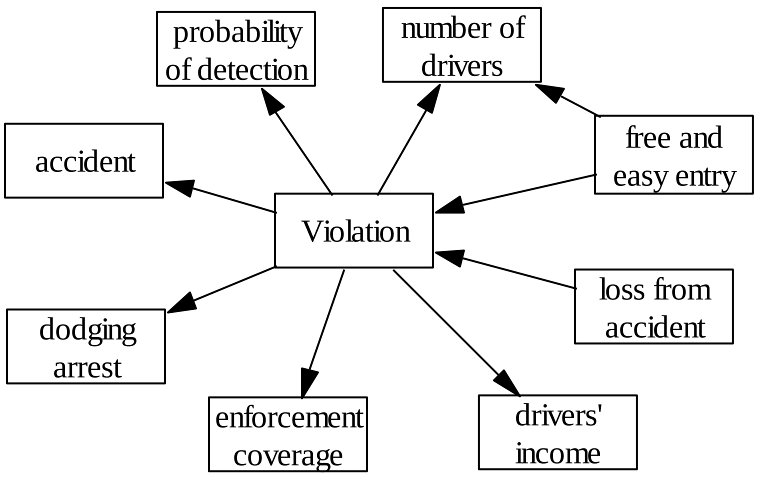

Figure 8.9: Violations causal links

(A causal fragment representing violations themes)

Table 8.13: Description of causation codes relating to violations

Causation code	**Description**	**Quotes**
Loss from accident affects violation	The awareness of the losses that result from accident serves as a deterrence for drivers and can discourage committing a violation	"*Now we meet every month and discuss all these issues you're asking about. And it's been a while now that we have been raising the issues and continue to tell them. But actually, it's like there has been a reduction in the frequency of accident since we started our monthly meeting. So it might be possible that through the (enlightenment) during our meetings, these problems might reduce" R6FG1*
Violation affects number of drivers`	The fact that commercial motorcycle operating system accommodates violators makes it easy for anyone to join. So the number of drivers is increasing	
Violation affects accident	The more violations drivers commit, the more the number of accidents occurring.	*"Almost every one of them (accident) results from violation. That violation will be on rules and regulations. It may be on safety standards, like taking alcohols, this and that" R1I*
Violation affects enforcement coverage	The increasing size of enforcement agencies is as a result of increasing number of violations amidst drivers	*"But thank God, part of the investment on road management by this present administration is this creation of EKSTMA... Because when Mr Governor came, he saw the situation on ground and immediately, he set up a committee and that EKSTMA was set up. … But the only problem is this political influence."*R4IX
Violation affects probability of detection	The probability that a violator would be arrested increases with increasing number of violations	*"Looking at such situations, we admonish our members not to pick two passengers because of police and make sure you have number plates. No police officer would arrest you if you follow this. But when you don't have a plate number and you go ahead to pick two passengers at a time, police would arrest you oh" R1FG1*
Violation affects drivers' income	Many violations which drivers commit are intended to increase their income or conserve it	*"There are other drivers who are simply presumptuous. Though they have plate number, they pick two passengers. The law does not allow this. Only one passenger at a time is allowed. You can pick a passenger, drop him/her, pick another and go your way. But greed, some would say, he might be considering what he would get as fare. So he would say if I'm able to pick two passengers together, I earn more money." R1FG1*
Violation affects dodging arrest	In many instances, drivers dodge arrest due to the violation(s) they commit	*"But if you look at the drivers too, there are some who don't have vehicle number plates. This situation provides a platform for the need to flee from the police." R1FG1*

8.6.2.3.2 <u>Alcohol</u>

Table 8.14: Matrix showing responses about alcohol and drugs use

Cause and effect codes		Respondent divisions		
Cause	**Effect**	**Enforcer**	**Expert**	**Operator**
Alcohol and drug use	Work capacity	R3IX,	R1I; R3I	R4FG1; R3FG2
Alcohol and drug use	Risky and dangerous drivers	R1IX, R2IX, R3IX		
Alcohol and drug use	Violation	R2IX, R3IX	R1I; R2I,	R2FG1; R1FG2; R2FG2; R3FG2; R4FG2; R5FG2
Alcohol and drug use	Accident	R1IX, R3IX	R1I, R3I,	R1FG1; R3FG1; R4FG1; R5FG2
Inclement weather	Violation (alcohol drug use)			R4FG1; R1FG2
Peer influence/norm	Alcohol drug use	R2IX	R1I	R2FG1; R3FG2

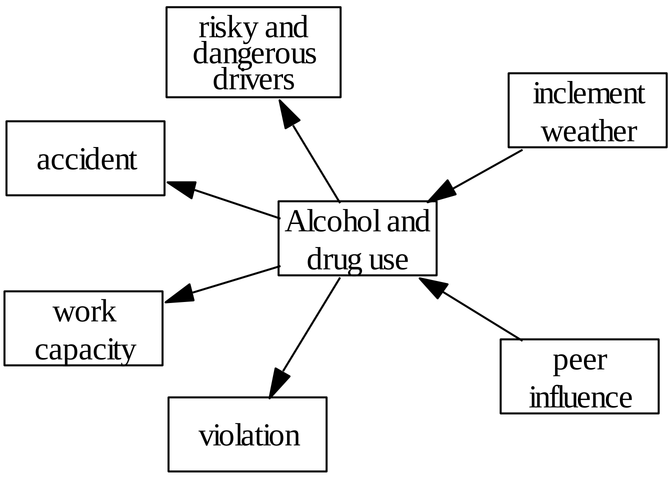

Figure 8.10: Alcohol and drug causal links

(A causal fragment representing alcohol and drug use themes)

All respondent divisions agreed that alcohol use caused accident a lot. Many also acknowledged that some other capacity enhancing drugs were in use too (R2I, R3I, R1FG1, R2FG1). Both drivers who took alcohol and those who did not alluded to the dangerous impact of alcohol and the prevalence in its use. Respondents from the operator's and enforcer's division also remarked that many of the risky and dangerous habits drivers manifest were caused by the use of alcohol (R1IX, R2IX, R3IX, R2FG1, R1FG2, R2FG2, R3FG2, R4FG2 and R5FG2). Those who took alcohol blamed the sales of alcohol next to commercial motorcycle stops. Some respondents also offered reasons adduced by users to include the use of these substances as a defence against inclement weather and to increase ability to work better or longer or be stronger (R4FG1, R1FG2, R2FG2, and R5FG2). Finally, all divisions of respondents were worried that majority of drivers used alcohol: a respondent from the operator's division said about 90% of drivers were drinking; respondents from the expert's and enforcer's divisions quoted values between 60% and 80%. Respondents (R1I and R2FG1) acknowledged that peer influence increases alcohol use. More support for this coding is provided on tables 8.14 and 8.15 and the description is illustrated with figure 8.10.

Table 8.15: Description of causation codes relating to alcohol and drug use

<table>
<tr><th>Causation code</th><th>Description</th><th>Quotes</th></tr>
<tr><td>Alcohol and drug use affect accident</td><td>The use of alcohol and other capacity enhancing drugs increases accident rate.</td><td>"Those who drink most are those who are involved in accident most on the street …" R5FG2</td></tr>
<tr><td>Alcohol and drug use affect violation</td><td>Drivers who use of alcohol and other capacity enhancing drugs tend to commit more violations.</td><td rowspan="2">"There are people who wake up in the morning and turn to drinking joints. These things too control (influence) many such that they are found to speed abnormally as if there are things worrying them. Really they know that speeding is bad but they are being pushed by other influences to speed" R2FG1</td></tr>
<tr><td>Alcohol and drug use affect risky and dangerous drivers</td><td>The more the use of alcohol and other capacity enhancing drugs, the more risky and dangerous drivers there are in the system</td></tr>
<tr><td>Alcohol and drug use affect work capacity</td><td>The use of alcohol and other capacity enhancing drugs gives drivers more capacity for work</td><td>"Because of drinking, they have energy; they can do things they wouldn't have done normally; they can go to distances they couldn't have gone to; they can talk (anyhow) to people; they can carry heavy loads; they're charged and they're energised, 'energy'". R1I</td></tr>
<tr><td>Inclement weather affects violation (alcohol drug use)</td><td>Inclement weather causes drivers to take alcohol and other capacity enhancing drugs</td><td>"The reason why some take alcohol is that some believe that cold, if they take alcohol, they will not be susceptible to cold." R1FG2</td></tr>
<tr><td>Peer influence (norm) affects violation (alcohol and drug use)</td><td>Drivers influence one another in the use of alcohol and other drugs</td><td>"Sometimes, when you get to some places, okada drivers would park in a number and be drinking." R3FG2
"For example, my members, whenever I am passing by the junctions in the evening, when going home after the day's work, each of them would offer me a sachet of alcohol. I'll collect everything and keep them in my pocket. Do you expect me to throw them away? As I return home, I would take a few sachets, and that way, I have taken alcohol. If it were to be a driver still in operation, how would this affect him?" R2FG1</td></tr>
</table>

8.6.2.4 Training in commercial motorcycle operation

In this section, the training theme is considered. The data shows that drivers' participation in training was important in influencing whether they drove safely or were risky and dangerous in their driving habit (R4IX). Respondent R2FG1 stated that drivers were generally ignorant and R4IX noted that this ignorance was the reason for drivers' violations which made them dangerous. Respondents from both enforcer and operator divisions (R1I, R4FG2) stated that training could help to reduce risky habits. Nevertheless, a respondent from the enforcement division (R4IX) acknowledged that there were no training opportunities for motorcycle drivers, a situation attested to by R1I. A substitute was however being provided in the form of safety enlightenment (R3IX, R4IX, R2FG1, R3FG1, R6FG1). This "training-substitute" was specially designed for commercial motorcycle drivers (R4IX), but R1I, R4FG1 and R3IX mentioned that many drivers were not attending it. An informal discussion with a driver also noted that the very risky ones amidst drivers might not be interested in driver training. Respondent R1I said the reason was that some were so ignorant that they did not believe they needed training. Respondent (R4FG1) said some drivers preferred to work and earn money than to attend events where safety tips would be provided. Those who spent all their time working did not make time for training (R4FG1). However, a respondent from the operator's group suggested that every driver should be trained, that: "… *even we who already know how to ride. We can learn more by retraining. Those who don't know how to ride, they can be trained as well" R4FG2.* Another respondent also noted that people generally would want to learn and drivers might be interested in training if some were organised for them (R3I). It was generally agreed to that many drivers were ignorant (R1IX and R2FG1) and required some form of training (R3I).

Finally, the issue of literate/ well educated people joining commercial motorcycle trade received attention. Respondent R1I was of the opinion that graduates joining commercial motorcycle trade were better off with respect to training than the less educated. The view of respondents from the operator's division was however different:

> "*He (an unemployed graduate) would be feeling that to start okada trade is better than robbery for him. "Let me use the opportunity of okada business", though not knowing anything about okada*" R3FG2

This respondent R3FG2 felt educated new drivers might be at equal or more risk and that school education did not count in commercial motorcycle safety. Tables 8.16 and 8.17 provide additional support for this theme and figure 8.11 illustrates it graphically.

Table 8.16: Matrix showing responses about training issues

Cause and effect codes		Respondent divisions		
Cause	**Effect**	**Enforcer**	**Expert**	**Operator**
Available spare time	Willingness to give time for training		R1I	R4FG1
Availability of training opportunity	Participation in training		R1I	
Ignorance (Level of education)	Risky and dangerous drivers	R2IX, R3IX, R4IX	R1I, R3I	R2FG1, R3FG1, R4FG1, R1FG2, R2FG2, R3FG2, R4FG2
Ignorance	Participation in training	R2IX,	R1I	
Ignorance (Low mentality)	Violation	R3IX	R1I	
Ignorance	Willingness to give time for training	R3IX	R1I	R4FG2
Participation in training	Ignorance	R1IX, R2IX, R4IX	R1I, R3I	R4FG2
Participation in training	Accident	R2IX, R4IX	R1I	R3FG1, R4FG1, R6FG1, R6FG2,
Participation in training	Risky and dangerous drivers	R4IX		R2FG1, R4FG21, R6FG2
Willingness to give time for training	Participation in training	R3IX	R1I	R2FG1, R4FG1, R4FG2

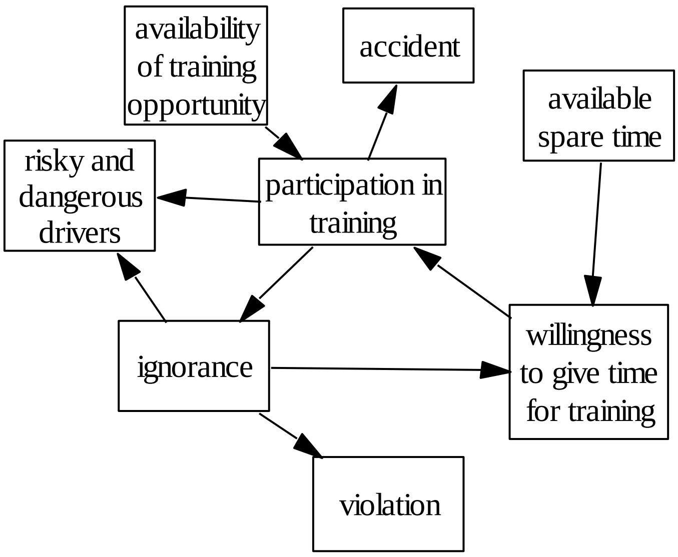

Figure 8.11: Drivers' training related causal links

(A causal fragment representing drivers' training themes)

Table 8.17: Description of causation codes about drivers' training

Causation code	Description	Quotes
Participation in training affects ignorance	Drivers who train and or attend safety enlightenment programmes learn and so are less ignorant	*"No training opportunity for them oh … When there is no training opportunity, how will they know? That is why we say okada; they don't know where to overtake; where not to overtake." R4IX*
Participation in training affects risky and dangerous drivers	Drivers who are trained and those who attend safety enlightenment programmes are less risky and less dangerous than those who do not	"*Now we meet every month and discuss all these issues you're asking about. And it's been a while now that we have been raising the issues and continue to tell them. But actually, it's like there has been a reduction in the frequency of accident since we started our monthly meeting. So it might be possible that through the (enlightenment) during our meetings, these problems might reduce" R6FG1*
Participation in training affects accident	Drivers' training will reduce the incidence of accident	
Willingness to give time for training affects` participation in training	Training for drivers is a matter of time; some are not able to train because they are not willing to spare the time for it	*"Because people just take their bike and they go out and operate and when they operate for a week, you call them to come and train. They say "what?" "I've been making money, come and train, after one month of making money?" Whereas before they go, they ought to be trained! Since it's a laissez-faire business, there's no training, and everybody becomes an expert a day. Yes, so that's the issue. So the willingness to train is not there because government is slack. So, but they will tell you they're willing oh. If you get to them, if you get to an okada man. The okada man will tell you "I am willing to be trained" But it's not true." R1I*
Available spare time affect willingness to give time for training	Drivers usually work with almost all the time available for them so as to earn as much as is possible. So they are usually not willing to allow anything to take their time, including training	*"Whenever we call for a meeting, it's only about half of us who are able to attend. Those working/ operating in Ado, only about half of them are able to come. The other half wouldn't come. They'll be away operating to raise enough money for their contributions and other financial needs... So for this reason, as they are more interested in making money, since when we call for a meeting, we would expect 5000+ in attendance but only 2000 people/drivers would come. So 3000 drivers stay away." R4FG1*
Availability of training opportunity affects participation in training	If more opportunities are available for drivers to train, more of them will attend trainings than is the case now.	*"You see, what I observe as a solution is that government should provide counselling for every one of us - whether it's FRSC, or the police that would be called. Or maybe there are other officers that might be called upon to counsel us. Or we should be trained how to ride, even we who already know how to ride. We can learn more by retraining. Those who don't know how to ride, they can be trained as well" R4FG2*
Ignorance affects violation	The more ignorant of traffic rules a driver is, the more likely he is to commit violations.	*"No training opportunity for them oh… When there is no training opportunity, how will they know? That is why we say okada; they don't know where to overtake; where not to overtake." R4IX*
Ignorance affects risky and	Many drivers are risky and dangerous simply because	

Causation code	Description	Quotes
dangerous drivers	they are ignorant of traffic rules and requirements.	
Ignorance affects participation in training	The probability that a driver will be trained or that a driver will attend training is affected by his awareness of training benefit. Some don't participate in training because they are ignorant of training benefits.	"*They're not willing to be trained. Unwillingness to be trained is very high. They're not willing to be trained. Because they themselves don't believe they're not trained. He has been driving his own personal something before and of course he's there to make money. So are you going to waste his time training, for what? So they don't believe in training. Willingness to train is very low, and that will be a major factor in, because if you don't know how to manoeuvre, there is" R1I*
Ignorance affects Willingness to give time for training	The reason why some drivers cannot commit time to training is that they are ignorant of the benefits/ necessity of training	*"Because people just take their bike and they go out and operate and when they operate for a week, you call them to come and train. They say "what?" "I've been making money, come and train, after one month of making money?" Whereas before they go, they ought to be trained! Since it's a laissez-faire business, there's no training, and everybody becomes an expert a day. Yes, so that's the issue. So the willingness to train is not there because government is slack. So, but they will tell you they're willing oh. If you get to them, if you get to an okada man. The okada man will tell you "I am willing to be trained" But it's not true." R1I*

8.6.2.5 Enforcement and regulation in commercial motorcycle operation

This section treats the causal fragment emerging from enforcement and regulation theme. Deterrence effect of sanction was noted to be weak in enforcement. The operator's division scored enforcement process low (R2FG1, R6FG1 and R3FG2). The experts expressed disappointment in enforcement operation and concluded that commercial motorcycle operation could not improve except corruption in enforcement ceased (R1I and R3I). From the enforcement division, a respondent expressed frustration about the inability to successfully regulate commercial motorcycle operation and called for a national framework that could address regional inadequacies (R4IX). Another respondent within the enforcement (R3IX) accused a sister agency as lawless. Yet another respondent from the enforcer scored enforcement 65% and expressed hope that performance could rise to 99% with improvement in motivation and equipment for officers.

Another reason from the enforcer's division adduced for low deterrence effect of sanction was the intervention of politicians in the course of justice (R1IX, R4IX). Respondents (R1IX and R4IX) noted that drivers who had political affiliations often ignored rules. In many instances, their party stalwarts defended them so that they escaped the course of justice (R4IX). Political influence was equally strong in commercial motorcycle operation because politician regularly distributed motorcycles to drivers as well as party members as poverty alleviation gesture and this increased the number of drivers (R1I, R1IX, R4IX and R2FG1).

Another feature of enforcement process was the practice by commercial motorcycle drivers to dodge enforcement officers (R1IX, R2FG1, and R3FG2). In most instances, this happened when a driver had violated traffic law. Respondent R2FG1 gave an instance of this action that ended up in an accident. One of the reasons blamed for this action was corrupt practices among the officers as shown below:

> *"They make daily contribution (savings) and they wouldn't want to fail this contribution. Do you understand? If traffic-warden only controlled traffic according to their duties, as that is their role. But what they now do is to arrest okada drivers. And whenever okada drivers see them, they turn back." R2FG1*

Moreover, there were allegations of framing by officers too (ID and R1FG1). In an informal discussion with a driver, he noted that there were times drivers were arrested for no reason whatsoever and were asked to pay some amount of money. Respondent R1FG1 too noted it when he said:

> "*But there are times when the police would arrest our members for no reason. They arrest for flimsy reasons even after our union leaders have gone to meet the police and discussed*." R1FG1

Thus, respondent R2FG1 noted that drivers always wanted to avoid the officers because of this unnecessary cost and this was causing accidents. Respondent R3FG2 supported this view that the corrupt practice of extortion by some officers often ended up in accidents for drivers. Thus violators were not deterred; some even believed they had a "*leeway of going out of it by just settling one person or the other*" (R3I). The researcher's informal discussion with drivers further confirmed this as the drivers noted that most violations drivers were caught for were settled by paying un-receipted amount of money to the enforcer. So because deterrence was weak, violations were high (R1I, R3I and R1IX).

Another reason for the weak deterrent effect of sanctions was the inadequate coverage of the streets by officers and lack of adequate enforcement equipment (R3I, R1IX, and R4IX). Notwithstanding, enforcement operation was shown to still make some impact. A respondent noted that when police posts were everywhere, fewer drivers were operating (R4FG2). Another respondent noted that drivers still abided by some laws for fear of arrest (R1I).

Finally, the contributions of other road users to the risky road environment were mentioned. Respondents showed that the environment in which commercial motorcycles operated was risky and that drivers alone could not take all the blame for safety problems (R1I, R3I, R4IX, R1FG2, R3FG2 and R6FG2). All these are represented in the causal fragment presented in figure 8.12 below. A matrix table showing who said what is shown in table 8.18 while the links described above, their meanings, and some supporting quotes are shown in table 8.19.

Table 8.18: Matrix showing responses about enforcement and regulations

Cause and effect codes		Respondent divisions		
Cause	**Effect**	**Enforcer**	**Expert**	**Operator**
Corrupt practices	Deterrence		R1I; R3I	R2FG1
Corrupt practices	Dodging arrest		R3I	R2FG1
Corrupt practices	Prosecution		R3I	
Corrupt practices	Violation		R3I	
Corrupt practices	Accident			R6FG1
Deterrence	Violation	R1IX; R4IX	R1I; R3I	
Dodging arrest	Accident	R1IX		R2FG1
Other road users	Accident	R4IX		
Other road users	Risky road environment	R4IX	R3I;	R1FG1; R2FG1; R3FG1; R4FG1; R1FG2; R2FG2;R3FG2; R6FG2
Enforcement coverage	Deterrence	R1IX, R4IX	R1I; R3I	R2FG1; R3FG2; R4FG2
Enforcement coverage	Probability of detection	R4IX	R3I	
Enforcement coverage	Drivers' income			R2FG1; R3FG2
Enforcement coverage (Method of arrest)	Dodging arrest		R3I	R2FG1
Enforcement coverage	Accident	R4IX,	R2I	R2FG1; R2FG2; R3FG2
Probability of detection	Violation	R1IX	R1I, R2I	
Political influence	Corruption	R1IX; R4IX		
Political influence	Risky and dangerous drivers	R1IX		
Political influence	Number of drivers	R2I		
Political influence/ Local condition	Deterrence	R3IX, R4IX	R2I	
Political influence	Violation	R4IX		,
Risky road environment	Accident	R3IX; R4IX	R1I, R2I, R3I	R1FG1; R2FG1; R3FG1; R4FG1; R1FG2; R2FG2; R3FG2; R6FG2

Table 8.19: Description of causation codes about enforcement and regulations

Causation code	Description	Quotes
Enforcement coverage/arrest /method of arrest affects accident	The process and method of conducting arrest often results in accident as drivers attempt to flee enforcement agents whenever they think officers might arrest them	*"Also, the police. At times, we while riding, we have observed that the police worry us a lot. Just before we get to police stand, we begin to fidget. Some okada drivers, especially when Road safety (FRSC officers), when some okada drivers remembers they don't have helmet, will want to (make a sudden U-turn) turn back suddenly (enforcement method). Doing that causes problem for the driver behind who might be having helmet. Because of fear of arrest by Road safety -they charge N2000, N3000. All these things are reason why accident happens." R2FG1*
Enforcement coverage (method of arrest) affects dodging arrest		
Dodging arrest affects accident	When drivers attempts to dodge arrest, it can result in an accident	
Deterrence affects violation	The extent to which drivers are dissuaded from violating affects the number of violations they commit.	*"Policy laws made for okada have not been followed up, e.g., use of crash helmet. Thus the laws have not been obeyed. Excuses given by the public about the use of crash helmet include: possibility of putting charms inside helmet; likelihood of it spreading skin infections, and religious factor, particularly in the north." R1IX*
Enforcement coverage affects arrest/ probability of detection	The number of enforcement officers determines whether a typical violator will be arrested or not	*"…even when they know that the patrol team of FRSC passes somewhere, all of them will continue to avoid that particular route until the patrol team is gone." R3I*
Enforcement coverage affects deterrence	With more enforcement officers on patrol, more compliance to law can be achieved.	*"You see, okada wouldn't have been so many. But since the police have been directed to dismount all roadblocks. That's why there are so many okada. During the aggressive check of driver's license, were there so many okada? There were not so many okada like this then." R4FG2*
Probability of detection affects violation	If the probability that a violator will be arrested increase, the number of violations will reduce	
Enforcement coverage affects corrupt practices	The increase in the number of enforcement officers promotes corrupt practices as this raises the number of officers collecting bribe on the streets	*"Just of recent, I was at the junction of Government House. I suddenly saw some police officers there. So I greeted: 'hello officer, why are you here?' They retorted: what kind of foolish question are you asking?' Then I responded: 'what do you mean by foolish question? The IG (Inspector General of Police) has directed that all road blocks be dismounted. Here you are arresting okada drivers. What is your duty schedule?'… This is because they knew if they were on legal/official duty, they wouldn't release the arrested drivers. But they knew they were on an illegal assignment." R2FG1*
Enforcement coverage affects drivers' income	What a driver makes is also affected by the number of enforcement officers at work at any time. This is because of legal and illegal	*"Some of the police can stand by the road side doing nothing and just collecting money from road users without any contribution to improving free flow of traffic. At times, they would suddenly stop okada drivers asking for money to buy*

Causation code	Description	Quotes
	payments usually made to these officers	*packaged water, when they receive salaries. This can cause accident at times."* R3FG2
Corrupt practices affects deterrence	Corrupt practices of enforcement officers make effect of sanctions low.	*"Some of them, they also bribe their way out of it that even if you if I'm arrested, when I get there it's just to pay some amount and you'll be freed. So that's another important issue in this country in which when somebody has done something wrong he has that leeway of going out of it by just settling one person or the other. So bribery and corruption must be dealt with if you want to, real enforcement, if you want the okada system to work very effectively"* R3I
Corrupt practices affects prosecution	Corrupt practices of enforcement officers affect the prosecution of violators.	
Corrupt practices affects violation	Corrupt practices of enforcement officers make some drivers to think "*there's nothing anybody can do about them any longer*" (R3I) and so continue to violate	
Corrupt practices affects dodging arrest	Corrupt practices of enforcement officers causes drivers to want to dodge arrest.	*"Secondly, some police officers, some police officers can because of N20 or N30, do you understand now? The N20 or N30 that an okada man would give them, they would suddenly jump to the front of the with the intention: "this coming machine, I will not allow it to go". He might now want to dodge, thinking: "I'll swerve a little from this police officer" so that he doesn't hurt him. He might not know he has been very close to the road drainage and turn that way. He wouldn't know how to control himself, due to that fact that he wouldn't want to become a man slaughter. At times, accident might occur."* R3FG2
Corrupt practices affects accident	Corrupt practices of enforcement officers also affect the number of accident. This is particularly because drivers want to dodge.	
Political influence affects risky and dangerous drivers	Politicians usually distribute motorcycles as poverty alleviation measures. These are distributed to political supporters who take the law for granted and drive dangerously.	"*Because they mostly obtain their motorcycles by hire-purchase. Some others obtain their motorcycles as politician gifts. Both groups violate a lot… About 75% of them belong to political parties and these ones are worse offenders. This size of politicians among them also makes them enjoy a lot of political support.*" R1IX
Political influence affects number of driver	Politicians often distribute motorcycles for the purpose of commercial service thus increasing the number of drivers	
Political influence affects violation	Politicians do encourage drivers to violate by defending them when they don't have a licence or a vehicle plate number	*"Ehhh, for political reasons, you know anytime there is going to be election, they used to use them as one of the touts or thugs for the elections. And as you're seeing the okada people, most of we law enforcement agents, we, maybe we're trying to enforce the law, order will come from above that "don't embarrass them; they are our people" So it's because of the logistics; this political issue, …, when you're doing something for government and they're telling you to soft-pedal, you have to make sure that you … you have to be very careful."* R4IX
Political influence affects (corrupt in) prosecution	Corrupt practices in the execution of sanctions are partly blamed on the interference of politicians in enforcement operations	
Political influence/ Local condition	Compliance to law by drivers varies from place to	

Causation code	Description	Quotes
affects deterrence/ enforcement coverage	place depending on the level of interference by the politicians	
Other road users affects risky road environment	The road environment is regarded as largely unsafe. Other road users (such as pedestrians, other drivers, etc.) contribute to this risky road environment.	*"Some other accidents, at time, are caused by (other) vehicle drivers. At times, a driver might be driving and be receiving (calls), not looking forward, he would have been so close to the okada." R1FG1* *"Pedestrians also have poor knowledge of the route and because of that, they don't know where to cross and sometimes we blame okada for everything and pedestrians also must take their own share, fair share because they don't also know where to cross..." R3I*
Other road users affects accident		
Risky road environment affects accident	This describes the concept that accident causation has contribution from the risky road environment.	

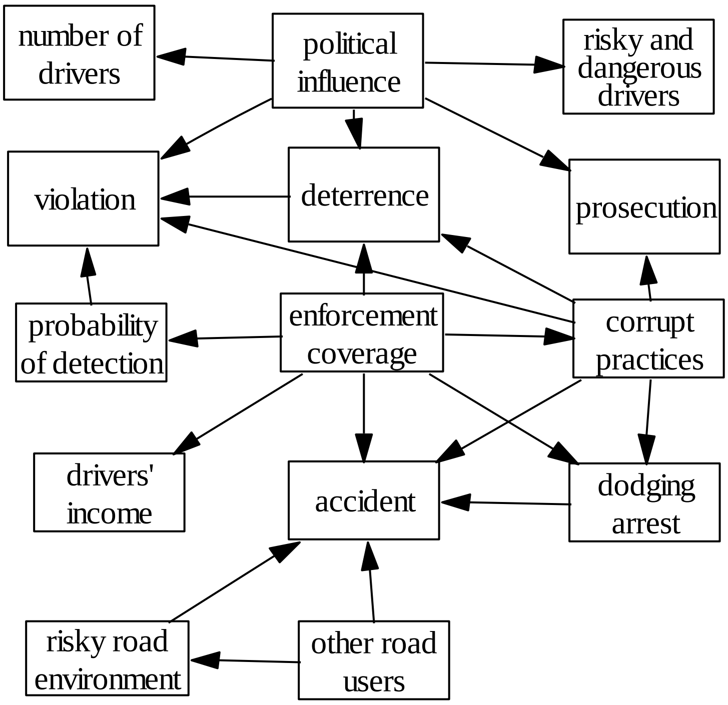

Figure 8.12: Enforcement and regulation causal links

(A causal fragment representing enforcement and regulatory themes)

8.7 Reflections

This section relates to the steps addressed in stage 14 of figure 8.1 as found in Burnard, (1991). Specifically, it provides the researcher's interpretation of the analysis outcome and supports it with the literature

8.7.1 Reflections on the individual five thematic statements

Reflection is the process of deciphering the "core meaning" of data (Saldana, 2013, p.5). It involves comparing analysis outcome with the literature. The need to provide the reflection section separately from the core analysis section (sections 8.6.1 and 8.6.2) follows from Saldana's (2013) recommendation on improving transparency in data analysis. Improved transparency is achieved by discussing codes separately and first (as done in sections 8.6.1 and 8.6.2) before providing a reflection on how they fit into existing literature as well as how the codes connect. In this section, a set of reflections is presented for the themes generated in sections 8.6.1 and 8.6.2. Saldana (2013) noted that categorising themes enhances generation of theories. The process of generating theories from this analysis starts with the presentation of a set of reflections that tells a story of rich relationships identified in the data by the researcher. These stories also include graphs of causal fragments that support the accounts. The graphs are used to show how interrelated and operative the coding outcome is and to provide a broader sense of the constitutive characteristics of the main themes (Miles et al., 2014). Moreover, as Miles et al., (2014, p.93) note, the "ultimate power of field research lies in the researcher's emerging map of what is happening and why… Coding, working through iterative cycles of induction and deduction to power the analysis, can accomplish these goals". Following therefore, from the several runs of coding that produced sections 8.6.1 and 8.6.2, the emerging map of "what and why" discussed in the reflections is presented using causal fragments in this section.

8.7.1.1 The commercial motorcycle trade and the changing pattern of drivers' population

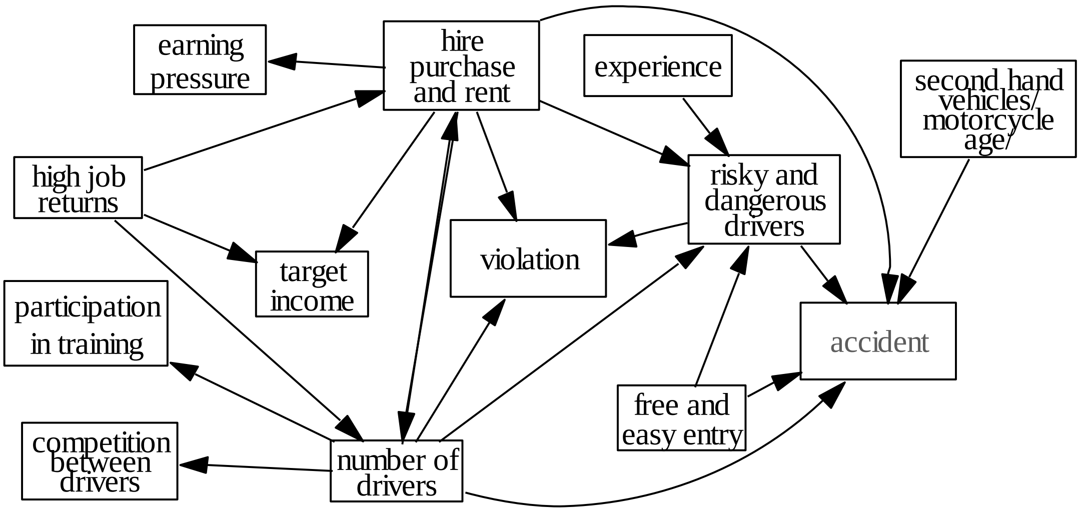

Figure 8.13: Causal fragment of commercial motorcycle drivers' characteristics themes

This section introduces the general characteristics of commercial motorcycle trade. The data shows that the characteristic of the drivers' population had shifted from mainly elderly, experienced and matured adult-owner drivers working on part-time basis to young untrained school leavers who worked on full-time but were renting their motorcycles or obtained them through hire-purchase (i.e., **expensive repayment options**). This implies that there were fewer qualified drivers in commercial motorcycle operation as the population continued to increase. It also means that more of the drivers did not own their motorcycles. Ogunrinola (2011) notes that as much as 45% of drivers are renting their motorcycles while Arosanyin et al. (2011) finds 55.6% of drivers are renting their motorcycles in their studies. This was far below what a respondent indicated when he said 90% of drivers did not own their motorcycle. Because no statistical data was collected during this research, the true condition in the study location could not be confirmed. But since most drivers were from a humble background, as noted in the data, there might be more motorcycles obtained through hire-purchase and rent than those who started with a self-owned motorcycle. This is more so as the literature categorises those on hire-purchase as owner-drivers[23].

Moreover, hire-purchase and rent types of ownership required repayments which motivated drivers to work hard so as to become free from debt quickly. The implication is that drivers were introduced into strenuous working and repayment condition from the start. These drivers were therefore always "hurrying"[24]. This working condition, coupled with the fact that many new drivers were untrained, unqualified and taking a job in an unregulated system, was likely the cause of drivers' risky behaviour (Adeniji, 1987) which might diminish over the life of the driver probably slowly as the driver gained experience (Johnson, 2012; Adisa, 2010).

Moreover, the data shows that the number of drivers rose rapidly and that this rapid growth came with problems including safety problem – a situation that necessitated earlier attempts to regulate the operation of commercial motorcycle. While the rapid growth would have contributed to the problem through increased competition, the effects of motorcycle ownership and the quality of incoming drivers must have played their parts too. With particular reference to the quality of drivers, the system seemed to have replaced drivers' training prior to taking up the job with experience. Iribhogbe and Odai (2009, p.356) describes this situation as one with drivers "who are ill-prepared and ill-equipped for the road. This is a recipe for traffic crash-related

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[23] The literature consulted classified drivers as either renting or owning their motorcycles. So those who take motorcycle on hire-purchase are regarded as owners, even though they have usually expensive loan to pay on their motorcycles.

[24] Hurrying is a more common word for describing drivers' risky and dangerous stance

injuries…”. Measures that are able to minimise the negative impact of ownership structure and improve the quality of drivers might be helpful to the system.

Finally, the researcher considers that the contribution of mechanical failure is insignificant. This is more so as the drivers noted that most motorcycles in use were bought new in recent times, a view supported in the literature too (Oni et al, 2009). It is therefore possible that most drivers were using second hand motorcycles earlier in the history of the trade.

This description of the system is captured in figure 8.7, section 8.6.2.1 and is presented in figure 8.13 above. Because “hurrying” is captured under risky and dangerous drivers as mentioned in table 8.9, it is not included in figure 8.13.

8.7.1.2 Life as a commercial motorcycle driver

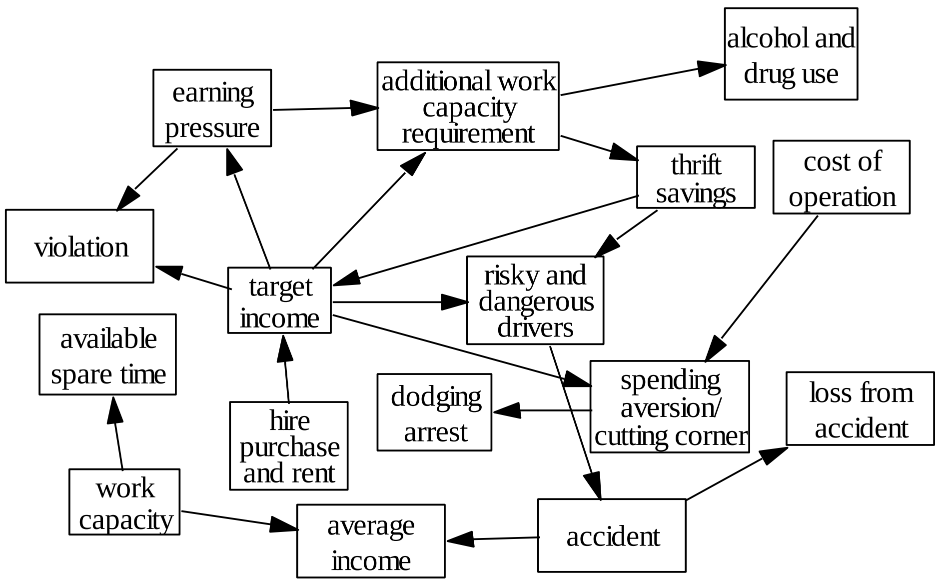

Figure 8.14: Causal fragment of money themes

This section introduces how some of the driver behavioural traits were related to money issues as coded in the analysis. While there are overlaps, efforts are made to minimise repetition in this presentation.

Drivers were generally regarded as always impatient (hurrying) and speeding. They had come to be known by these habits. According to Oluwadiya et al. (2009, p.298) “risky behaviours among motorcycle riders (are) common features of motorcycle crashes…”. In the data, some reasons adduced for this characteristic included drivers’ participation in thrift savings and motorcycle cost repayment. As said in section 8.6.1.2, thrift savings was a form of savings where friends contributed regularly and took the sum in turn. Repayment cost were regular rent paid to motorcycle lessor by the driver or a payment made to cover the purchasing cost plus interest on the motorcycle. Arosanyin et al. (2013) shows that the average payment for rent in a drivers' population is over 33% of their gross earning – showing the huge amount that goes into repayment. These two payments types (thrift and motorcycle cost) were noted to be very serious issue in the operation of commercial motorcycles and were regarded as contributing substantially to safety problems. As shown in the data, this is how it happened: What a driver made depended on how long he was able to work for and the frequency of lifting passengers. A driver who was able to sacrifice safety for the frequency of lifting passengers might be able to make as much as he wished (Oluwadiya et al., 2009). Because drivers were generally less safety-conscious, they earned more. This gave the impression that commercial motorcycle trade was lucrative. As a result, more new drivers joined the trade but through these **expensive repayment options**. But this only raised the average income target (or target income) drivers wanted to make each day. A situation resulted in the system where everyone was under huge earning pressure and drivers needed to work more to meet up with their repayment. But meeting up with their repayment sustained the impression that commercial motorcycle trade was lucrative, making even more people to join[25]. This was at the cost of a strenuous working pattern. Thus Arosanyin et al. (2013) show drivers' average working time per day to be 13 hours. But working over long hours resulted in fatigue which brought the impression that the trade was strenuous and should not be a permanent career. The data shows that some drivers were of the opinion that commercial motorcycle trade should be a transitory career and wanted to raise enough capital to switch trade[26]. So drivers often made savings to raise capital for a future trade. This has been noted in the literature (Ogunrinola, 2011). The effect of thrift savings is another important factor in the system.

The discussion here is represented in the causal fragment in figure 8.14. This figure is an extension of figure 8.8, section 8.6.2.2; however, through a broader reflection on the system, figure 8.8 has been extended to indicate the link between risky and dangerous drivers and accident occurrence. In addition, hire-purchase and rent is now connected to target income. These additional links to figure 8.8 can be found in table 8.9, section 8.6.2.1.

[25] For example, Ogunmodede, T.A. and Akangbe, C.A. 2013. Effect of road safety information availability and utilization on commercial motorcycle accidents in Nigeria. *Academic Journals.* **5**(3), pp.68-76. notes that 25.6% of drivers' population sampled had less than two years of experience – an indication to the rate at which new drivers joined the trade

[26] Iribhogbe and Odai, 2009 noted that 65.8% of drivers said they are not enjoying the job; Ogunrinola, 2011 found that 50.8% of drivers are in the trade "to raise capital for business start-up

8.7.1.3 Violation practices with emphasis on alcohol

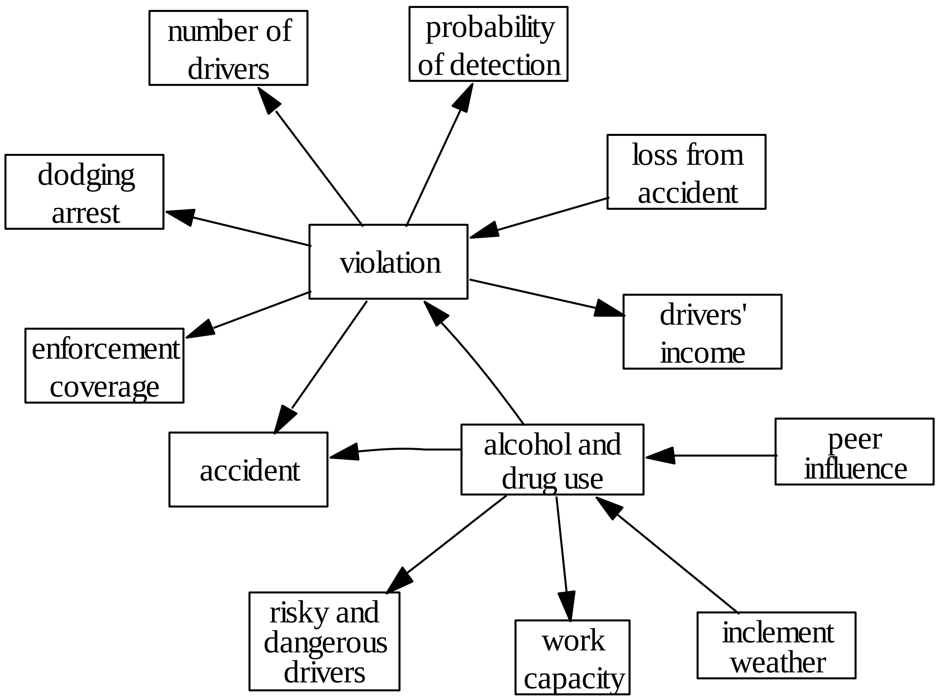

Figure 8.15: Causal fragment of violation themes

This section concentrates on the relationship between violations and other codes. Drivers were mostly guided by what they wanted to earn as shown in section 8.7.1.2. So they embraced risky habits that might increase their income, such as overloading, over-speeding, etc. Many violated to conserve their income (particularly with respect to possessing drivers' licence). Others violated traffic rules simply out of ignorance. As a result, committing violations naturally formed part of their habit. The data suggests that well over half of all accidents resulted from one form of violation or the other. This is also supported in the literature (Iribhogbe and Odai, 2009; Oluwadiya et al., 2009). While the list of violation types is a long one, some were more common and were mentioned in the data. The two most serious as shown in the data were speeding and driving under influence. Driving under influence was particularly serious. According to the data, apart from being a violation itself, driving under influence promoted committing other violations. Alcohol influence was noted to be more prominent and is shown to be so in the literature too (Adisa, 2010; Iribhogbe and Odai, 2009). All the drivers acknowledged that drink-driving was not safe, including those who drank and those who were not drinking. They noted that alcohol use was a major cause of accident and that by avoiding its use safety could substantially improve. Unfortunately, due to poor facilities at the hospitals and the poorly equipped enforcement officers, the contribution of alcohol to crashes in Nigeria is not known (Oluwadiya et al., 2009).

Furthermore, the data shows that drivers took alcohol because it enhanced their capacity to work both when more strenuous tasks were required and when adverse weather effect needed to be combated. The data shows that there were no serious attempts to discourage alcohol use within the drivers' population, especially by the drivers themselves or their unions. Rather, the availability of alcohol promoted its use and it was usual to share alcohol within the drivers' community out of courtesy: so those who would want to gain more confidence or even relax did find alcohol a ready option too. Iribhogbe and Odai, (2009) attests to this and showed that regular intake of alcohol was present in 39.8% of drivers. The finding came from a self-reported study and actual percentage might be more than what is found. Adisa (2010) finds the percentage to be 60% in his study.

Yet some were not drinking and believed that alcohol use was not necessary. The same thing was said of other capacity enhancing drugs which the data notes their availability was an open secret. Some drivers used these drugs, though not as much as alcohol. These drugs too were believed to contribute to safety problems.

Finally, accident occurrence is well acknowledged in the data with all respondents expressing worries about it. The trend could not be agreed to in the data, however, as views were divergent. The enforcer division was split on this trend: some felt it was rising while some felt it was falling. A respondent from the expert division indicated that the trend was rising while respondents from the operator division felt it was going down. The interview with the expert division showed that accurate information was not available.

What is described above is the combination of figures 8.9 and 8.10 and shows the links between violation, alcohol and drug use and other factors. This is represented in figure 8.15.

8.7.1.4 The necessity of drivers' training

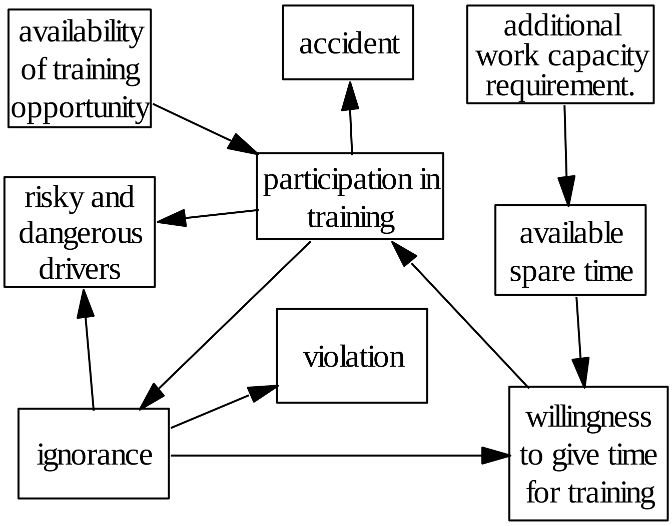

Figure 8.16: Causal fragment of training themes

This section introduces the relationship between training and other codes. As noted in section 8.7.1.2, driver training was found to be largely non-existent for most people newly joining commercial motorcycle trade. Most of the drivers learnt driving by practice over time. Due to lack of training and knowing the consequence of an accident, a respondent from the expert division felt that the drivers should be able to design for themselves appropriate training programmes. The drivers in the operator's division acknowledged the need for driving education and training and noted that they were actually doing it. The data shows that enlightenment on safe driving was part of drivers' union regular meeting agenda. In addition, one of the leaders undertook a weekly radio program called "Balelayo" meaning "Arrive Safely". These steps indicated the extent of self-effort these drivers put in. In addition, the data shows that FRSC[27] conducted safety education program from time to time. These platforms provided some form of (informal) training opportunities which drivers could utilise. But not many drivers explored these opportunities. This was despite the fact that drivers were described as being generally ignorant in the data. On the other hand, the data notes the call for training opportunity for drivers by the various respondent divisions despite the available ones. This call reinforces an impression that available training opportunities were informal and not structured well enough to reach the entire population and, probably, in a manner that they could bring about improved driving knowledge. The supposed lack of interest in training opportunity might be partly

[27] FRSC is Federal Road Safety Corps as described in section 6.6

caused by the difficulty associated with accessing training opportunities. Particularly, a respondent explained that people love knowledge and would be interested in participating in training if they were aware of it, though with the condition that such arrangement should not take much of the drivers' time. Another possibility was the view of some respondents that the drivers were generally unwilling to train as they were usually time-constrained. The possibility that drivers were not willing to train due to time constraint might be an indication to the excessive working pattern of some drivers that made them unwilling to share their time with anything. Unwillingness to be trained has been found in the literature: Iribhogbe and Odai, (2009) finds that about 10% of untrained drivers were not willing to receive training due to time constraint. With most of the people in this group of untrained drivers being recent drivers as suggested in the data, it could be the case that training was usually unavailable or ignored at the most critical time it was required in the system. This might also be an indication to how working condition made participation in driving education less important to drivers.

Unfortunately, the place of training had been given to experience. Some of the respondents from the operator's division suggested that safe driving improved with drivers' experience. The effect of experience has been found in the literature too (Borowsky et al., 2010; Johnson, 2012). A study by Johnson, (2012) notes that the compliance of a set of drivers who went through training improved by 48.5% over a three months review while their untrained counterparts only improved by 12%. But experience should not replace training. This is more so as it takes time.

Finally, since the level of ignorance was very high in the system, improving on training availability could improve drivers' participation in training and make the system safer. The researcher holds that with more available opportunities for training, more drivers would participate in training. Since drivers' training has been found to improve safety[28] (French et al., 2009) in the literature, looking at how current driver population can be progressively taken through training while designing a scheme that compels every new member to train before starting to operate is important as suggested in the data. That such attempt should not take excessive time and should be easy to access was recommended by some respondents. This discussion is represented in figure 8.16. Figure 8.16 is simply an extension of figure 8.11. What is newly added to it now is the relationship between additional work capacity

[28] The effect of drivers' training on safety improvement is controversial with studies generating opposing results. There are however evidence that it can still be very helpful.

requirement and available spare time. This is not stated in the data; it is an outcome of researcher's reflection on the data.

8.7.1.5 Enforcement and regulation in commercial motorcycle operation

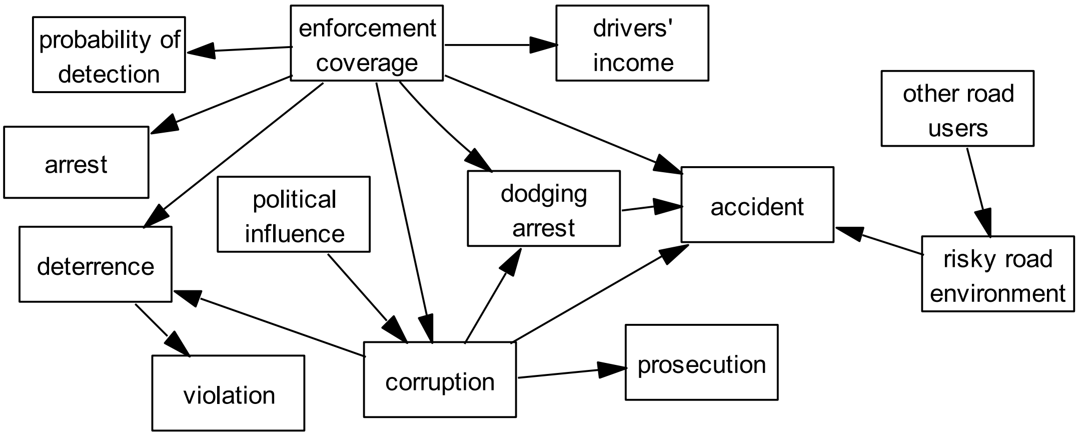

Figure 8.17: Causal fragment of regulation themes

This section centres on the activities of enforcement officers as it relates to the causation coding. The data shows that there have been attempts to regulate commercial motorcycle operation. But most of these attempts failed. There were so many laws that were neither known to many of the drivers nor enforced by the enforcement agencies. Arosanyin et al. (2012) described the situation as "traffic law enforcement is still below optimal" (p.98). Some of the reasons adduced for this failure were noted. One was the political influence that made some drivers who were loyal to political parties difficult to prosecute. Some of these drivers could be released on the instruction of their political god-father should they be arrested for any offences. This contributed to the problem of compliance. A respondent from the enforcer's division felt the reason for the difficulty in managing the drivers was due to lack of a formal and national framework for enforcement operation. But another from the same enforcer's division noted that some national regulations did not succeed due to variation in local/ regional political preferences. They both however agreed to the influence of politicians (and in some places, religion) on enforcement operations.

The other and probably more serious reason was the corruption within the law enforcement system. The data shows that corruption made sanction less effective and violations probably beneficial. Drivers at times preferred to take the risk of being caught and then pay off officers rather than to comply with the law. There was therefore not much improvement in compliance to law. This was despite the increasing number of enforcement officers. Moreover, enforcement officers were not forgiving: they arrested for any and every reason. This contradicts the findings of Sherman et al. (2003, p.229) who state “that arrest, especially for minor offenses (which are by far the most common), provokes a response by offender making them more likely to commit future crime than if they had not been arrested.” The drivers therefore were not taking officers very serious and would want to dodge arrest after committing a violation. For example, many of these drivers treated obtaining legal documents for operation as of secondary importance – an issue which was the emphasis of enforcement officers. Drivers preferred to dodge, at least for some time before eventually obtaining the documents. Dodging police arrest was risky and often resulted in accident. The complication with regulation and enforcement process made many to wonder if it is possible to successfully regulate commercial motorcycle operation in Nigeria. The data provides an answer by showing that there was still a level of deterrence amidst drivers, though very low. This was particularly noted by the indication that the more officers on the streets there were (or the more the probability of being arrested), the less the number of violations. Moreover, the drivers believed in the necessity of enforcement operations and wanted officers to be professional.

Finally, the data shows that other road users had some common characteristics with commercial motorcycle drivers, such as drink-driving, being in a hurry, etc. They therefore contributed to commercial motorcycle safety problems too while using the road. A more holistic approach to dealing with road safety which treats the interest of all users will therefore be beneficial. This is however beyond the current research. A causal fragment of enforcement codes is presented in figure 8.17. It is obtained from figure 8.12 in section 8.6.2.5.

8.7.2 Causal network

In this section, the five causal fragments in section 8.7.1 are brought together to form a whole picture - a causal network. The outcome of this combination is shown in figure 8.18. This is in line Spector et al. (2001) recommendation of providing both the parts and the whole picture in a bid to provide improved understanding about a system. In addition, combining enables it to be seen how different parts contribute to make a whole. Furthermore, in this section, combining the parts enables a better review of the causal links and the removal of redundant links. Figure 8.18 on page 154.

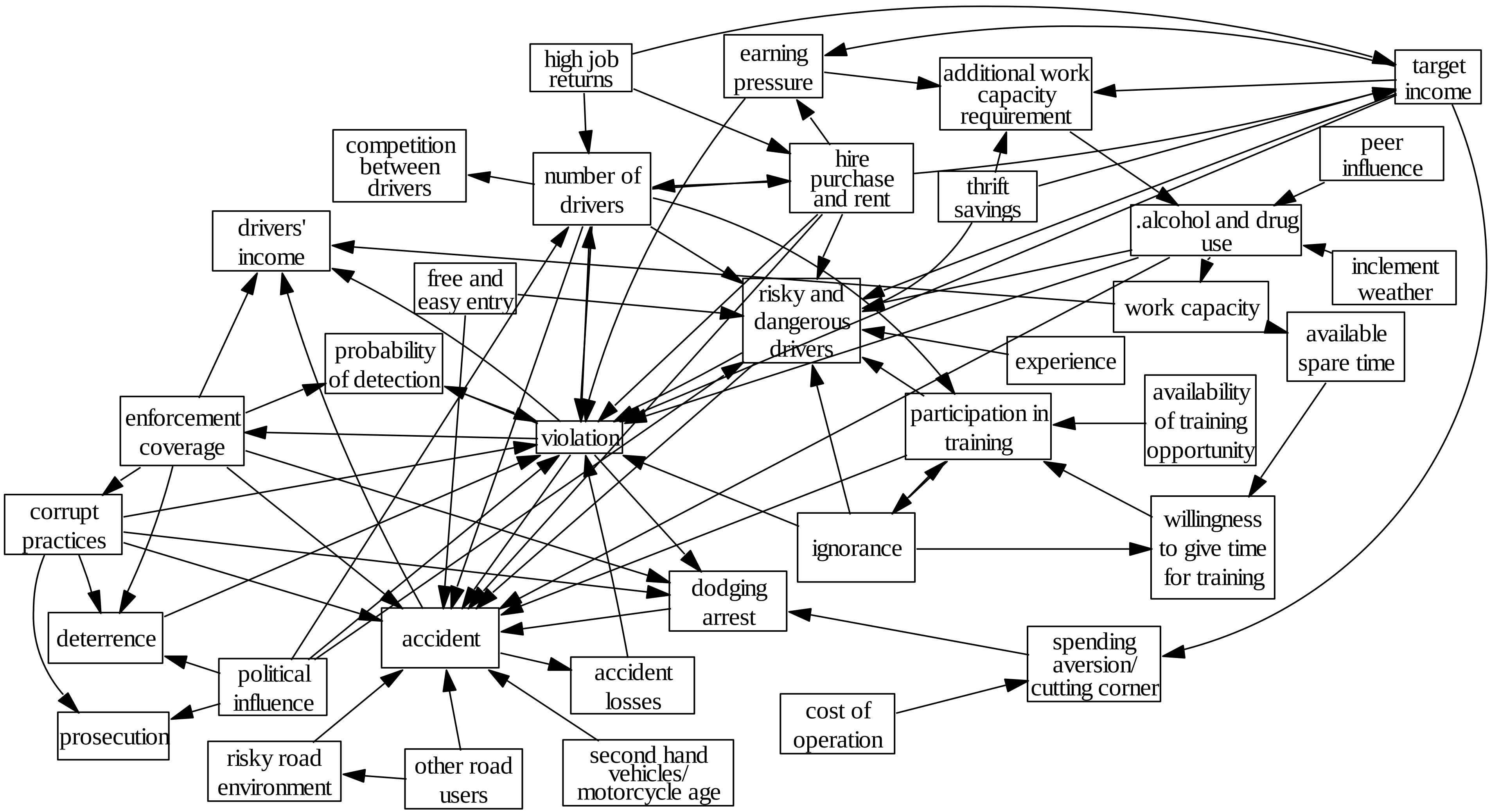

Figure 8.18: Causal network

Table 8.20: Redundant causal links removed from figure 8.18

Deleted link	Appropriate link	Justification
Accident affects drivers' income	Accident losses affects drivers' income	It is the losses that results from accident that affect drivers' income. These losses include union taxes, working time, cost of treatment, and cost of vehicle repairs
Corrupt practices affects accident	Corrupt practices affects deterrence	Corruption in enforcement increases accident indirectly. But the direct impact of corrupt practices is their effect on deterrence
Corrupt practices affects violation		Corruption in enforcement increases violations indirectly. But the direct impact of corrupt practices is their effect on deterrence
Free and easy entry affects accident	Free and easy entry affects risky and dangerous drivers	The unregulated nature of commercial motorcycle trade affect accident indirectly but has a direct effect on the quality of people joining as drivers
Hire-purchase and rent affects accident	Hire-purchase and rent affects target income	Obtaining a motorcycle by hire-purchase or by rent does not result in accident directly. But drivers set high target income because of it.
Hire-purchase and rent affects earning pressure		Obtaining a motorcycle by hire-purchase or by rent does not constitute earning pressure until drivers set high target income because of it.
Hire-purchase and rent affects risky and dangerous drivers		Obtaining a motorcycle by hire-purchase or by rent does not make a driver risky or dangerous if he does not set high target income because of it.
Participation in training affects accident	Participation in training affects ignorance	Lack of training results in accidents. But it can only be due to ignorance. Otherwise, such accident cannot be attributed to not participating in training
Enforcement coverage affects accident	Enforcement coverage affects dodging arrest	Enforcement operations lead to accidents as drivers attempt to dodge arrest
Enforcement coverage affect violation	Enforcement coverage affects probability of detection	Enforcement operations affect violations by changing the probability of detection and the deterrence effect
Risky and dangerous drivers affect accident	Risky and dangerous drivers affect violation	Drivers who may be classified as risky and dangerous cause accident by violating safety rules.
Target income affect violation	Target income affect spending aversion and cutting corners	Target income results in violation indirectly through for example not obtaining necessary papers so as to minimise operating cost

Target income affects addition work capacity requirement	Target income affects earning pressure	Target income does not require working more than normal if it is within the limit where it does not constitute a earning pressure
Thrift savings affects addition work capacity requirement	Thrift savings affects target income	Thrift savings results in drivers requiring to work more than necessary only when a target income has been set which exceeds what the driver would easily earn
Thrift savings affects risky and dangerous drivers		Thrift savings does not constitute a risk if drivers do not set high target income which is difficult to raise and require them to take risks.

Table 8.21: Some causal links newly added

New links	Type	Explanation
Competition affects drivers' income	Implied in the data; supported in the literature (Mahlstein, 2009)	As the number of drivers increases, so does competition which also affects drivers' income.
Prosecution affects violation	Implied in the data; supported in the literature (Sherman et al, 2003)	The more violators are prosecuted, the less violations there will be
Enforcement coverage affects free easy entry	Implied in the data	The presence of the police still prevent some drivers' excesses such as underage driving and difficulty in driving without a license
Addition work capacity requirement affect work capacity	Implied in the data	When additional work capacity requirement is met, work capacity increases

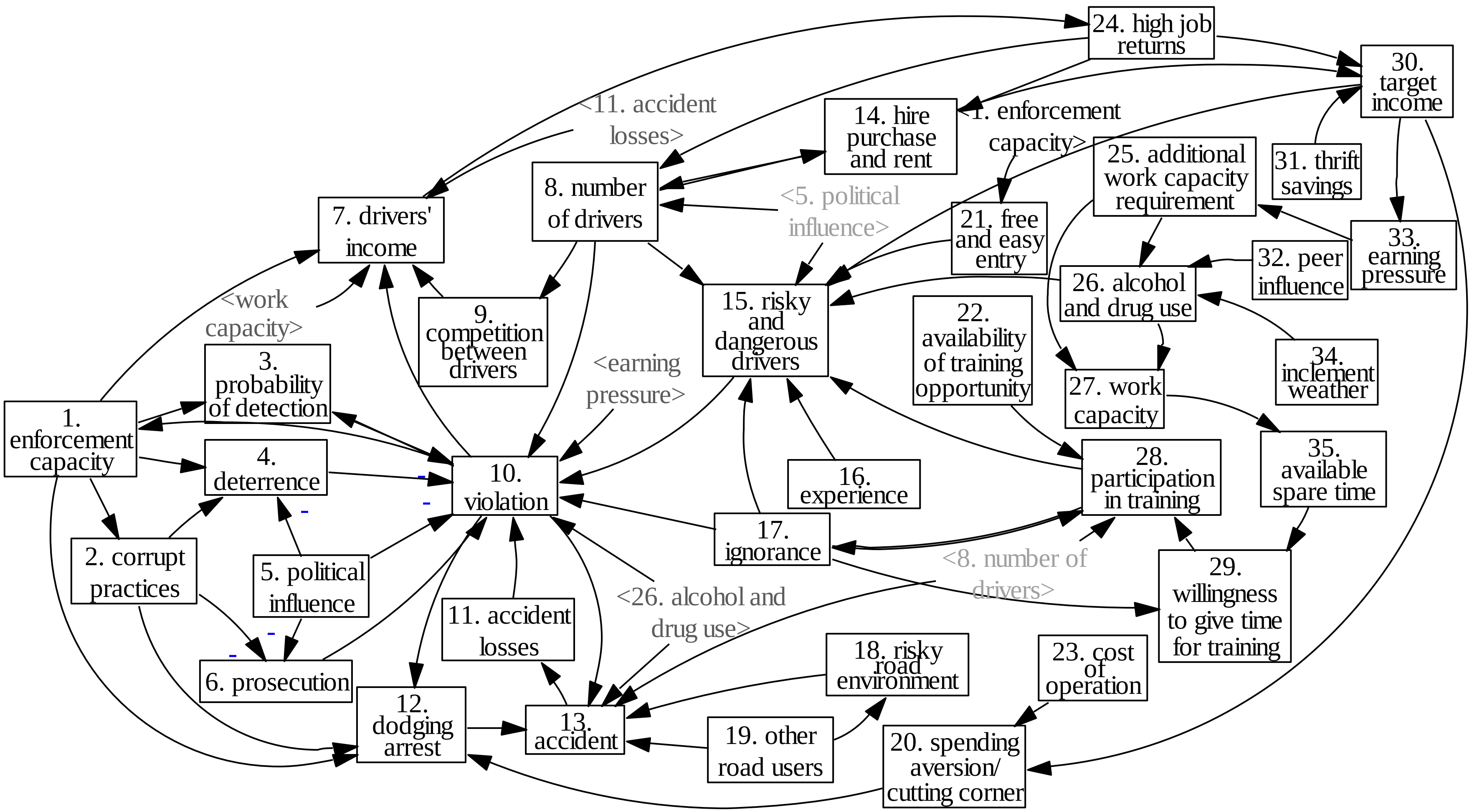

Figure 8.19: Reviewed causal network

Redundant links arose in the analysis in the cause of generating causation under different categories in the data – a situation that led to the repetition of some descriptions/ links under multiple themes. The process of removing redundant links became particularly important when the final causal network generated from the combination of the five themes emerged as a very crowded and unimpressive outcome of the analysis stage (see figure 8.18). What was done was to read through all the links leaving and entering each code and to establish direct causality and remove the indirect/ repetitious ones. Some new links were also added. This review generated the causal network shown in figure 8.19. In addition, the links removed and new links added are presented in tables 8.20 and 8.21 respectively. A justification for each of the added and removed links is also provided on the tables.

8.7.2.1 Causal network narrative

Miles et al. (2014) recommend writing a narrative that lists all items in a causal network. According to them it helps analysis to be less mechanistic and more coherent. A narrative for the causal network in figure 8.19 is presented here:

Enforcement capacity (1) which represents the combined ability of traffic enforcement agencies in the study location affected several other items. It was found that whenever there were more officers on patrol, fewer drivers worked due to increased probability of detection (3) of a violation by enforcement officers. This was more so as more monitoring by officers meant more spending on fines and bribery for the drivers. Thus, more violations (10) led to more enforcement capacity (1) which led to reduced drivers' income (7). Notwithstanding, there were times an increase was noted in violations (10). This was because violations (10) offered some financial benefits too (increased drivers' income (7)). Whenever violations increased, more officers were drafted to increase enforcement capacity (1) and match the problem. This obviously would result in increase in the probability of detection (4) and violation would go down. It was also noted that some drivers were naturally deterred (deterrence (4)) from violating laws due to increased likelihood of being arrested. In this way, increasing enforcement capacity (1) could reduce the total number of violation (10).

Meanwhile, the increasing size of enforcement capacity (1) was also proliferating corrupt practices (2) among officers. This was the reason for the drivers' habit of dodging arrest (12) after they had committed violations (10). Corrupt practices (2) influenced deterrence (4) and prosecution rate (6), making both very low. But both deterrence (4) and prosecution rate (6) were affected by political influence (5) too. It was noted that politicians used commercial motorcycle drivers in political campaigns and often defended them whenever they violated traffic laws.

Thus, political influence (5) was seen as contributing to violations (10). Moreover, because deterrence (4) and prosecution (6) rate were low, the level of violations (10) was high. The consequence of high violations (10) was accidents (11). Between 60% and 85% of accidents were blamed on violations. But other things caused accident too. Dodging arrest (12), for example, often resulted in accident (13). Dodging arrest was blamed on drivers' spending aversion/ cutting corners (20) and violations (10), in addition to other factors. Other causes of accidents (13) included other road users (19), the risky road environment (18) in the study area, and alcohol and other drug use (26). Other road users (19) were particularly blamed for the risky road environment (18). In addition, the increasing number of drivers (8) meant that the number of accidents (13) had been increasing since more people were getting exposed to road risks.

Whenever an accident happened, it resulted in loss of life or/and damage to properties which meant less of drivers' income (7). It was found that these accident losses (11) could caution drivers to reduce their violations (10). Many other things however affected drivers' tendency for violations (10). These included the increasing number of less cautious drivers. These were called risky and dangerous drivers (15): they joined commercial motorcycle trade untrained and unqualified, and highly ignorant (17) of traffic rules. In addition, alcohol and drug use (26) amidst drivers as well as drivers' earning pressure (33) affected violations. Earning pressure (33) was the outcome of the desire to make a target amount (target income (30)) by a driver each day. Finally, as the number of drivers (8) increased, so was the number of violations committed.

The rising number of drivers (8) was caused by many factors. The main one was high job returns (24). For example, it was found that most drivers started with hire-purchase and rent options and paid off all credit within a year indicating that the interest to take these expensive options (i.e., 14) was related to drivers' ability to pay back quickly (high job returns (24)). The availability of hire-purchase and rent (14) options thus supported drivers' population growth. In addition, politicians (5) distributed motorcycles at times to youths many of which eventually became commercial motorcycles. This distribution of motorcycles by politicians (5) therefore was contributing to risky and dangerous driving (15). The increasing number of drivers (8) also contributed to some other problems. It (8) was increasing competition between drivers (9); competition between drivers (9) led to a reduction in drivers' income (7). It (8) was also increasing the number of risky and dangerous drivers (15) since the trade has free and easy entry (21) structure and inefficient police enforcement (1). Particularly, many of new drivers were ignorant (17) of safety rules and inexperienced (16) in driving a motorcycle. Notwithstanding, they worked hard and set high target income (30) which necessitates working more, using alcohol and other drugs (26), and not having time to participate in training (28). All these put together made drivers risky and dangerous (15).

Furthermore, the increasing number of drivers (8) was also increasing the number of drivers who took motorcycles on hire-purchase and rent (14). This hire-purchase and rent (14) was increasing drivers' population (8) as well as raising drivers' target income (30). As earlier shown, hire-purchase and rent (14) was due to the high job returns (24) characteristic of the trade. But high job returns (24) in commercial motorcycle trade depended on the ability of the driver to work hard. Drivers therefore worked hard to make high drivers' income (7) and so maintained the high job returns (24) characteristic of the trade. They did this by setting high target income (30) which put pressure on them while working. This is earning pressure (33). The high target income (30) was also as a result of the need to pay for hire-purchase and rent (14) and the thrift savings (31) drivers engaged with.

As noted, drivers did use alcohol and other drugs (26). They often used them because of peer influence (32), inclement weather (34) and the need to work more (when additional capacity for work was required (25)). Whenever they used alcohol and other drugs (26), they increased their ability to work (work capacity, 27), and were able to increase their income (7). But their need to work more (25) was usually caused by the pressure to earn more (earning pressure, 33). This earning pressure (33) therefore promoted thrift savings (31) in some ways: because drivers worked under pressure, they saw the trade as too strenuous and planned to switch to easier trades as quickly as possible. So they would decide to save money and raise some capital for another trade. This raised their target income (30) and earning pressure (33) further and increased the need to work more (**additional work capacity requirement** (25)) in a vicious cycle.

Similarly, as the **additional work capacity requirement** (25) (the need to work more so as to earn more) increased, drivers worked more. If their **additional work capacity requirement** (25) rose, they would need to increase their work capacity (27). They would then spend more time working and would have less spare time available (35) to them. The combination of ignorance (17) about driving requirements and less available spare time (35) were responsible in some instances for low willingness to give time for training (29) which caused many of the drivers to jettison participation in training (28). Thus it was shown that there were fewer trained (those who had ever participated in training (28)) drivers now than there were when the population of drivers (8) was small.

Ignorance (17) and participation in training (28) fed back to one another: ignorance (17) made some drivers think they did not need training. Not participating in training reinforced ignorance too by making drivers believe they could do without it. However, one other factor contributed to low participation in training (28) – the lack of training opportunities for motorcycle drivers (availability of training opportunity (22)).

Finally, drivers who set high target income (30) might delay essential vehicle maintenance, showing a trait of spending aversion/ cutting corners (20). Such drivers did not possess necessary vehicle/driver's documents (20) either and would want to dodge officers (13).

Taken as a whole, these explanations seem complex. But there is sufficient evidence that each causal link worked as described. The network will look less complicated if the following basic observations are noted:

1. Officers could enforce law by detecting and arresting violators; they could deter drivers from engaging in violations. But these were not happening as appropriate because of corruption in enforcement process.
2. As a result, violations were many and so were accident occurrences. Though violations were caused by many factors, the most important was the growing number of drivers (as it led to competition amidst drivers, increased the number of drivers who took motorcycles on expensive hire-purchase or rent terms, and most of these drivers were unqualified, etc.). This drivers' population growth was however supported by the high job returns.
3. Similarly, expensive ownership structure in the trade was a consequence of high job return. But it caused high pressures. The high pressure led to strenuous working condition and made drivers contemplated a career-switch plan. In the bid to fulfil the career-switch plan, drivers would initiate high savings and increase their target income. This process created a vicious cycle.
4. Finally training deficiency was reinforcing itself through ignorance and excessive work pattern in the system.

8.7.3 Extending the analysis: Making predictions

As noted in section 2.7.2 it is possible to hypothesise trajectories of action based on the analysis outcome (Miles et al., 2014). This requires identifying the strength of the factors present in the causal network in the context of the data. Table 8.22 below presents a chart of network factors and their relative strength. These strength measures are based on the data. For ease of analysis, this strength is rated as low, medium and high. It must be mentioned that this rate is the researcher's understanding of the data. It is nevertheless part of the analysis process.

Table 8.22: Table of system factors and their strength

	Variables	Rating	Section		Variables	Rating	Section
1	Enforcement capacity	Medium	8.6.2.3	19	Other road users (risk)	Medium	8.6.2.5
2	Corrupt practices	High	8.6.2.5	20	Spending aversion/ cutting corners	Low	8.6.2.2
3	Probability of detection	Medium	8.6.2.3	21	Free and easy entry	High	8.6.2.1
4	Deterrence	Low	8.6.2.5	22	Availability of training opportunity	Low	8.6.2.4
5	Political influence	High	8.6.2.5	23	Cost of operation	High	8.6.2.2
6	Prosecution	Low	8.6.2.5	24	High job returns	High	8.6.2.1
7	Drivers' income	High	8.6.2.2	25	Additional work requirements	Medium	8.6.2.2
8	Number of drivers	High	8.6.2.1	26	Alcohol and drug use	High	8.6.2.3
9	Competition between drivers	Medium	8.6.2.1	27	Work capacity	Medium	8.6.2.2
10	Violations	High	8.6.2.3	28	Participation in training	Low	8.6.2.4
11	Accident losses	Medium	8.6.2.2	29	Willingness to give time for training	Low	8.6.2.4
12	Dodging arrest	Low	8.6.2.2	30	Target income	High	8.6.2.2
13	Accident	Medium	8.6.2.3	31	Thrift savings	High	8.6.2.2
14	Hire-purchase and rent	High	8.6.2.2	32	Peer influence	High	8.6.2.3
15	Risky and dangerous drivers	High	8.6.2.3	33	Earning pressure	High	8.6.2.2
16	Experience	Medium	8.6.2.1	34	Inclement weather	Medium	8.6.2.3
17	Ignorance	High	8.6.2.4	35	Available spare time	Medium	8.6.2.4
18	Risky road environment	Medium	8.6.2.5				

Miles et al. (2014) indicated that by looking at relationships on the causal network and generating a matrix showing antecedents it is possible to determine the consequence of the current state of factors. Table 8.23 is used to apply this process in predicting the future state of deterrence, violations, and number of drivers. This is shown below.

Table 8.23: Prediction matrix

1st prediction				2nd prediction				3rd prediction			
Variable of interest	**Antecedent variables**	**Current conditions**	**Future condition**	**Variable of interest**	**Antecedent variables**	**Current conditions**	**Future condition**	**Variable of interest**	**Antecedent variables**	**Current conditions**	**Future condition**
Deterrence		**Low**	**Low**	**Violations**		**High**	**High**	**Number of drivers**		**High**	**High**
	Enforcement capacity	Medium (+)			Risky and dangerous drivers	High (+)			Hire-purchase and rent	High (+)	
	Corrupt practices	High(-)			Earning pressure	High (+)			High job returns	High (+)	
	Political influence	High (-)			Number of drivers	High (+)			Political influence	High (+)	
					Ignorance	High (+)					
					Probability of detection	Medium (-)					
					Political influence	High (+)					
					Prosecution	Low (-)					
					Accident losses	Medium (-)					
					Alcohol and drug use	High (+)					
					Deterrence	low (-)					

A matrix table for developing predictions from data. (+) indicate that corresponding antecedent variable promotes variable of interest while (-) indicates the reverse

In table 8.23 above, three codes/ factors were considered and their future conditions examined. This process involved looking at all the antecedent factors and applying a form of quantitative measure (high, medium, and low in the analysis above) to determine their likely future conditions. The table shows that deterrence might continue to be low since corrupt practices in enforcement operation was high and political influence which subverted justice for wrong doing was high, even though enforcement capacity was fairly good. Similarly, violations might continue to be high since risky and dangerous drivers were rated high, and earning pressure that propelled drivers to violate was high. All the other factors that supported high rating of violations were high whereas those factors that inhibited violations were medium or low in rating. Finally, the number of drivers might continue to be high because all the factors (hire-purchase and rent, high job returns, and political influence) that promoted it were high. As recommended by Miles et al. (2014), the following statements can be derived from the analysis on table 23:

1. Deterrence will most likely continue to be low even though enforcement capacity is moderate.
2. Violations will likely remain high because there are no strong factors (such as deterrence, prosecution, etc.) that are able to reduce its strength.
3. The number of drivers will tend to remain high since all the three factors (hire-purchase and rent, high job returns, and political influence) related to it in the data are high

The above show the findings from the causal network analysis.

8.8 Validity of causal network

Following the tests of validity provided by Bryman discussed in section 3.5.3, this chapter has provided evidence of measurement validity by outlining the method adopted and how it has found out what it sought. The causal network (figure 8.19) and narrative presented in section 8.7.2 provide internal validity by showing that the intended question can be answered by the outcome of the analysis. While the researcher may not be able to generalise the entire result of this analysis, section 8.7.1 on reflections shows that some of the findings in this research have literature support. The section also provided a form of “crystallisation” for the findings of the research. To confirm the “ecological validity” of this finding, the narrative was shared with colleagues for critical evaluation as suggested by Miles et al. (2014).

8.9 Researcher's reflexivity

Mason (2002, p.5) describes reflexivity as "thinking critically about what you are doing and why, confronting and often challenging your own assumptions, and recognising the extent to which your thoughts, actions and decisions shape how you research and what you see". This section offers an opportunity to convert the reflexivity of the researcher into words.

This chapter reports the analysis of the qualitative data obtained (described in chapter 7) for this research. The analysis adopted inductive coding method to arrive at both descriptive and causation codes. It is necessary to clarify the thinking pattern of the researcher. Unlike many qualitative research works that focus on adopting triangulation to provide internal validity for a study, this research combines triangulation with what (Thorne, 2000) called "crystallisation". According to her, while similar findings from different data sources help to increase internal validity, the absence of similar findings does not provide a basis to reject the findings. This is because qualitative research acknowledges the existence of multiple views of equal validity and this is what makes it different from quantitative research that assumes a central truth against which all findings are measured (Thorne, 2000). Thus crystallisation is described as meaning complementary rather than competing perspectives. As such, the analysis did not attempt to add more credence to more popular themes; it presents the views as they are shown by the respondents, including where there have been contradictions and divergent views about the same issues. This is more so as qualitative research is rather about the social context of thinking or feeling rather than validating them (Thorne, 2000) and "a more realistic goal for qualitative research is comprehensiveness rather than internal validity" (Barbour, 2001, p.1117)

Moreover, despite the fact that at every stage of the analysis, the researcher referred back to the data (as recommended by Burnard (1991)) to ensure that the process has been conscientiously conducted, it does not insist that all possible themes have been coded. This is because qualitative research is rather a complex exercise. For example, (Barbour, 2001) showed that that considerable variation was found in the way the same data was analysed by different people and that even when a researcher revisits previously collected data, its original interpretation may shift. Miles et al., (2014) suggested that 85% to 90% level of coding would be acceptable. But since the ethical requirement of this research requires data to be private and the researcher is a lone researcher, the requirement that a third party code data for validity as noted by Burnard (1991) and described as investigator triangulation and theory triangulation in Guion et al. (2011) is not considered. Notwithstanding, as suggested by Miles, et al. (2014)

narratives of the findings were presented to researchers in other fields who are conversant with the study theme to provide some criticism for result validation.

8.10 Conclusion

This chapter has used an amended Burnard's (1991) analysis approach to analyse interview data obtained from the field work conducted in this research. Using mainly an inductive approach, the data was coded as descriptive and causation codes. This process generated 42 descriptive codes and 83 causation codes. These codes and what they mean formed the content of sections 8.6.1 and 8.6.2. A reflection on these codes is reported in section 8.7.1 while section 8.7.2 presents the final result of the analysis. In this final result are the factors relating to safe operation of commercial motorcycles and how they are related. This result is represented with a causal network shown in figure 8.19 (page 157) and a narrative that summarises the analysis outcome (on pages 158 to 161). The analysis was pursued further to attempt causal predictions as shown in section 8.7.3. This process reveals that the qualitative data can provide some opportunity for quantification as well as predictions (mentioned in section 3.2). It is however not possible in this research to undertake any tests of the predictions and it might therefore simply remain as conjectures. Nevertheless, what is done in this chapter has fulfilled the first research objective stated in section 5.4.10 which seeks to identify factors that affect commercial motorcycle safety and their relationships with one another. In the next chapter, the second research objective is pursued.

Chapter 9 Causal loop diagram development

9.1 Introduction

In chapter 8, the fieldwork data was analysed to obtain a causal network shown in figure 8.19 (page 157). In this chapter, the analysis is extended to obtain a causal loop diagram. As noted in section 4.2, CLDs are a qualitative system dynamics model and are very useful. They provide an explanation for the dynamics characterising a problem in terms of the underlying feedback structure of the system. They make it possible to learn from a modelling process for real world applications. They can therefore be useful in improving the understanding about commercial motorcycles' safety performance. The causal network obtained in chapter 8 will be analysed to obtain a CLD.

Generating the CLD for this research involves identifying the problematic structures within the system described by the causal network. These problematic structures are identified by further reflecting on the system characteristics shown in the causal network and its narrative. This step is supported in qualitative research. Miles et al. (2014) indicate that it is possible to generate a theory through the data analysis process by further querying the outcome of the analysis process. The problematic structures in commercial motorcycle operation are therefore identified by thinking through the causal network and its narrative to obtain a summary of the system problems. This process gave rise to nine key summary statements. These statements exhibit feedback structure in their nature. This chapter lists these nine key summary statements (with feedback structures) and turns them into a CLD which represents the theory of driver behaviour in commercial motorcycle trade. The chapter concludes with the final CLD and a comparison of the outcome of chapter 8 with this chapter.

The order of presentation in this chapter is as follows. Section 9.2 lists out identified key problematic summary statements emanating from section 8.7.2 (i.e., the dynamic hypothesis). In section 9.3, a CLD is developed in a sequence following the listing of the problematic summary statements. Section 9.4 presents the final CLD and compares it with the causal network which represents the whole system. Section 9.5 provides a conclusion for this chapter. This chapter overview is shown in figure 9.1.

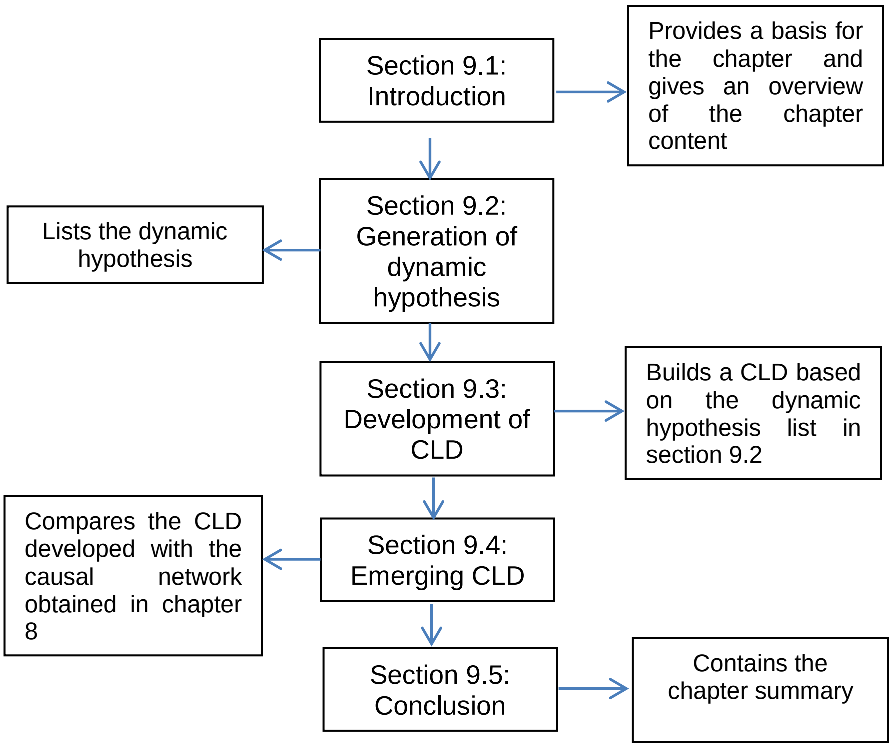

Figure 9.1: Chapter overview

9.2 Generation of dynamic hypothesis

Figure 8.19 in section 8.7.2 presents the causal network obtained from the analysis process in chapter 8 (sections 8.6 and 8.7). Reflecting further on this causal network and its narrative[29] reveals some insights. There are four major players in the commercial motorcycles' driver behaviour realm which can be found in the figure. These are the enforcement officers, the drivers, the political class, and the other road users. The enforcement officers (are expected to) work in a manner to promote safety and maintain safe driver behaviour. The enforcement officers' performance are however affected by corrupt practices, including the interruption of the course of justice by politicians who provide some informal (and often, illegal) support for drivers. The following summaries can be generated for the nature of enforcement operations as shown in the causal network and indicated in summary number 1 in sections 8.7.2.1, page 161:

i. Officers enforce law by detecting and arresting violators but this process is weak.

ii. The process of enforcement should deter drivers from engaging in violations and build the culture of safe driving behaviour but this process too is weak.

[29] The narrative is in section 8.7.2.1, page 158

iii. There is the problem of corruption in the enforcement process and this affects both drivers and officers. This is particularly with respect to rent paid to officers.[30]

Secondly, there is the drivers' group. It is shown that there has been a huge increase in drivers' population over the last fifteen years due to the awareness that commercial motorcycle trade is lucrative. More importantly, it is shown that the changing population of drivers is affecting commercial motorcycle ownership structure as more new drivers employ the options of hire-purchase and rented motorcycle to acquire motorcycles for use. But these options are substantially expensive. The huge cost of repayment that results impacts on drivers' income projection (**target income**) and causes an **earning pressure**. The **earning pressure** causes drivers to have to work more, a situation which leads to earning high income and further gives the impression that the trade gives a **high job returns** so that more people are joining and more drivers are taking hire-purchase and rented motorcycles. But as drivers work more, another impression is created that the trade is too strenuous and should be a transitory career. So many exert themselves more, intending to save some money and change to other trades. Thus, even when drivers have finished their repayment, many of them are still subjected to the **earning pressure** in the bid to raise capital for other trades. This pressure is also contagious as others who do not have such job-switch ambition do not want to earn below their colleagues either. This pressure is maintained over time and only starts to fall with more years of **experience** on the trade. But while the pressure remained, the drivers were risky.

In addition, because the trade is open to all, there are many unqualified and untrained drivers in it. These are called **risky and dangerous drivers**. They are increasing in number as the number of drivers increases. They engage in violations and, in response to **earning pressure** use alcohol and other drugs to support themselves, a situation which makes them more dangerous. In addition, drivers are spending more time working, and having less interest in training and less time to commit to improving their driving ability so that there is more ignorance which affects drivers' **willingness to give time for training** and leads to dangerous violations. This description generates the following issues:

[30] In the three issues identified above, it was considered important to separate the role of the officers (first statement) from its effect on drivers (second statement). The third statement also needs to stand alone as a key problem.

iv. A growing drivers' population is causing further growth through the increasing awareness of the high profit margin in the trade. This is mentioned in summary number 2 in section 8.7.2.1

v. Expensive ownership options available are promoting population growth but raising earning pressure within the trade. This is mentioned in summary number 3 in section 8.7.2.1

vi. Increasing competition should reduce population growth but its effect is weak. This is mentioned in summary number 2 in section 8.7.2.1

vii. Strenuous working condition is making drivers to turn to violations and career-switch plans. This is mentioned in summary number 3 in section 8.7.2.1

viii. Career-switch plans are promoting savings habit and adding to or sustaining earning pressure. This is mentioned in summary number 3 in section 8.7.2.1

ix. Training deficiency is reinforcing itself with drivers needing to work more but having less time for driving education. This is mentioned in summary number 4 in section 8.7.2.1.

The third player in the system, the politicians, contributes to the system by providing motorcycles to drivers. While this is important, it is infrequent. The rather more common influence of the politicians in the system is their contribution to weak deterrence by interrupting the process of prosecution. This directly contributes to the corruption in the enforcement process mentioned under the first group of player. It is therefore not repeated.

The last group is the other road users. Other road users including other vehicle drivers, pedestrians and even commercial motorcycle passengers all contribute to make the roadway risky for commercial motorcycle operation. Nevertheless, Mehmood (2010) notes that vehicle, road and environmental conditions have only slight effect on driver behaviour. More importantly, this last group will be excluded from further analysis so as to keep the system boundary within manageable limits.

The description provided above in the form of nine listed issues represent what is known as dynamic hypothesis in system dynamics. As noted in section 5.5.2, a dynamic hypothesis is an explanation of the cause of the problem structure of a system from a dynamic perspective; it is a theory of the problem structure for the system. This theory is however usually represented using graphs. The process of graphically representing this hypothesis is shown in sections 9.3 and 9.4.

9.3 Development of CLD

Table 9.1: List of issues developed into CLD

	Issues		Section and theme	Division	
	Description	**Loop Name**		**Player group**	**Section and title**
1	Officers enforce law by detecting and arresting violators but this process is weak.	Detection	9.3.1.1 Detection loop	Enforcement officers	9.3.1 Enforcement and regulation related concepts
2	Enforcement operation should deter drivers from engaging in violations and build the culture of safe driving behaviour but this process too is weak.	Deterrence	9.3.1.2 Deterrence loop		
3	There is the problem of corruption in enforcement operation and this affects both drivers and officers. This is particularly with respect to rent paid to officers	Payment of rent	9.3.1.3 Payment of rent loop		
4	A growing drivers' population is causing further growth through the increasing awareness of the high profit margin in the trade.	Drivers' population growth	9.3.2.1 Drivers' population growth loop	Drivers' group	9.3.2 Drivers' and work characteristics concepts
5	Expensive ownership options available are promoting population growth but raising earning pressure within the trade.	Expensive ownership options	9.3.2.4 Competition, ownership and strenuous working condition loops		
6	Increasing competition should reduce population growth but its effect is weak.	Competition reduces drivers' population			
7	Strenuous working condition is making drivers to turn to violations and career-switch plans.	Trade is strenuous			
8	Career-switch plans are promoting savings habit and adding to or sustaining earning pressure	"…not a lifetime trade"	9.3.2.5 Training and career-switch loops		
9	Training deficiency is reinforcing itself with drivers needing to work more, having no time for driving education, and ignorantly taking further risks	Time for training			

The interest henceforth is to further illustrate the structure of commercial motorcycle safety problem identified in section 9.2 by using a CLD. As noted in sections 4.3.1 and 5.6.2 a CLD is appropriate to illustrate this understanding. A CLD focussing on these specific issues is therefore developed with the support of the background knowledge from chapter 8. In the following sections, the nine important concepts listed in section 9.2 above (i.e., items i to ix) are adopted for the development of a CLD. For convenience, these concepts are grouped into two since the interplay of actions within the system is summarised under two main actors in section 9.2. These actors are the enforcement officers and the drivers. Table 9.1 shows this list of key issues. In the succeeding discussion, what is first presented are the issues relating to the enforcement officers and is titled the enforcement and regulation related concepts. This is followed by drivers' and work characteristic concepts which covers all the other concepts. In each of the two sections, a table that relates the causal links to data (particularly, section 8.7) and to the literature is provided for each CLD structure. These tables also indicate links that emerged from the researcher's understanding of the data as well as links that serve as mere connections. Those links that emerged from the researcher's understanding of the data are referenced as "insights" while those that serve as mere connections are labelled "completing links". Finally, for all the CLD structures, blue links indicate newly introduced descriptions while red links indicated previously treated descriptions.

9.3.1 Enforcement and regulation related concepts

The concepts in this section are all related to the activities of enforcement officers. Three causal loops are identified and described. These are detection loop, deterrence loop, and payment of rent loop.

9.3.1.1 Detection loop

The causal network in figure 8.19 indicates that drivers' awareness of the possibility of being caught and arrested for a violation is an important factor in the decision on whether to commit a violation or not. It shows that when there were more police posts in the city, there were fewer drivers. This was because it was more difficult to get away with violations. Nevertheless data notes that drivers were still able to get away with violations because they were not caught by enforcement officers. The discussion here relates to section 8.7.1.5. It is also well established in the theory of deterrence as well as studies on policing and crime (Polinsky and Shavell, 2001; Garoupa, 1997; Chang et al., 2000). From the causal network, it can be shown that increase in **enforcement coverage** leads to increase in the **probability of detection**. Increase in **enforcement coverage** is often reflected in the number of police posts mounted on highways. Thus the number of police posts on highways often relates to the level of violation/ adherence to traffic rules. As the **probability of detection** increases, there is a fall in the number of violations committed by drivers and this can ultimately result in less **enforcement coverage**. This is shown in figure 9.2 below.

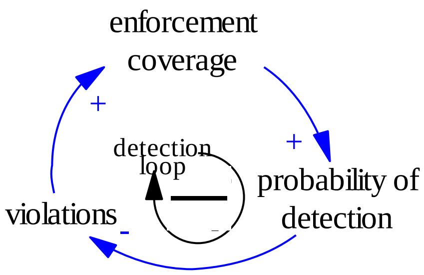

Figure 9.2: Detection loop

Loop description

The detection loop in figure 9.2 shows that if the probability of a violator being caught increases, the number of violations will decrease. If the number of violations decreases, the level of **enforcement coverage** would decrease. And if the level of **enforcement coverage** decreases, the probability of being arrested for violations would decrease. It is a balancing loop. Table 9.2 gives more information about figure 9.2. The table provides an overview of the source and meaning of figure 9.2. Further information on the description of the relationships in figure 9.2 above can be found in tables 8.13, 8.15 and 8.19 while more information on the themes are presented in tables 8.5 and 8.7.

Table 9.2: Support table for figure 9.2

Definition	**Link**	**Data support**	**Literature support**
Enforcement coverage: is the level of monitoring of traffic provided by the enforcement agencies.	Enforcement coverage affects probability of detection	R3I	Sherman et al., 2003
Probability of detection: is the likelihood of a violator being caught by an officer.	Probability of detection affects violations	R1I, R2I, R1IX	Sherman et al., 2003; Polinsky and Shavel, 2001
Violations: is used to describe all unsafe and illegal habits of drivers.	Violations affects enforcement coverage	R4IX	Sherman et al., 2003; Polinsky and Shavel, 2001

9.3.1.2 Deterrence loop

Figure 9.2 can be further extended based on the causal network (figure 8.19). For example, figure 8.19 shows **violation** to be related to **deterrence**. **Violation** is also related to **prosecution** (rate) and to **political influence**. **Deterrence** is a product of the effect of sanction: sanction has the potential of building a behavioural pattern, which is calls deterrence (Polinsky and Shavell, 2001; Garoupa, 1997; Chang et al., 2000). This means that enforcement operation is not only intended to discourage crime, but also to discourage criminal tendencies. But section 8.7.1.5 notes that corruption in enforcement is one major reason identified as being responsible for low deterrence. It shows that drivers have come to assume that some enforcement officers are on the street to make money rather than improve traffic. It also indicates that in some instances, increase in **enforcement coverage** is fuelled by the intention to raise money for enforcement agencies/ officers rather than to promote deterrence. Since the drivers have come to assume this view as reflected in section 8.7.1.5, it is shown here that it affects their attitude to violation, and by that fact, their deterrence level. This is more so as it is also shown in section 8.7.1.5 that drivers flee from enforcement officers because they (drivers) see them (officers) as extorting money. This structure when included in figure 9.2 yields figure 9.3.

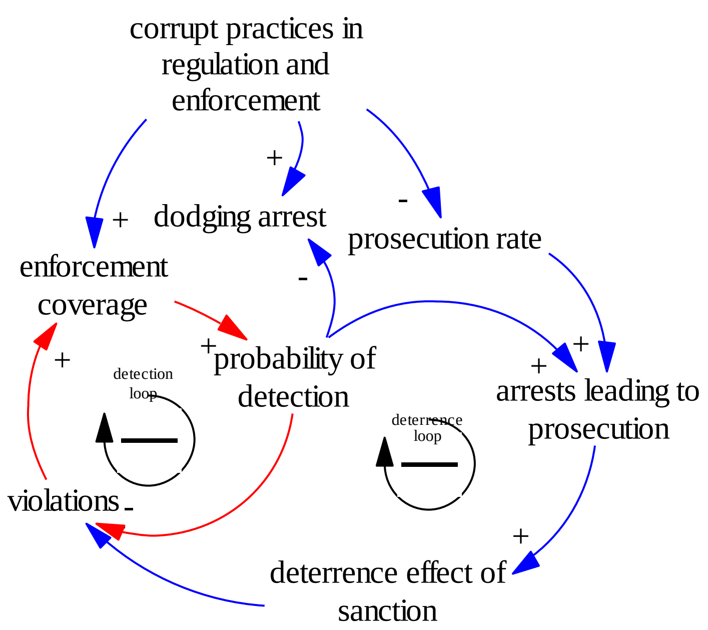

Figure 9.3: Deterrence loop

<u>Loop description</u>

The deterrence loop in figure 9.3 shows that if the **probability of detection** increases, the number of arrests that is prosecuted will increase, depending on prosecution rate. If the number of arrest that is prosecuted increases, the **deterrent effect of sanction** will improve. If the **deterrent effect of sanctions** improves, then the number of violations committed will reduce. If violations fall, **enforcement**

coverage will reduce, causing the **probability of detection** to fall and the arrests that are prosecuted to fall. This is a balancing loop.

Table 9.3 provides an overview of the source and meaning of figure 9.3. Further information on the description of the relationships in figure 9.3 can be found in tables 8.13, 8.15 and 8.19 while more information on the themes are presented in tables 8.5 and 8.7.

Table 9.3: Support table for figure 9.3

Definition	Link	Data support	Literature support
Arrests leading to prosecution: means the number of arrested violators who face prosecution Dodging arrest: is when drivers flee officers to avoid being arrested Corrupt practices in regulation and enforcement: is the acknowledgement of corruption in regulation and enforcement processes. Deterrent effect of sanctions: is the behavioural pattern that the application of sanctions is able to cultivate particularly with respect to the tendency to refrain from committing a violation. Prosecution rate: is the percentage of arrested violators that are prosecuted	Arrests leading to prosecution affects deterrent effect of sanctions		Sherman et al., 2003; Polinsky and Shavel, 2001
	Corrupt practices in regulation and enforcement affects enforcement coverage	R2FG1, R3FG2	Anbarci et al., 2006
	Corrupt practices in regulation and enforcement affects dodging arrest	R3I, R2FG1	
	Corrupt practices in regulation and enforcement affects prosecution rate	R3I	Sherman et al., 2003; Polinsky and Shavel, 2001
	Deterrent effect of sanctions affects violations	R1I, R3I, R1IX, R4IX	Sherman et al., 2003; Polinsky and Shavel, 2001
	Probability of detection affects arrests leading to prosecution		Polinsky and Shavel, 2001
	Probability of detection affects dodging arrest	R1IX, R2FG1	
	Prosecution rate affects arrests leading to prosecution		Polinsky and Shavel, 2001

9.3.1.3 Payment of rent loop

As noted above and shown in section 8.7.1.5, other factors that affect deterrence are the influence of the politicians and corruption. Politicians often defend or excuse drivers who violate laws. This is one of the excuses enforcement agencies gave for their inadequate performance and is therefore shown in the next figure. But corrupt practices in the form of rent-seeking by officers is a major contributor to weak deterrence, as discussed in section 8.7.1.5. This practice has a way of reinforcing itself as noted by Anbarci et al. (2006). It is therefore represented with a feedback loop. As shown in section 8.7.1.5, this follows from the fact that as officers prosecute violating drivers less and receive rent from them, the officers benefit more. This leads to a desire to prosecute less so as to benefit more. This is often the case when illegal police post are mounted with the goal of extorting money from motorists. In this situation, the number of violations may not reduce as it should do even though the number of arrest is increasing because prosecution rate is reducing. This structure is therefore included in the emerging CLD to generate figure 9.4.

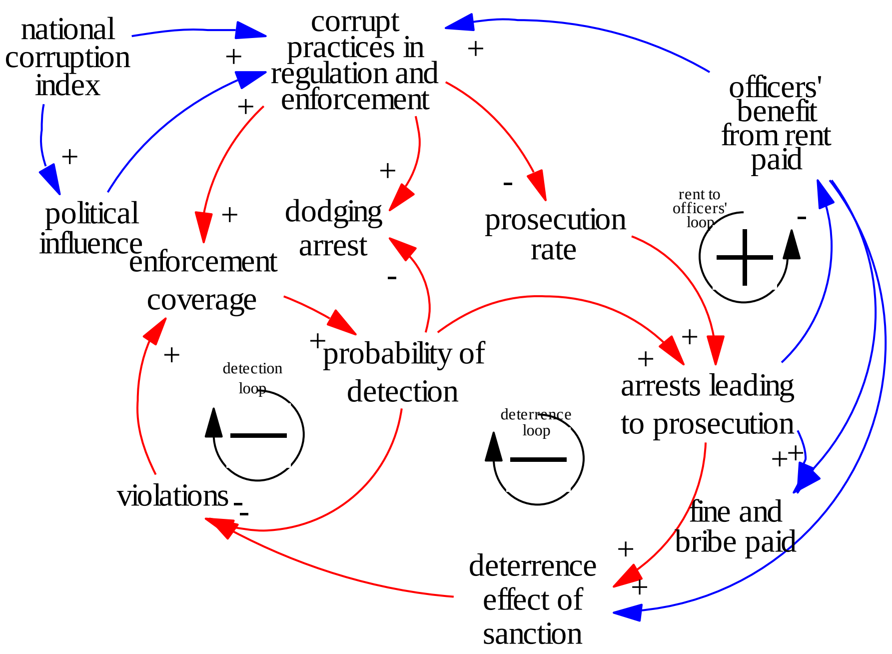

Figure 9.4: Payment of rent loop

Loop description

The **payment of rent** loop in figure 9.4 shows that if the rent paid to officers by violators in place of prosecution increases, the **corrupt practices in regulation and enforcement** becomes more appealing. As corrupt practices become more established, prosecution rate falls. As prosecution rate falls, the number of arrests leading to prosecution falls and this further leads to increase in **officers' benefit from rent paid** by violators. This is therefore a reinforcing loop.

Table 9.4 provides an overview of the source and meaning of figure 9.4. Further information on the description of the relationships in figure 9.4 above can be found in tables 8.13, 8.15 and 8.19 while more information on the themes are presented in tables 8.5 and 8.7. The two themes national corruption index and officers' benefit from rent are extensions to corrupt practices.

Table 9.4: Support table for figure 9.4

Definition	Link	Data support	Literature support
<u>National corruption index</u>: means the level to which a country is corrupt. Index is as measured by international organisations <u>Officers' benefit from rent paid</u>: means payment to enforcement officers as gratifications by the drivers. Sometimes, these payments are extorted <u>Political influence</u>: means the use of political powers by politicians to influence prosecution and not follow due process <u>Fine and bribe paid</u>: is the summation of monies paid to for committing violation	Arrests leading to prosecution affects officers' benefit from rent paid	R3I, R2FG1	Sherman et al., 2003; Polinsky and Shavell, 2001
	Arrests leading to prosecution affects fine and bribe paid		Polinsky and Shavell, 2001
	Officers' benefit from rent paid affects corrupt practices in regulation and enforcement	R2FG1, R3FG2	(Bowles and Garoupa, 1997)
	Officers' benefit from rent paid affects deterrent effect of sanctions	R3I, R2FG1	Anbarci et al., 2006
	Officers' benefit from rent paid affects fine and bribe paid		(Polinsky and Shavell, 2001)
	National corruption index affects corrupt practices in regulation and enforcement	R1I, R3I	(Talvitie, 2012; Anbarci et al., 2006)
	National corruption index affects political influence	R3I	Talvitie, 2012
	Political influence affects corrupt practices in regulation and enforcement	R1IX, R4IX	

9.3.2 Drivers' and work characteristics concepts

The concepts in this section are all related to the drivers and their characteristics. Six causal loops are identified and described. These are drivers' population growth loop, competition-reduce-drivers'-population loop, expensive ownership options loop, trade-is-strenuous loop, time for training loop, and "…not-a-lifetime-trade" loop.

9.3.2.1 Drivers' population growth loop

The causal network (figure 8.19) indicate that drivers' population growth is supported by the awareness that the trade is lucrative. The data indicates that individual with no means of livelihood can join the trade and thrive. Commercial motorcycle trade is a lucrative one with evidence that drivers make above the national minimum wage from the trade (Arosanyin et al., 2011; Ogunrinola, 2011). It also shows that unlike most other informal trades, commercial motorcycle trade does not require long apprenticeship or training. This is the reason why people from various other trades switch job to commercial motorcycle trade on full time or part time basis. As shown in section 8.7.1.1, the awareness of this high job returns contributes to the rising number of drivers. This awareness would normally be created as drivers interact with members of the public so that the more the number of drivers the more people became aware of this highly profiting trade. This structure can be represented in a CLD as shown in figure 9.5 below.

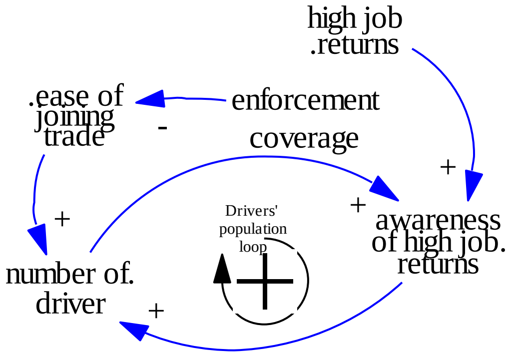

Figure 9.5: Drivers' population growth loop

<u>Loop</u> description

The drivers' population growth loop in figure 9.5 shows that as the **number of drivers** increases, so does the **awareness of high job returns** of commercial motorcycle trade. As the awareness that the trade offers a high return increases, so does the **number of drivers** increase. It is a reinforcing loop.

Table 9.5: Support table for figure 9.5

Definition	**Link**	**Data support**	**Literature support**
<u>Awareness of high job returns</u>: means the awareness in the public domain about commercial motorcycle's profitability <u>Ease of joining trade</u>: means the trade is free for anybody to join; there are no restricting requirements to be met by a prospective driver, though the presence of enforcement officers might give some restraint. <u>High job returns</u>: means the return on investment into the trade is very high. It also means the trade can guarantee livelihood <u>Number of drivers</u>: the population of commercial motorcycle drivers	Awareness of high job returns affects number of drivers	R1I, R2FG1	(Rogers, 1962 in Struben and Sterman, 2008)
	Ease of joining trade affects number of drivers	R1I, R5FG1	
	High job returns affects awareness of high job returns	R1I	Arosanyin et al., 2011; Ogunrinola, 2011
	Number of drivers affects awareness of high job returns		Rogers, 1962 in Struben and Sterman, 2008
	Enforcement coverage affects ease of joining trade	Table 8.21	Garoupa, 1997; Chang et al., 2000

Table 9.5 provides an overview of the source and meaning of figure 9.5. Further information on the description of the relationships in figure 9.5 above can be found in table 8.9. Also additional information on the themes is presented in table 8.3. The theme “awareness of high job returns” did not appear in chapter 8. Its introduction here is intended to provide a link between “number of drivers” and “high job returns”. As its name reads, “awareness of high job returns” is the awareness in the public domain about commercial motorcycle’s profitability i.e., the “high job returns” characteristics of the trade. The structure in figure 9.5 is a common concept in diffusion theory (Rogers, 1962 in Struben and Sterman, 2008).

9.3.2.2 Expensive ownership options

Furthermore, sections 8.7.1.1 and 8.7.1.2 indicate that the availability of hire-purchase and rent options for prospective drivers make joining the trade a lot easier for many who could not afford the cost of a motorcycle. These people take these expensive options based on the awareness that the trade is lucrative and actually become owners after some time as shown in section 8.7.1.1 and 8.7.1.2. This structure thus shows that increase in the number of motorcycles on hire-purchase and rent is an important influencing factor in the determination of the number of commercial motorcycle drivers.

It is also shown that just anyone could start the trade at any time, so that competence was not a pre-requisite for joining (see section 8.7.1.4). The implication is that drivers were often not trained and were not qualified to drive even while driving. This leads to an army of risky and dangerous drivers. But earlier in the history of the trade, competence was not a problem. Section 8.7.1.1 shows that early operators of commercial motorcycle were motorcycle owners who were experienced in driving before starting the trade. But as the number of drivers increased, the number of drivers without previous driving experience started to increase so that there were probably more of the less competent drivers in the system than the competent ones. As shown in section 8.7.1.1, the literature agrees with the data. It notes that early commercial motorcycle drivers were motorcycle owners (proficient in driving motorcycles) who turned their motorcycles into taxis (Ogunbodede, 2008). But as the number of commercial motorcycle grew, there were fewer of such expert drivers and those who were newly joining did not care about training (Iribhogbe and Odai, 2009). This structure can be added to figure 9.5 so that a new CLD emerge as shown in figure 9.6 below.

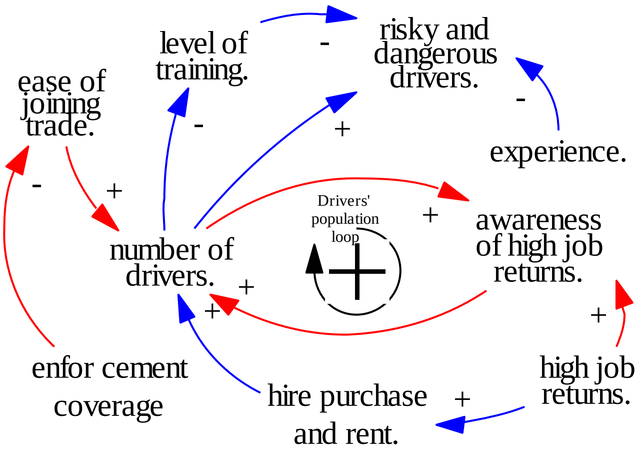

Figure 9.6: Drivers’ population growth loop extension

Table 9.6: Support table for figure 9.6

Definition	Link	Data support	Literature support
Experience: is a measure of the length of time for which a driver has been working as a commercial motorcycle driver, usually in years. Hire-purchase and rent: This describes motorcycle ownership options where driver who do not own their motorcycles can acquire motorcycle by purchasing on instalment or by renting it Level of training: refers to how competent a driver is. Here it refers to drivers’ population competence level. It can be treated as the share of drivers who participate in training Risky and dangerous drivers: describes drivers who have relatively high tendency to commit violations. This is usually as a result of lack of training or work pressure.	Experience affects risky and dangerous drivers	R2FG1; R6FG2	
	High job returns affects hire-purchase and rent	R1IX	
	Hire-purchase and rent affects number of drivers	R2FG1	Olubomehin, 2012
	Level of training affects risky and dangerous driving (drivers)	R1I, R3IX, R4IX	Lee (2010); Iribhogbe and Odai, 2009; Oluwadiya et al., 2009
	Number of drivers affects level of training	R2I, R2FG1	
	Number of drivers affects risky and dangerous drivers	R4FG2	Olubomehin, 2012

Table 9.6 provides an overview of the source and meaning of figure 9.6. Further information on the description of the relationships in figure 9.6 above can be found in tables 8.9 and 8.11 while more information on the themes are presented in tables 8.3 and 8.4.

9.3.2.3 More work concept (working more/ longer)

Further causalities can still be identified in the causal network. It can be seen that the increasing number of drivers results in competition for picking passengers which also affects drivers' income. While this is not emphasised in the data, table 8.21 in section 8.7.2 notes that drivers compete for passengers. Mahlstein's (2009) study shows that drivers were willing to pick passengers for a lower fare than they would have otherwise done due to this rising competition. This has an implication on how drivers work. For example, to make a desired target amount, drivers might have to work more than they would otherwise do. Arosanyin et al. (2013) finds drivers' average working period to be as high as 13 hours a day.

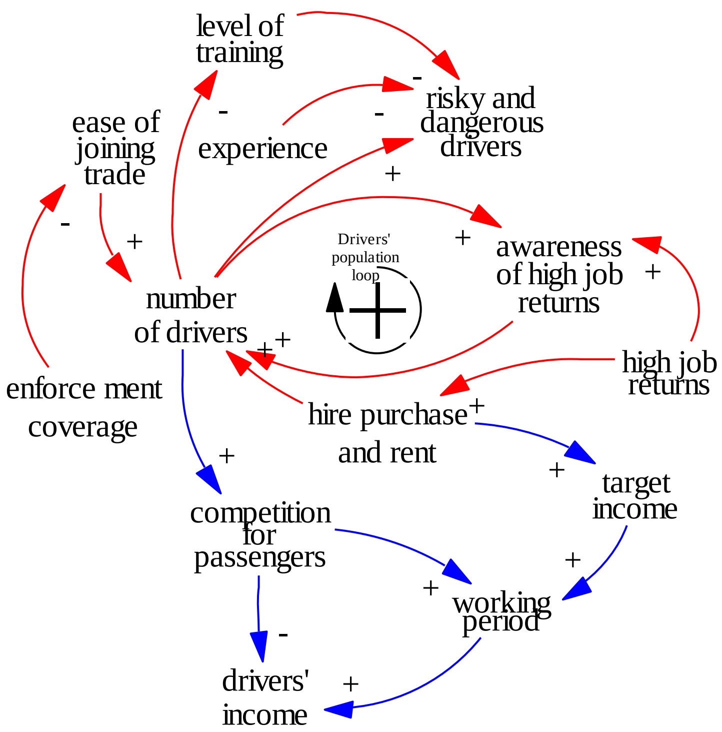

Figure 9.7: Drivers population growth effect

In addition, drivers who joined the trade through hire-purchase and rent needed to make payments for the cost of the motorcycle and raise enough for their personal maintenance. Section 8.7.1.1 and 8.7.1.2 show that such drivers worked more and were more pre-occupied with what they wanted to make (when compared with others who own their motorcycles). This structure is shown in figure 9.7 above and table 9.7 is used to provide an overview of the source and meaning of figure 9.7. Further information on the description of the relationships in the figure can be found in tables 8.9, 8.11, and 8.17 while more information on the themes are presented in tables 8.3, 8.4, and 8.6.

Table 9.7: Support table for figure 9.7

Definition	Link	Data support	Literature support
Drivers' income: is the average daily earning of the drivers' population Competition for passengers: means drivers are so many that they often contend to pick passengers Target income: describes the average for all drivers of the desired income a driver proposes to work towards on daily basis Working period: is the average daily number of hours the drivers population work for	Competition for passengers affects drivers' income		Mahlstein, 2009
	Competition for passengers affects working period	***Insight***	
	Hire-purchase and rent affects target income	R1IX, R2FG1	Adeniji, 1987
	Number of drivers affects competition for passengers	***Completing link***	
	Target income affects working period	R2FG1, R2FG2	
	Working period affects drivers' income	R3I	Ogunrinola, 2011

9.3.2.4 Competition, ownership and strenuous working condition loops

By considering a factor that can be called earning pressure in the system, it is possible to extend figure 9.7 still further. Since more work was done to earn more, drivers were pushed to work more and were able to increase their average working time per day in order to realise their desired target. This "push" termed earning pressure resulted from high target income set by drivers as well as the increasing competition for passengers. As drivers reached their target, the perception that commercial motorcycle trade is lucrative was maintained, especially as long as drivers could work more. But working for a longer time would normally result in fatigue as drivers stretched their work capacity to the limit. Section 8.7.1.3 notes that one of the reasons why drink driving/ "driving under influence" was common is that these substances enhanced drivers' capacity to work. The section also shows that their adverse effects are notable, particularly in causing violations and accidents. This is shown in figure 9.8 below.

Loops description

Competition-reduce-drivers'-population loop: The competition-reduce-drivers'-population loop shows that as the number of drivers increases, competition amidst drivers increases, which lowers drivers' income. As drivers' income falls, the impression that the trade is no longer as lucrative as it was arises. This reduces the awareness of the public about the profitability of the trade (with some delay), a situation that should lead to a reduction in the number of drivers and thus less competition. But this might not be happening because of the time delay between the actual reduced profit and the awareness about it. This loop is reflected in figure 9.8 below.

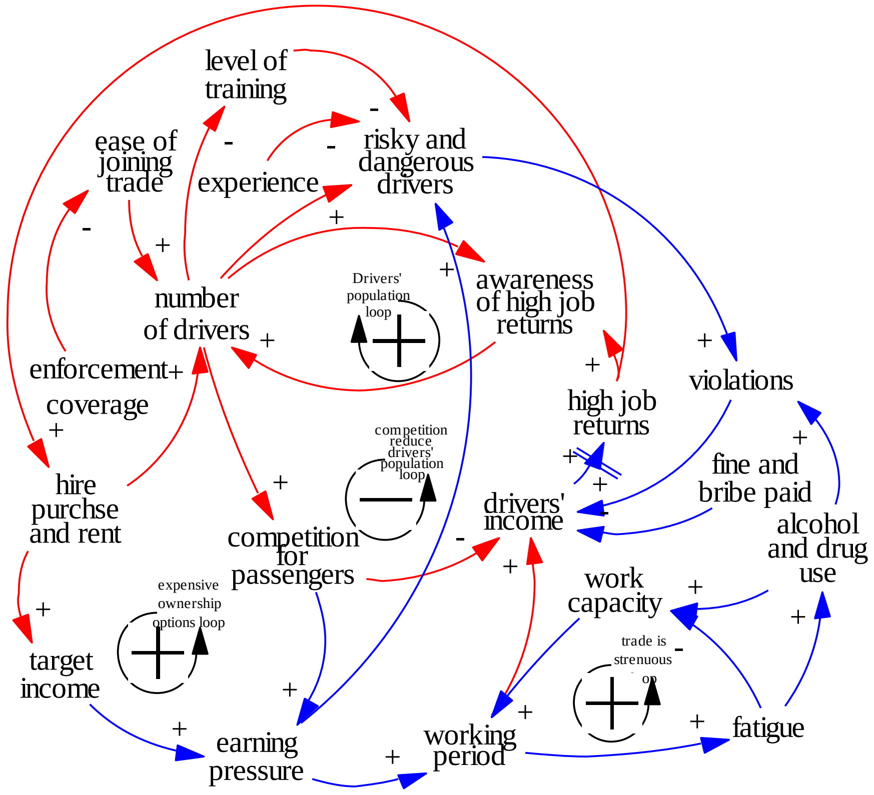

Figure 9.8: Competition, ownership and strenuous working condition loops

Expensive ownership loop: The expensive ownership loop in figure 9.8 above indicates that if the number of drivers taking **hire-purchase and rent** options increases, **target income** within the system on the average will increase. If **target income** increases, the pressure to earn more money will increase. As the pressure to earn more money increases, drivers work for longer hours which lead to high drivers' income. High drivers' income further gives the impression that commercial motorcycle trade is lucrative so that more drivers come in through **hire-purchase and rent** option. This is a reinforcing loop. Moreover, this loop generates a state where drivers tend to remain under **earning pressure** even when they no longer have payments to make.

Trade-is-strenuous loop: The trade-is-strenuous loop above indicates that as drivers increase their working period, fatigue sets in which reduces their capacity to work, bringing down their working period again (e.g., through occasional sicknesses). This cycle makes drivers see commercial motorcycle trade as strenuous. But it also makes some drivers to turn to the use of alcohol and other drugs for support.

Table 9.8: Support table for figure 9.8

Definition	Link	Data support	Literature support
Alcohol and drug use: Refers to the population of drivers engaged in using alcohol and drugs Earning pressure: refers to pressure that results from target income and harsh working condition Fatigue: refers to physical exhaustion that results from extended working period Work capacity: describes drivers' ability to work which is the time drivers can work for within a 24 hours period	Alcohol and drug use affects work capacity	R1I, R3i, R1IX, R4FG1, R3FG2	Cevero, 2000, Olubomehin, 2012
	Alcohol and drug use affects violations	R1I; R2I, R2IX, R3IX, R2FG1; R1FG2; R2FG2; R3FG2; R4FG2; R5FG2	Iribhogbe and Odai, 2009
	Drivers' income affects high job returns	***Insight***	
	Competition for passengers affects earning pressure	***Insight***	
	Earning pressure affects risky and dangerous drivers	R1IX, R2IX	Oluwadiya et al., 2009
	Earning pressure affects working period	R1IXR2FG1; R4FG1	Cevero, 2012
	Fatigue affects alcohol and drug use		Olubomehin, 2012; Iribhogbe and Odai, 2009
	Fatigue affects work capacity	***Insight***	
	Fine and bribe paid affects drivers' income	***Insight***	
	Risky and dangerous drivers affect violations	R2IX,	
	Target income affects earning pressure	R2FG1, R2FG2	Oluwadiya et al., 2009
	Violations affects drivers' income	R1FG1,	Chang et al., 2000
	Work capacity affects working period	***Insight***	
	Working period affects fatigue	***Insight***	

Table 9.8 provides an overview of the source and meaning of figure 9.8. Further information on the description of the relationships in figure 9.8 above can be found in tables 8.9, 8.11, 8.13, 8.15, and 8.17 while more information on the themes are presented in tables 8.3, 8.4, 8.5, and 8.6. In the case of the link "Violations affects drivers' income", literature on commercial motorcycle shows this relationship to be

the reverse. It is shown that violation costs money (Arosanyin et al., 2011). However, based on the theory of deterrence, drivers still choose to violate and bear the consequence if they think it offers some ultimate positive reward (Garoupa, 1997; Chang et al., 2000).

9.3.2.5 Training and career-switch loops

Working longer is shown in section 8.7.1.4 to contribute to drivers' unwillingness to commit time to training[31]. But this does not seem to be all the reason as it is also blamed on the unavailability of training opportunity and the inability to regulate the system. Moreover, the literature shows that only about 10% were not willing to give time for training in a study conducted by Iribhogbe and Odai (2009), whereas, many more did not attend available training programmes. Nevertheless, since available training opportunities are not fully explored, it is good to evaluate drivers' willingness to train.

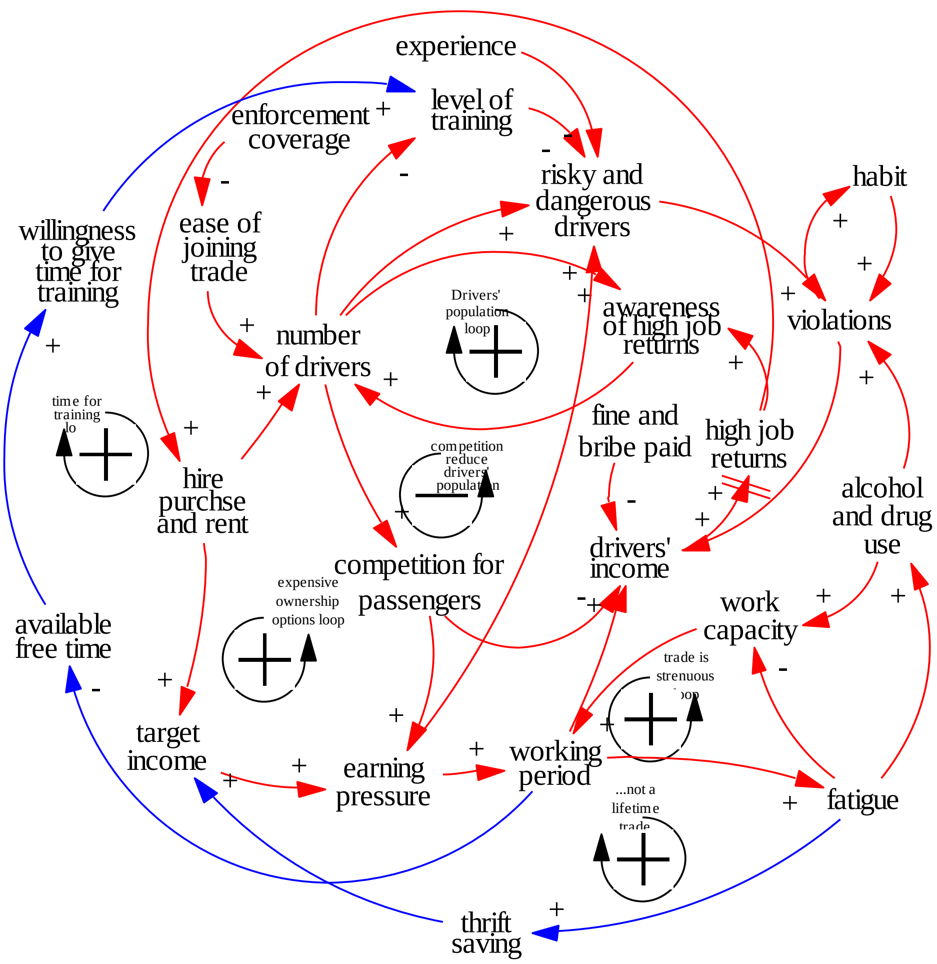

Figure 9.9: Training and career-switch loops

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[31] For training here, emphasise is laid on driving education as current training opportunity is limited to driving education and awareness campaign about safety tips.

As noted in section 9.3.2.4, working longer resulted in fatigue. Fatigue, in addition to promoting the use of alcohol and drugs also brought the impression that the trade should not be a permanent career. The implication on drivers was the decision to raise capital for a different trade by making savings (thrift savings). Thrift savings made them work more, generating another vicious cycle or at least maintaining their pressure. Figure 9.9 above shows these relationships.

Loops description

" …not a lifetime trade" loop: This loop in figure 9.9 shows that as increasing working period results in fatigue, drivers contemplate a job switch and so raise their thrift savings to raise money for an alternative trade. As the thrift savings rises, target income rises too, leading to increased earning pressure. The rise in earning pressure further leads to increased working period causing a reinforcing loop.

Time for training loop: The time for training loop on the other hand shows that as working period increases, drivers have less free time. As the free time available to drivers reduces, their willingness to give time for training reduces too. This results in a lower level of training amidst drivers in the system than it should otherwise be. A lower level of training makes drivers more risky and dangerous and leads to more violations. Violations do often increase/ conserve drivers' income and so support the high drivers' income that reinforces the high job returns perception about the trade. This is a reinforcing loop too.

Table 9.9: Support table for figure 9.9

Definition	**Link**	**Data support**	**Literature support**
Available free time: time a driver has to commit to other things different from work Habit: group behaviour of drivers. This is treated under deterrence effect of sanction Thrift savings: an informal savings scheme which drivers normally enlist to. May also include bank savings Willingness to give time for training: drivers' readiness to spare time to attend available training opportunities	Available free time affects willingness to give time for training		Iribhogbe and Odai, 2009
	Fatigue affects thrift savings	***Insight***	
	Thrift savings affects target income	R2FG1, R2FG2	
	Social norm affect violations	R1I	Oluwadiya et al., 2009
	Violations affects social norm		Oluwadiya et al., 2009
	Working period affects available free time	***Insight***	
	Willingness to give time for training affects level of training	R1I, R4FG1	

Table 9.9 provides an overview of the source and meaning of figure 9.9. Further information on the description of the relationships in figure 9.9 above can be found in tables 8.9, 8.11, 8.13, 8.15, and 8.17 while more information on the themes are presented in tables 8.3, 8.4, 8.5, and 8.6.

Finally, section 8.7.1.3 shows that drivers are generally viewed as violators. This is an indication that violation is a practice for many of the drivers. Oluwadiya et al. (2009, p.298) refer to this attitude as "risky behaviour" amidst drivers and argue that this attitude has become a habit for the drivers. Thus, it is shown that violation practices develops into a habit which further affect driver behaviour and reinforces dangerous practices. This habit has been fully treated under deterrence loop previously as drivers' level of deterrence and will be integrated into this diagram in figure 9.10 in section 9.4.

9.4 Emerging CLD

The final CLD is presented in figure 9.10. This figure is the combination of the CLDs generated from the enforcement and regulation themes and the drivers' and work characteristics themes. It was derived from the identified key causal summaries (listed in section 9.2) extracted from the causal network in section 8.7.2. The process of extracting and converting these summaries into a CLD followed the recommendation of Goh et al. (2010, p.308) who note that it is necessary to adopt typical causal analysis tools to identify the "facts of the case and key causal summaries systematically. The key causal summaries can then be further analysed in causal loop diagrams" to highlight the structure at play in the system. The result of this further analysis is what is shown in figure 9.10.

The CLD shown in figure 9.10 provides a representation of commercial motorcycle system. It shows how the drivers' violation behaviour can be influenced by different factors supported in one feedback loop or the other. It offers a clear representation for thinking through what problems are in the system and how they influence the system. As noted by Goh et al. (2010), this type of analysis identifies points of leverage within the system. An analysis using CLD may therefore be able to provide a structure that can guide in formulating an all-encompassing policy that is able to treat system problems more holistically. As Videira et al. (2014) showed, it is possible to frame better debates and obtain a procedure for the elaboration of plausible future pathways with the use of this analysis method.

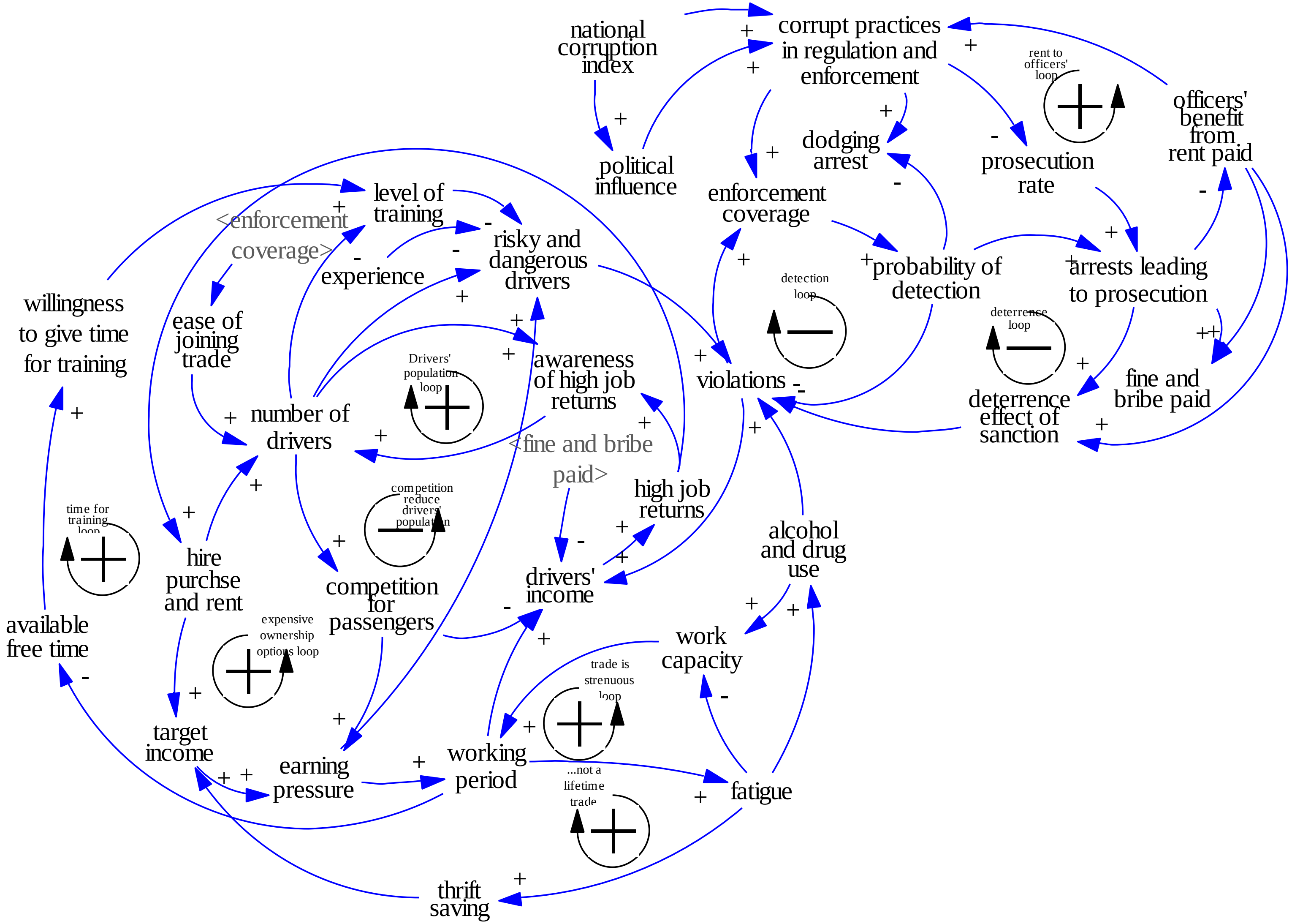

Figure 9.10: Complete system CLD

9.4.1 Comparison of the structures of CLD and causal network

The CLD in figure 9.10 is different from the causal network that emerged at the end of section 8.7.2. This difference is as a result of a number of reasons. First, the causal network provides a description of the safety system of commercial motorcycles: it is the outcome of "investigation" and "fact-finding" about the problem structure. It is therefore expected to be verbose. In addition, the causal network looks at the safety system as a whole. On the other hand, the CLD, in line with the second research objective, is narrowed down to driver behaviour. Secondly, the CLD is a representation of the key factors responsible for the problem structure of the system. The CLD also outlines some feedbacks within the system that cannot be easily captured by the causal network. Thus, the two offers different messages: the causal network shows system relationships; while the CLD shows key problematic system structures with their feedbacks loops. In addition, table 9.10 lists out the differences in the factors represented on the two graphs.

Table 9.10: CLD deviation from the causal network

Excluded factors	**Newly added factors**
Accident	Fatigue
Accident losses	National corruption
Additional work capacity requirement	Officers' benefits from rent
Availability of training opportunity	
Cost of operation	
Ignorance	
Inclement weather	
Other road users	
Peer influence	
Risky road environment	
Spending aversion/ Cutting corners	

A particular case worth explaining is the exclusion of **accident** occurrence in the CLD. This research opted to consider drivers' high-risk behaviour as an indication for system safety characteristics rather than **accident** occurrence as a factor. The reason agrees with the second objective of the research and the need to avoid too complex analysis since several other factors contribute to **accident** occurrence.

Because **accident** occurrence is not included, the factor, **losses from accident**, is not included in the CLD.

In the case of **additional work capacity requirement**, the factor became a concept represented in the links relating **working period** to **fatigue** and **work capacity**. While the name does not explicitly appear, the concept it describes is still preserved in the CLD.

Another factor is **availability of training opportunity**. This factor is ignored in the CLD. The data indicates that there are some available opportunities which are not exploited by the drivers. It also indicates that increasing training opportunities can increase drivers' **participation in trainings**. The factor: **availability of training opportunities** is therefore considered as a potential policy option that might be tested for rather than a problem concept[32].

Similarly, the **cost of operation** has not been reflected explicitly in this CLD. The **cost of operation** is related to daily operating cost and one of the most important cost items for commercial motorcycle drivers is the **hire-purchase or rent** repayment they have to make. Since other costs are small compared to this major one, **cost of operation** is replaced by **hire-purchase and rent**. In the case of costs relating to violations, e.g., licencing and taxes, these costs are covered under violation factors.

Ignorance is another excluded factor as it is covered under the factor: **level of training** since training helps to remove **ignorance**. Similarly, **inclement weather** and **peer influence** are not directly reflected in this CLD as influencing factors. Their effect is, however, subsumed under **alcohol and drug use** where they mainly apply. Furthermore, **risky road environment** and **other road users** are not treated in this CLD to keep the analysis simple and limit boundaries of the research to what is manageable within the available time. In addition, extending beyond the scope of concentrating on commercial motorcycles will make the research too expensive for the researcher to conduct.

Finally, **spending aversion/ cutting corners** is a **violation** and is not treated in the CLD. All violation types are treated under the theme violations except **alcohol and drug use** for the reason shown in section 8.6.2.3. Treating violations individually would require more data than is affordable in the current research.

[32] This test is not done in this research as policy issues are not intended to be treated

While the factors discussed above have been excluded, some new ones have been added to more properly illustrate the concepts in the CLDs. **Fatigue** is added to partly reflect the concept of the needed **additional work capacity** by the drivers. Similarly, **corrupt practices** (see figure 9.10) is mainly influenced by national attitude to corruption and this is reflected in the CLD. The last item, **officers' benefit from rent paid** by drivers is intended to reflect the relationship between **enforcement coverage**, **corruption**, and **prosecution rate**.

With the exception of the reduced boundary covered by the CLD, both CLD and causal network identify similar causalities. However, the CLD presents these causalities as nine structures that are easier to follow, understand and interpret unlike what the causal network offers.

9.4.2 Comparison of CLD insight with causal network prediction

Sections 8.7.2 and 8.7.3 show that it is possible to identify likely future condition of a variable through the use of the causal network and prediction matrices (in tables 8.22 and 8.23). However, this method is only able to offer a linear structure of the cause and effect sequence. Specifically, Miles et al. (2014) recommends not treating more than 12 antecedent variables in causal predictions. In the case of the CLD, the cause and effect relationships appear with the feedback structures that drive them. The systemic structure at play is easier to recognise and project without strongly putting a cap on how many relationships to consider. This difference makes CLD a more effective method for dealing with complex problems that manifest feedback structures. According to Goh et al. (2010) linear causal methods may not be effective as they support fragmented problem identification and treatment with solutions. The use of CLDs helps to understand systemic structure that contributes to problem situation more readily than traditional causal analysis tools.

Nevertheless, CLDs have their limitations. While they are able to show the feedback structures in a system, they are not able to indicate which feedback structures are more important that the others. They do not provide sufficient information about what feedback loops should be prioritised in dealing with system problems. They may therefore offer more demanding and expensive policy framework than would be optimally necessary.

9.5 Conclusion

This chapter has been able to identify and describe nine key causal summaries important in shaping drivers' risk taking behaviour. These key causal summaries are presented as nine feedback loops and developed into a CLD shown in figure 9.10. This CLD represents the dynamic hypothesis about commercial motorcycle driver behaviour. It shows that the population of drivers is growing and causing competition amidst drivers as well as forcing some of them to take expensive motorcycle ownership schemes to start the trade. This, in addition to the desire to switch jobs, is contributing to making the trade a strenuous one and contributing to unsafe driving behaviours and violations. Notwithstanding, the high-job-return characteristic of the system is still preserved. Unfortunately, many of the drivers are not qualified and are doing nothing to become qualified or safer. The enforcement operation responds to this by arresting violators. But corrupt practices in enforcement process causes deterrence to be low and at the same time promote unsafe behaviour amidst drivers. This explains why the system is in perpetual state of risk. This description is represented in the CLD. It (the CLD) is therefore presented as a framework that might be able to more clearly represent the system and be useful as a guide in developing a more efficient management for the system. The next chapter continues with the system dynamics approach to develop a quantitative model.

Chapter 10 Stock and flow model development

10.1 Introduction

In the previous chapter, a CLD was developed to represent a dynamic hypothesis for the high-risk behaviour problem in commercial motorcycle operation. This chapter takes the CLD further by developing a simulation model for the dynamic hypothesis. As shown in section 4.2.1, CLDs help to depict the basic causal mechanisms of the system, thereby providing the opportunity to "improve the process of thinking about the structure underlying a problem" (Homer and Oliva, 2001, p.349). They are however not sufficient to identify the root causes of system problems as they only give the structure and not the dynamics of the system (Homer and Oliva, 2001). The development of a stock and flow model (a quantitative system dynamics model) in this research follows from this limitation of the CLDs. This chapter will therefore develop a stock and flow model that tests the dynamic hypothesis represented by the CLD as well as provide opportunities for learning from the model. The core interest in the model is drivers' attitude to violations and is named: **tendency to violate**.

The process of developing a stock and flow model is a combination of skills from various fields. Thus, as part of the process a mixture of sketches, worded descriptions and equations is used to provide an explanation for the model developed. The methods used to quantify variables and the assumptions and justifications for the constructed relationships between variables are based on section 5.6.4 and are provided in this chapter. The modelling process takes the following steps: the approach to model development is presented in section 10.2; model boundaries are discussed in section 10.3; section 10.4 shows model assumptions; sections 10.5 to 10.8 describe the development of model structure and functional definition of model equations. In section 10.9 some of the tests conducted on the model are reported. These tests include structural assessment, parameter assessment, boundary adequacy, sensitivity, behaviour replication, and extreme conditions tests. Section 10.10 takes the tests further by checking for model responsiveness to interventions while the chapter conclusion is presented in section 10.11. Figure 10.1 diagrammatically shows this chapter overview.

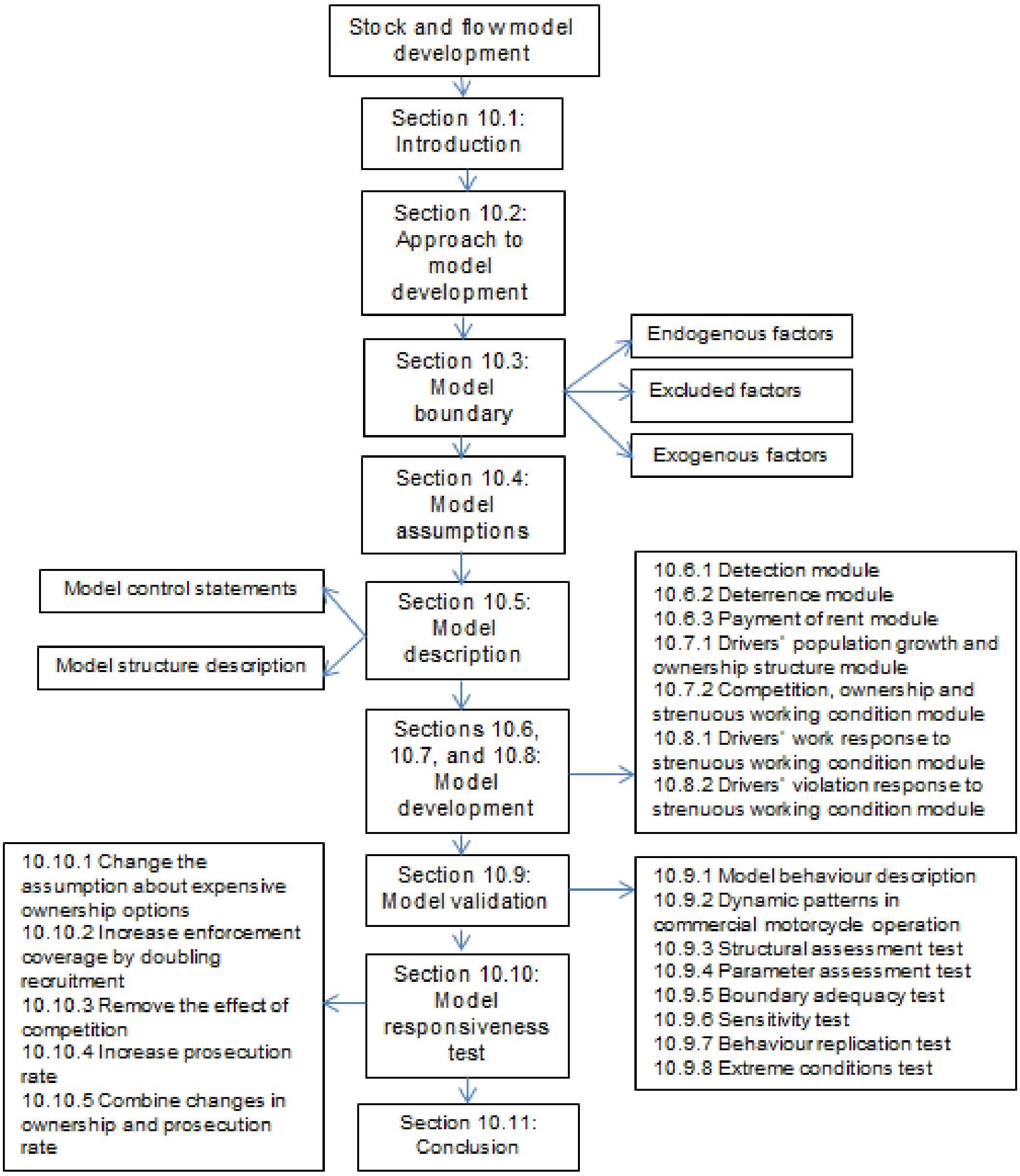

Figure 10.1: Chapter overview

10.2 Approach to model development

As previously shown in section 2.4, commercial motorcycle has proven resistant to policy measures targeted at improving its safe operation. It is therefore intended in this chapter to present a quantitative method that can identify why the system has been resistant to policies.

The approach to developing a stock and flow model in system dynamics is followed: the CLD in figure 9.10 (page 188) is transformed into a mathematical model. As described in section 5.6.4, this formalisation is done iteratively in small incremental bits, checking system behaviour against expected trend, and improving model equation to obtain better results. As a result, at this point of the model development, more information is added in the formulation of the model structure in order to replicate real life situation as closely as practicable.

10.3 Model boundaries: CLD factors treated within the model

The CLD adopted in this chapter already provides the model boundaries (see discussion in section 9.4.1) for the model to be developed. However, it became necessary to further narrow down these model boundaries. In this section the CLD factors are classified based on how they are treated in the model. This process is in line with Sterman's (2000) suggestion on making clear model boundaries, assumptions and limitations. The three divisions of factors based on their use in the model are: endogenous, exogenous and excluded factors. These are described below with some justification.

10.3.1 Endogenous factors

Endogenous factors are those whose behaviour can be explained as a consequence of the interactions within the system. "System dynamics seeks endogenous explanations for phenomenon" (Sterman, 2000, p.95). Twenty-five CLD factors are treated as endogenous factors in the model in this chapter. These 25 factors are discussed further during the process of developing model equations.

10.3.2 Excluded factor (from the CLD)

Excluded factors are treated as outside the boundary of the system and thus ignored. The factor **dodging arrest** (from the CLD in figure 9.10) is being excluded in the model because it is treated as a violation and all violations are combined and grouped under "detectable" and "undetectable" violations. **Dodging arrest** is as much an unlawful action as it is an unsafe action. Since the model does not treat individual violation types dodging arrest is not treated separately[33].

10.3.3 Exogenous factors

Exogenous factors are factors which are considered as outside the boundary of a system but yet influence the system in some ways. They explain the behaviour of the system as being caused by external factors. They are therefore not explicitly modelled; their influence is considered to be unidirectional with no significant feedbacks anticipated (Sterman, 2000). Based on this understanding about

[33] Due to lack of data, individual violation types are not treated. An exception to this is a violation type: alcohol and drug use. More information is provided later

exogenous factors, four factors are treated as exogenous factors as shown on table 10.1. For example, the ease of joining commercial motorcycle trade is not explicitly modelled because it is a national challenge of unemployment problem relating to the country's economic development. Cerevo (2000), Cerevo and Gulob (2007), and Arosanyin et al. (2011) note that high unemployment rate in many developing countries make the transport sector para-transit modes attractive and a ready means for many unemployed to earn a living. Similarly, the level of national corruption is given as exogenous factor because the focus of the model is to understand driver behaviour under the current conditions in the case study. Anbarci et al. (2006) shows that corruption is characteristic of most developing countries rather than being a peculiar characteristic of their transport system. This same problem of national corruption is the reason for the political influence that brews corrupt practices in commercial motorcycle safety system. Finally, the value for **hire-purchase and rent** factor is extracted from the literature.

An abridged model boundary chart showing the CLD factors treated as exogenous and excluded factors in the model is shown below in table 10.1.

Table 10.1: An abridged model boundary chart

Excluded factors	Exogenous factors
Dodging arrest	Ease of joining trade
	National corruption index
	Political influence
	Hire-purchase and rent

10.4 Structural model assumptions

Because models are a simplification of the real world, it is usually necessary to make assumptions about the real world to realise this simplification. As emphasised by Sterman (2000), it is important to state the assumptions underlying any model to avoid its misuse. Particularly, stating the assumptions made in a model helps to understand and appreciate its strength and limitations. It is also useful in guiding users about its applicability as well as provides opportunity for future improvement. Some basic assumptions made in the model described in this chapter are presented below:

1. The model's scope has been previously treated under model boundaries. The model concentrates on driver behaviour and how it is shaped by drivers' and work characteristics, and enforcement operations.

2. While there were many enforcement agencies and the involvement of each in traffic monitoring differed, the model assumes an aggregation of all agencies.

3. The model also shows that corruption in enforcement is not restrained. So officers have no fear in engaging in corrupt practices.

4. The model treats the population growth characteristics of a case study that started from insignificant drivers' population, went through a period of rapid growth and is now approaching saturation. This is rather a model peculiarity than an assumption as it emerged from the qualitative data.

5. Violation in this model is treated as all aberrant behaviours of drivers. They include unsafe and illegal actions. This model does not discriminate between those that arise from errors and those that are purely violations[34].

6. The time horizon in this research is chosen to be between the year 1997 and the year 2011. Model testing is extended for a period of ten years beyond 2011. As noted by Sterman (2000), the choice of time horizon depends on the nature of the problem being studied and the cycle length of its longest causal loop (taking delays into consideration). In this research, the longest duration is five years making ten years further analysis suitable for testing purpose.

7. The terms "typical day" and "representative driver" are used in this model. A typical day represents a day when all the drivers' and enforcement characteristics used to develop this model are manifested in the operation of commercial motorcycles. A representative driver, on the other hand, is a driver with characteristics equal to the average for all the drivers in the system.

10.5 Model description

The equations for the parameters used in the model are shown in sections 10.6 to 10.8. The unit of measurement of time used in the model is week. This time is the simulation time period. The time interval for the simulation (time step) is taken as approximately the length of a day, i.e., 0.125 of a week. The integration type used is Euler integration. In the variable equations, subscripts $._{LKP}\ and\ t$ are used and they represent lookup graph functions and time respectively. Moreover, t represents current time, $t(t-1)$ represent time period just before the current time, while $t(0)$ represents time at the start of the simulation. The nomenclature for variables adopts acronyms which are mostly derived from the first letter of some of the words in the variable names. Table 10.2 below provides a list of all the symbols used in the model diagrams.

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[34] See section 2.6 for the description of errors and violation types in driver behaviour research

Table 10.2: Symbols used in model sketch description

Symbol	Name	Description
	Level	A variable that acts as a stock and accumulates
variable	Auxiliary or constant	Auxiliary is variable that depends on some other variables to take its value while a Constant is a parameter with a fixed value
<variable>	Shadow variable	Represents a variable that has been previously named in one part of the model and prevent variables from being represented more than once
	Flow	Is the source of accumulations into a level variable
	Information link	This is a connector that provides information from one variable to the other
	Delay link	A connector that indicates that there is a delay between when a variable affect the other
	Cloud	Represents a source or sink which a flow can lead to or come from but which is outside the model's boundary

(Source: adapted from Vensim documentation (Ventana Systems, 2007))

Model structure description

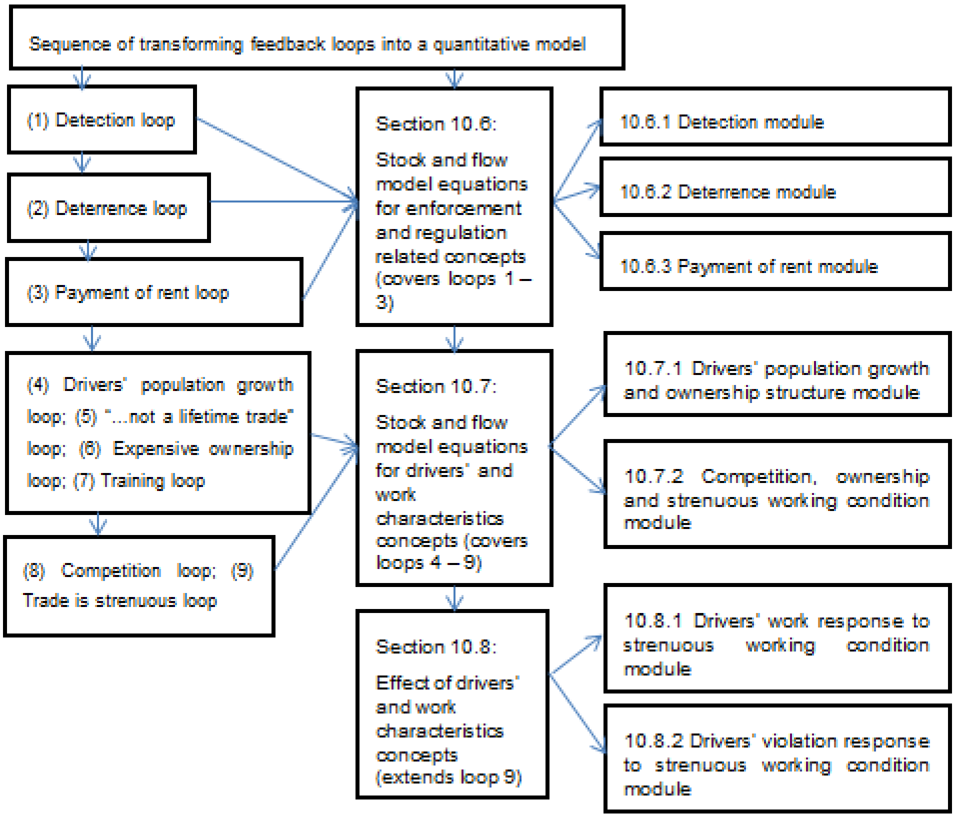

Figure 10.2: Sequence of model development[35]

Figure 10.2 shows the manner the sequence of developing the CLD in chapter 9 has been followed in this chapter. It shows that the nine loops in chapter 9

[35] For the sake of space in figure 10.2, **time for training loop** is shortened as **training loop** and **competition reduces drivers' population loop** is shown as **competition loop**

(numbered 1 – 9 and listed in five boxes on the left hand side of figure 10.2) are re-grouped and described in modules (seven boxes on the right hand side of figure 10.2). The sequence of discussion in sections 10.6 to 10.8 (see middle column of figure 10.2) follows this order. For this sequence, there are 12 stock and flow diagrams in all. This is because some loops are divided into more than one SFD for the purpose of clarity while some were combined. The justification for this is provided below using the information presented by figure 10.3. This figure lists all the nine feedback loops under keys A - G, combining two each under keys "E" and "F". It also lists all the 12 stock and flow diagrams, grouping them under the keys A – G.

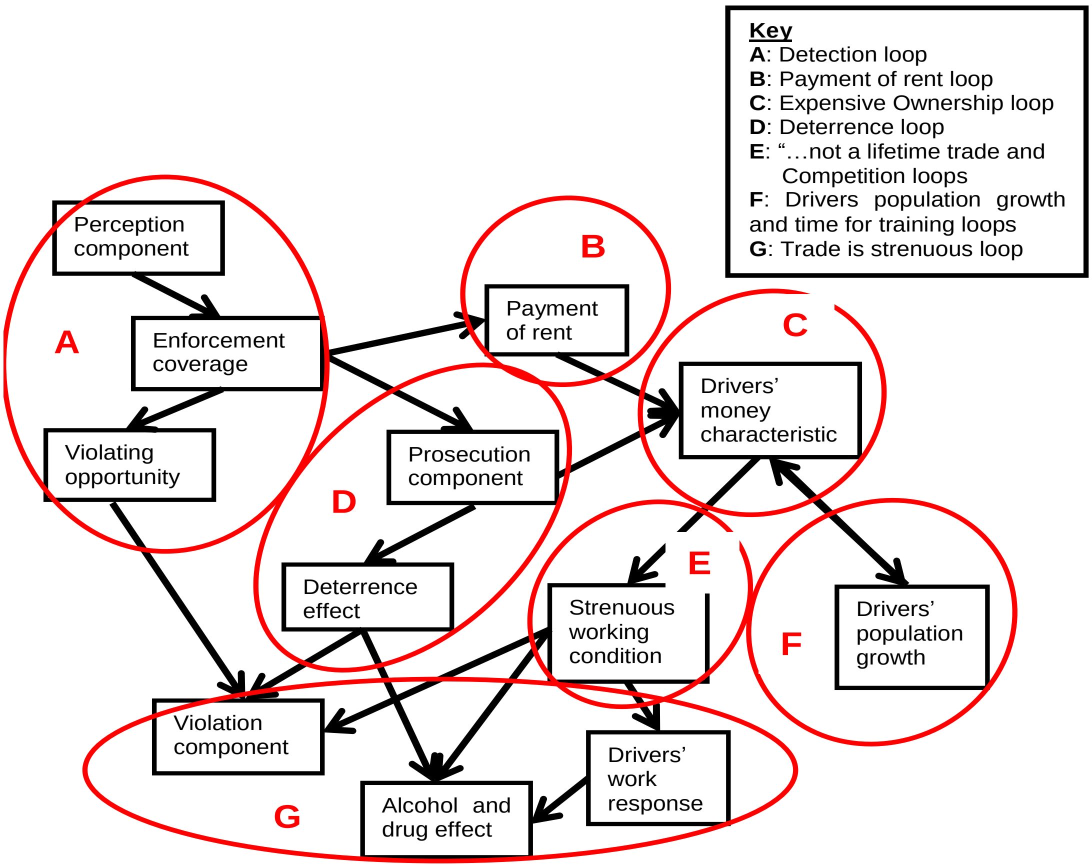

Figure 10.3: SFD relationship in the model

(Figure 10.3 shows how all stock and flow diagrams are related. The key provided with the figure shows what loops each oval shape represents)

1. **Detection** loop: This is covered by key "A". It is represented by three SFDs and renamed as **detection** module. These are **Enforcement coverage**, **violating opportunity**, and risk **perception component**. While the originating loop is essentially that of **enforcement coverage**, an assumption

is made for the decision rule guiding enforcement operations. This assumption is described with **perception component** of the module. The **perception component** indicates that the enforcement system has a floating goal decision rule that guides recruitment and layoff decisions. **Violating opportunity**, on the other hand measures the cumulative effect of increasing policing.

2. **Payment of rent** loop is covered by key "B" and represented by one SFD under **payment of rent** module.
3. **Expensive ownership** loop is covered by key "C" and represented by one SFD – **drivers' money characteristics** module
4. **Deterrence** loop is covered by key "D". It is broken down to **deterrence effect** and **prosecution** SFDs under **deterrence** module. Deterrence is an outcome of prosecution. Thus the two SFDs here are fully covered in the model CLD.
5. "…**not a lifetime trade** and **competition reduces drivers' population** loops form key "E" and are represented by one SFD – the **strenuous working condition** module.
6. **Time for training** loop and **drivers' population growth** loop are covered by key "F" and are represented by one SFD – drivers' population growth module.
7. Lastly, **trade is strenuous** covered by key "G" is extended to cover three more SFDs. These three SFDs are all indicated in the CLD: they are covered by concepts such as **alcohol and drug use**, **violations**, **working period**, **work capacity**, and **fatigue**.

Each of the SFDs represents in part the system description provided by stakeholders. These descriptions are also inherent in the CLD in figure 9.10. What follows from here is the presentation of the full diagram of the SFDs and presentation of model equations.

10.6 Stock and flow model equations for enforcement and regulation related themes

This section is divided into three as presented in figure 10.2, section 10.5. The SFDs treated are shown in the oval shapes A, B, and D in figure 10.3. The section addresses the part of the model that deals with enforcement process and describes six SFDs in all. For each SFD discussed, a brief introduction is first presented. This is followed by the corresponding SFD. Then equations for variables appearing in the SFD are presented. Each SFD description ends with a table showing a list of variables shown on the diagram but whose equations are not shown under the SFD. These tables give more information about such variables. Finally, in order to improve the reader's understanding, a more detailed description of the structuring process is provided for the first few feedback loops using simplified SFDs.

10.6.1 Detection module

The detection module shows the changes in the number and capacity of traffic enforcement officers. These changes are as a result of the need for more (or less) officers. This part of the model contains the main enforcement agencies' staff, officers who engage in overtime duty, and ad hoc officers who might be recruited from time to time to support the main staff in the enforcement agency[36]. These all add up to make the **enforcement coverage** in the system. A simple formalisation for enforcement recruitment is presented in figure 10.4 below.

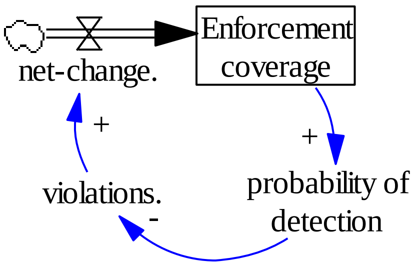

Figure 10.4: Simplified SFD for enforcement

In the qualitative data obtained for this research, respondents estimated recruitment rate within the enforcement system from hindsight. They also noted that officers were usually not enough for full traffic monitoring. As a result, the enforcement system normally recruited ad hoc support as the need arose. This information is employed in the model. Figure 10.4 shows that **enforcement coverage** is fed by **net-change** (i.e., net change in the number of officers). **Net-change** changes in response to **violations**. As **enforcement coverage** changes, the **probability of detection** of violation changes and this affects **violations**. This is a balancing loop and forms the discussion in section 10.6.1.1 under the theme **enforcement coverage**.

[36] While there are up to four different enforcement agencies in the study location, their combined effect is considered here

In addition, **enforcement coverage** usually creates an effect. If the **enforcement coverage** increases, it implies that police surveillance is more; so drivers have less opportunity to commit violations. This effect of less **violating opportunity** is represented for simplification by the variable **effect of enforcement coverage on violations**. The new simplified description is shown below in figure 10.5. It is the subject of discussion in section 10.6.1.2 under the theme **violating opportunity**.

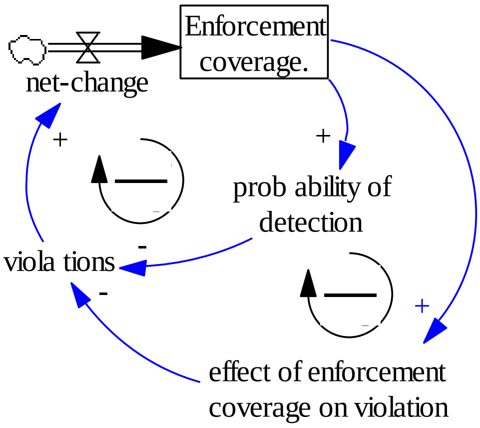

Figure 10.5: Extended simplified SFD for detection loop

Finally, a third unit is added as it provides additional information about enforcement operation. This third unit is titled **perceptions** and is described in section 10.6.1.3. **Perception** refers to the risk perception level in the community about commercial motorcycle operation. It is the gauge that tells enforcement agency to alter their enforcement coverage.

The three units are now presented.

10.6.1.1 Enforcement coverage

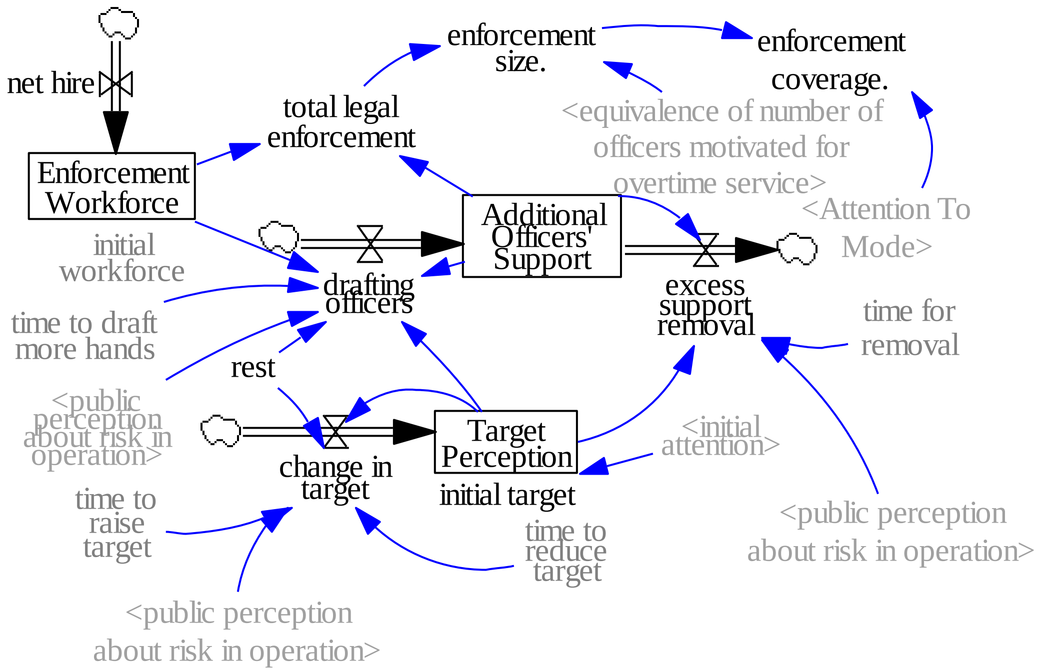

Figure 10.6: SFD for enforcement coverage

This is derived by adopting two stocks to separate steady officers' recruitment from the ad hoc officers' recruitment. These two stocks are **enforcement workforce** and **additional support officers** as shown below in figure 10.6

Enforcement workforce is the stock of traffic officers recruited steadily on annual (weekly in this model) basis. This rate does not respond to violation; it is a constant rate. The stock of **additional officers' support** is what responds to violation. To capture this response, a floating goal of enforcement system's target level of decorum in traffic operation (**target perception**) is operationalised. The equations are shown below.

Enforcement Workforce: is the term used to describe the number of officers in the traffic enforcement division who are the main personnel charged with the duty of traffic law enforcement. It is an accumulation and therefore treated as a stock in the model. Both its initial value (20) and current value are approximate number obtained during the field work exercise. Its equation is given as

$$EW_t = EW_{t(t-1)} + \sum NH_t \, ; \; EW_{t(0)} = IW = 20 \qquad (1)$$

where $EW_.$, the **enforcement workforce**, is the total number of officers in the traffic division, NH the **net hire**, is the number of new officers added to **enforcement workforce** each time step. The stock started with an initial value, named here **initial workforce**, of 20. **Enforcement workforce** has the dimension **officer**. The number of new officers added each time step is given as 0.0769, being the approximate value obtained during data collection and the unit of **net hire** is **officer/week**.

Additional Officers' Support: this parameter is the number of officers drafted as additional support on secondment basis to assist the traffic enforcement officers. It is treated as a stock and is given by

$$AOS_t = AOS_{t(t-1)} + \sum(DO_t - ESR_{t.}); AOS_{t(0)} = 0 \quad (2)$$

where AOS, the **additional officers' support**, is the additional officers provided to support traffic enforcement officers, DO, the **drafting officers**, is the officers drafted for support each time step, and ESR, the **excess support removal**, represents officers removed from the supporting duty when their services are no longer required. The unit of **additional officers' support** is given as **officer.**

Excess support removal: this is the parameter that shows how officers on secondment in the stock of **Additional officers' support** are withdrawn back to their primary duties. It is given by

$$ESR_t = \begin{cases} \frac{AOS_t}{TFR}, & AOS_t > 1 \; and \; (TP_t - PPRO_t) > 0 \\ & otherwise \\ & 0 \end{cases} \quad (3)$$

where AOS is the **additional officers' support**, TFR, the **time for removal**, is the length of time deemed suitable to have stabilised the traffic system, organise and implement removal of excess support staff and $ESR_.$, the **excess support removal**, is the number of officers whose service is no longer required each time period. $PPRO$ is the **public perception about the risk in operation** and TP, is the **target perception**. The unit of **excess support removal** is given as **officer/Week.**

Total legal enforcement: this is a parameter that estimates the total number of officers working legally in enforcement operations. It differentiates between illegal and legal enforcement operations. The **total legal enforcement** is the addition of enforcement officers and additional support provided to assist with traffic management, i.e., the sum of **Additional officers' support** and **Enforcement Workforce**

The equation for the model is given as

$$TLE_t = AOS_t + EW_t \quad (4)$$

where TLE is **total legal enforcement**, AOS the **additional officers' support**, EW_t is the **enforcement workforce**. The unit of **total legal enforcement** is given as **officer.**

Drafting officers: this is the number of officers drafted from the non-traffic police or other enforcement agencies to assist traffic officers with enforcement. This additional support depends on public perception about commercial motorcycle drivers' aberrant behaviour as viewed by the enforcement division and the level of perception set as target by the traffic enforcement unit. It is given as

$$DO_t = \begin{cases} \left(PPRO_{t(t-1)} - TP_{t(t-1)}\right) * \frac{EW_t}{TTDM}, \left(PPRO_{t(t-1)} - TP_{t(t-1)}\right) > 0 \; and \; AOS_{t(t-1)} < EW_{t(t-1)} \\ otherwise \\ 0 \end{cases} \quad (5)$$

where $PPRO$ is the **public perception about the risk in operation** of commercial motorcycle, TP, the **target perception**, is the level of public risk perception deemed acceptable to enforcement division, EW, the **enforcement workforce**, $TTDM$ the **time to draft more hands**, is the length of time required for the enforcement division to observe the difference in between current perception and target perception and execute a decision on drafting more officers. DO, the **drafting officers**, is the number of officers drafted each time step. The unit of **drafting officers** is given as **officer/Week.**

Target Perception: this is intended to show the level of public perception about commercial motorcycle safety/ aberrant behaviour that the enforcement division thinks is good and is striving to attain/maintain. It is given by

$$TP_t = TP_{t(t-1)} + \Sigma CIP_t; \; TP_{t(0)} = IT = IA \quad (6)$$

where TP, the **target perception**, is level of risk perception that the enforcement division intends to strive for based on emerging reality, IT the **initial target**, is the set target at the start of the simulation. This is taken as the value of the attention committed to commercial motorcycle mode previously and is given as IA. IA, the **initial attention**, is the level of attention committed to commercial motorcycle mode at the start of the simulation. **Target perception** is **dimensionless** in unit.

Enforcement size: This is the totality of the number of officers operating in the enforcement section. Because this total number is the sum of officers working on legal operations and illegal operations, enforcement size is used to add them all together. In this model, officers on legal operations are called **total legal enforcement** while those on illegal operations are called **equivalence of number of officers motivated for overtime service**. Enforcement size is therefore given as

$$ES_t = TLE_t + EMOS_t \tag{7}$$

Where ES is **enforcement size**, TLE is **total legal enforcement** and $EMOS$ is the **equivalence of number of officers motivated for overtime service**. The two are further treated later in the model. The unit of **enforcement size** is given as **officer.**

Enforcement coverage: this is used to measure the level of the physical presence enforcement officers create on the road. It is a function of both the population of enforcement officers (known as **enforcement size** in this model) and the level of attention enforcement operation is giving to commercial motorcycle mode. It is therefore given by

$$EC_t = ES_t * ATM_{\ t} \tag{8}$$

Where EC is the **enforcement coverage**, ES is the **enforcement size**, and ATM, is **attention to mode. Enforcement coverage** has the dimension **officer**.

Change in target: this describes a floating goal situation (Sterman, 2000) in which the enforcement system is constantly changing the target level of decorum they want to enforce based on their evaluation of public perception. This is represented below

$$CIT_t = \begin{cases} \frac{(PPRO_{t(t-1)} - TP_{t(t-1)})}{TTRT}, & \left(PPRO_{t(t-1)} - TP_{t(t-1)}\right) > TP_{t(t-1)} * REST \\ & otherwise \\ f(x) = \begin{cases} \frac{(PPRO_{t(t-1)} - TP_{t(t-1)})}{TTR}, & \left(TP_{t(t-1)} - PPRO_{t(t-1)}\right) > PPRO_{t(t-1)} * REST \\ & 0, \end{cases} \end{cases} \tag{9}$$

where CIT is **change in target**. Its unit is **1/week.** TTV is **Tendency to violate**. IT is **initial tendency**. $PPRO$ is **public perception about risk in operation**, TP is **Target Perception**, $TTRT$ is **time to raise target**, TTR is **time to reduce target**.

Other variables appearing in the figure 10.8 whose equations are not provided above are shown in table 10.3[37].

[37] In this table and all similar tables in this chapter the unit "Dmnl" mean "dimensionless"

Table 10.3: Table of constants and shadow variables for enforcement coverage representation

Other parameters	Value	Meaning	Unit
Constants			
Initial target	0.1	This is the initial value targeted by enforcement operations to maintain the perception of the public about commercial motorcycle safety. It is set low to the value of **initial attention** (see table 10.5) to indicate that this transport mode was not previously a problem in traffic management. The value of **initial attention** is 0.1	Dmnl
Initial workforce	20	The number of officers in the traffic division at the start of the simulation period	officer
Net hire	0.0769	This is the weekly rate of hiring into the enforcement system. Officers were about 20 15 years earlier and about 80 in the 2011. This gives an average weekly recruitment rate of 0.0769	Officer/ week
Rest	0.05	A small value introduced to indicate the minimum amount of changes perceptible	Dmnl
Time for removal	4	This is the estimated time it takes for enforcement agencies to remove ad hoc officers drafted in as **additional officers' support** when their services are no longer required	week
Time to draft more hands	1	Police formation meets weekly for security review, amidst other things. It is assumed decisions are taken at the meeting for work plans	week
Time to raise target	1	This provides the decision rule on how quickly the set goal of enforcement operations changes. Since police formation meets weekly for security review, amidst other things, it has the value of 1 week	week
Time to reduce target	4	This provides the decision rule on when the goals are reviewed downward	week
Shadow variables			
Variable		**Reference section**	
Attention to mode		Treated in section 10.6.1.3	
Equivalence of number of officers motivated for overtime service		Treated in section 10.6.3	
Initial attention		Treated in section 10.6.1.3	
Public perception about risk in operation		Treated in section 10.6.1.3	

The values of **initial workforce** and **net hire** are based on the estimates obtained during field work. The constants: ti**me for removal**, **time to draft more hands**, and **time to raise target**, are operational decisions of the enforcement agencies. In this model, their values are assumed based on the researchers’ hindsight.

10.6.1.2 Violating opportunity:

Violating opportunity is what shows the direct effect of changing **enforcement coverage** on the liberty of drivers to commit **violations**. The effect of increasing number of officers is partly an increase in the number of police posts on the road. An increase in the number of police posts tends to reduce the liberty to commit a violation. The SFD showing this part of the model is presented in figure 10.7 below while the equations representing it follow the figure.

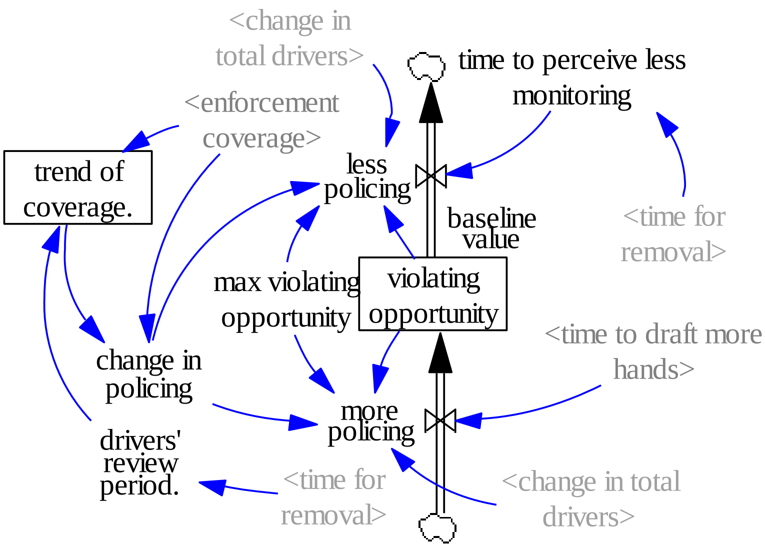

Figure 10.7: SFD for violating opportunity

Violating opportunity: This is the effect of increasing the number of police posts on the road. The effect is cumulative and is therefore represented as a stock with the equation below

$$VO_t = VO_{t(t-1)} + \sum(LP_t - MP_t); VO_{t(0)} = BV = 1 \qquad (10)$$

Where VO Is **violating opportunity**. Its unit is **dimensionless**. LP, is **less policing**, meaning that officers’ coverage is less than it was previously. MP, **more policing** and it mean that officers’ coverage is more than it was previously. BV is the **baseline value** of **violating opportunity** at the start of simulation. It has the value of one to indicate when there was no difference.

More policing and **less policing** are given by the equations

$$MP_t = \begin{cases} \frac{VO_t}{CITD} * \left(\frac{VO_t}{PVO_t}\right) * \frac{(CIP_t - 1)}{TTDM}, \ CIP_t > 1 \\ otherwise \\ 0 \end{cases} \qquad (11)$$

$$LP_t = \begin{cases} \frac{(1 - CIP_t)}{CITD} * \left(1 - \frac{VO_t}{PVO_t}\right) * \frac{VO_t}{TTPL}, \ CIP_t < 1 \\ otherwise \\ 0 \end{cases} \qquad (12)$$

where $CIP_.$ is **change in policing,** $CITD$ is **change in total drivers**, $VO_.$ is **violating opportunity**, $MVO_.$ is **max violating opportunity,** $TTDM_.$ is **time to draft more hands**, $MP_.$ is **more policing**, $TTPL_.$ is **time to perceive less monitoring**, and $LP_.$ is **less policing. This formulation shows a logistic function that indicates that additional policing becomes less effective with more officers just as in the law of diminishing returns.** The unit of **more policing** and **less policing** is **1/Week**.

Trend of coverage: this measures the perception of drivers about the attention (coverage) the enforcement system is committing to the commercial motorcycle mode. This is useful for the driver to determine changes in the amount of violating opportunity he has. This perception is calculated based on the average of enforcement coverage over the review period. It is given by a smooth function in Vensim as

$$TOC_t = \sum_{t(t-DRP)}^{t} \frac{EC_{.}}{DRP} \qquad (13)$$

where $TOC_.$ is **trend of coverage**, $EC_.$ is **enforcement coverage**, and $DRP_.$ is **driver's review period**. Its unit is **officer**.

Change in policing. This is the perception of drivers about differences in the coverage of officers at any time. It estimates the difference in the current coverage (EC) by officers and drivers' perception of previous coverage (given as TOC). Its equation is given by

$$CIP_t = CIP_{LKP}; \frac{EC_t - TOC_t}{TOC_t} = 1 + \frac{EC_t - TOC_t}{TOC_t} \qquad (14)$$

where $CIP_.$ is **change in policing.** It is **dimensionless** in unit. EC_t is **enforcement coverage** TOC_t is **trend of coverage**. CIP_{LKP} is a heuristic function added to limit the change between 0.2 and 1.8 as shown in figure 10.8.

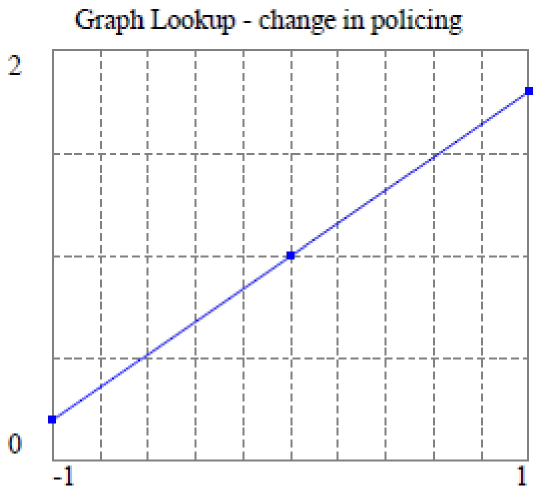

Figure 10.8: Heuristic modification to change in policing

Other parameters appearing in figure 10.7 whose equations are not provided above are shown in table 10.4.

Table 10.4: Table of constants and shadow variables for violating opportunity representation

Other parameters	Value	Meaning	Unit
		Constants	
Baseline value	1	Violating opportunity is initialised at the value of 1. This is taken as the reference value for violating opportunity at the start of commercial motorcycle operation. At "1", it means that there is no change in monitoring. Thus lowest violation opportunity can only be about zero[38], meaning the police are everywhere.	Dmnl
Drivers' review period	4	This is the time over which drivers review their perception about officers' coverage. It is similar to time for removal of excess officers. The value is set to the value of **time for removal** which is 4.	Week
Max violating opportunity	2	This parameter is used to set **max violating opportunity** to the value of 2. It is assumed that the initial level of **violating opportunity** can only double.	Dmnl
Time to perceive less monitoring	4	This is the same as **drivers' review period** and is equal to ti**me for removal**	Week
		Shadow variables	
Variable		**Reference section**	
Enforcement coverage		Treated in section 10.6.1.1	
Time for removal		Treated in section 10.6.1.1	
Time to draft more hands		Treated in section 10.6.1.1	
Change in total drivers		Treated in section 10.7.1.1	

[38] In the model, the minimum is however set to 20% using a lookup function

10.6.1.3 Perceptions

Moreover, it is shown that enforcement agencies respond to the feelings of the community by trying to maintain a “floating” level of “acceptable” traffic decorum (**target perception**). If this level is exceeded, then ad hoc officers are recruited so as to raise detection level. The formal model shows that the community’s feeling is named: **public perception about risk in operation** and that it determines enforcement system’s **target perception**. It also determines the level of attention (**attention to mode**) that is given to motorcycle mode during monitoring. How perception is determined and what it influences are shown in this unit. The SFD is presented in figure 10.9

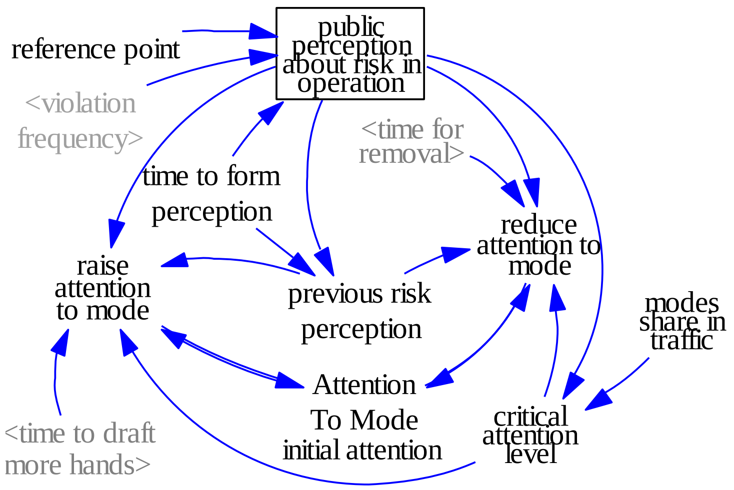

Figure 10.9: SFD for perceptions components

Public perception about risk in operation: this parameter estimates public view about the safety performance of commercial motorcycles, particularly with respect to the drivers’ aberrant behaviours. It is given as the average value of this perception over some time. But perception is difficult to measure. It is therefore estimated as an index between 0 and 1 using violating frequency as

$$PPAR_t = \sum_{t(t-TTFP)}^{t} \frac{VF/RP}{TTFP} \qquad (15)$$

where $PPAR$ is **public perception about risk in operation**, VF **violation frequency**, RP is **reference point**, and $TTFP$ is **time to form perception**. **Reference point** here takes a value of one, comparing **violation frequency** to an assumed baseline index of one violation per driver. Also introduced in the model is the **previous risk perception** which provides information about what the perception was just before the current perception. The unit of measurement of **public perception about risk in operation** is **dimensionless**

Raise attention to mode and **reduce attention to mode**: these parameters change the level of attention committed to commercial motorcycle mode by enforcement operation. They review changing risk perception in the operation of commercial motorcycle to do this. They are given by

$$DAM_t = \begin{cases} \Delta PPAR_t * \frac{ATM_t}{TFR} * (\frac{ATM_t}{CAL_t}), \ \Delta PPAR_t < 0 \\ 0 \end{cases} \tag{16}$$

$$RAM_t = \begin{cases} \Delta PPAR_t * \frac{ATM_t}{TTDM} * (1 - \frac{ATM_t}{CAL_t}), \ \Delta PPAR_t \geq 0 \\ 0 \end{cases} \tag{17}$$

$$\Delta PPAR_t = PPAR_t - PRP_t \tag{18}$$

$PPAR$ is **public perception about risk in operation**, PRP is **previous risk perception**, ATM is **attention to mode**, $TTDM$ is **time to draft more hands**, CAL is **critical attention level**. The **critical attention level** measures the increased amount of attention commercial motorcycle operation demands when its risk perception rises. RAM is **raise attention to mode**, and DAM is **reduce attention to mode**. The unit of measurement is **dimensionless**.

Attention to Mode: this parameter estimates the degree of attention that is focussed on commercial motorcycle mode by enforcement operation. In what Sherman et al. (2003) called directed patrol, it was established that focussing more attention on crime hot spot and at hot time can reduce crime in those places and times. Thus officers might decide to concentrate more on commercial motorcycle drivers than other road users to bring down their **tendency to violate** or even for the purpose of rent-seeking[39]. In this model, **attention to mode** is formalised as a stock to take into account an assumption that when it builds up its effect might last long as it becomes a norm. It is given an initial value of 0.1 which is an indication of previous share of motorcycle in traffic (Hathaway, 1993). Its equation is given as

$$ATM_t = ATM_{t(t-1)} + \sum(RAM_t - DAM_t); \ ATM_{t(0)} = 0.1 \tag{19}$$

where ATM is the **attention to mode** of a typical officer. Its unit of measurement is **dimensionless**. $(RAM_t - DAM_t)$ is the summation of changes in attention being given commercial motorcycle mode by a typical officer.

[39] Rent seeking as a term is used to describe benefits for individuals or a party that do not benefit the state

Other variables in figure 10.9 whose equations are not provided are shown in table 10.5.

Table 10.5: Table of constants and shadow variables for perception representation[40]

Other parameters	Value	Meaning	Unit
		Constants	
Initial attention	0.1	This is the share of attention enforcement operation was giving motorcycle at the start of simulation. . Hathaway (1993) shows that motorcycle accounted for just 12% of traffic in this study area prior to the advent of commercial motorcycles.	Dmnl
Reference point	1	This is used like a normalising function. It helps to normalise violation prevalence to a reference point	violation/ (Week* day*driver)
Time to form perception	8	This shows an estimated length of time required for the public to form perception about commercial motorcycle safety characteristics.	week
Mode's share in traffic	0.2	The current share of commercial motorcycles in traffic. It is based on the ratio of motorcycles to other vehicles registered by the government (Oni et al., 2011)	Dmnl
		Shadow variables	
Variable		**Reference section**	
Violations frequency		Treated in section 10.8.2	
Time to draft more hands		Treated in section 10.6.1.1	
Time for removal		Treated in section 10.6.1.1	

10.6.2 Deterrence module

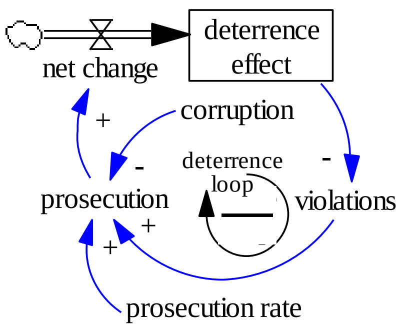

Figure 10.10: Simplified SFD for deterrence loop

The deterrence module represents the effect of sanction on the behaviour of drivers. This representation follows the theory of deterrence[41]. This part of the

[40] See appendix 2 for more equations

model particularly shows parameters such as the **effect of sanction**, the **effect of benefit from violation** as well as the cost of committing violations to the drivers. A simple formalisation for the deterrence effect is shown in figure 10.10. The figure shows that **deterrence effect** changes in response to **net change** while **net change** varies in response to **prosecution**. **Prosecution** is the consequence of **violations** but depends on **corruption** and **prosecution rate**. Thus, whether **prosecution** will improve **deterrence effect** and reduce **violation** depends on **prosecution rate** and **corruption**. These factors are treated under the following two units: **deterrence effect**, and **prosecution and associated factors**. These are represented in the model as follows:

10.6.2.1 Deterrence effect

The deterrence effect of sanction is an attitude (or behaviour) factor. It builds up over time and so can be represented by a stock. This stock is called **tendency to violate** in figure 10.11 below.

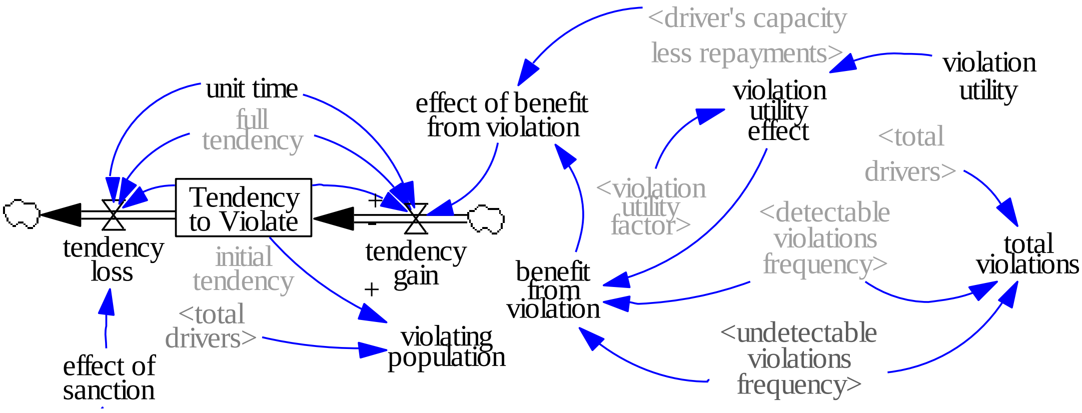

Figure 10.11: SFD for deterrence effect

Tendency to violate: this is a measure of drivers' attitude to violation, i.e., a measure of the likelihood of a violation action for a representative driver faced with the option of committing a violation. Driver behaviour is widely acclaimed in safety studies to be mainly responsible for safety problems drivers have (Cheng et al., 2011; Stanojević et al., 2013). In this model, it is depicted as a behavioural predisposition and by that assumption it develops over time and is therefore represented as a stock. Mehmood (2010) supports this variable as a stock by

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[41] This theory rests on the proposition that human behaviour is, to some degree, rational and that individual's actions can be modified when the potential punishment is weighed against the potential benefits. (more information can be found in Garoupa, 1997; Chang et al., 2000)

showing that past behaviour directly influences future behaviour. It is given an initial value of 0.45 in this model to indicate that tendency to violate was in place prior to the emergence of commercial motorcycle[42]. This parameter is given by

$$TTV_t = TTV_{t(t-1)} + \sum(TG_t - TL_t)\,;\ TTV_{t(0)} = 0.45 \qquad (20)$$

where TTV is the **tendency to violate** by a representative driver. It is given the unit **dimensionless**. $(TG_t - TL_t)$ is the summation of changes in the tendency at any time. TG and TL are **tendency gain** and **tendency loss** respectively and are described below:

Tendency gain and **tendency loss**: **Tendency gain** is a parameter that increases the level of **tendency to violate**. It is caused by the **effect of benefit from violation** on driver behaviour. **Tendency loss** on the other hand is caused by the **effect of sanction**. Since **tendency to violate** is presented as a behavioural tendency, it is treated as an index between 0 and 1. Its state at any time depends on its state at the previous time period. This is captured by assuming that the growth pattern follows a logistic function. This is represented in the equations for **tendency gain** and **tendency loss** given as

$$TG_t = \frac{EBF_t}{UT} * TTV_{t(t-1)} * \left(1 - \frac{TTV_{t(t-1)}}{FT}\right) \qquad (21)$$

where TG is the **tendency gain**, EBF is the **effect of benefit from violation**, FT is **full tendency** to violate, meaning 100% violation tendency, and TTV is **tendency to violate**, , UT is **unit time**. The unit of measurement is per time period, i.e., **1/week**.

In the case of **tendency loss**, the equation is similar as shown below

$$TL_t = \frac{EOSC_t}{UT} * TTV_{t(t-1)} * \left(\frac{TTV_{t(t-1)}}{FT}\right) \qquad (22)$$

where TL is **tendency loss**, UT is **unit time**, and $EOSC$ is **effect of sanction**. The unit of measurement is **1/week**.

Effect of sanction: this parameter measures how the cost of violation (i.e., money paid by drivers in form of fine and bribes) affects driver behaviour. It estimates this impact by taking the ratio of violation cost to drivers' income capacity. It is assumed that the more the value of this ratio, the higher the **effect of sanctions** and vice versa. The equation is given as

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[42] The literature indicates that the disregard for safety rule is one of the reasons for high accident rate in many developing countries. It is not peculiar to commercial motorcycles.

$$EOSC_t = \max_0 (\min_1 \frac{APPD_t}{DCLR_t}) \quad (23)$$

where $EOSC_.$ is **effect of sanction** on a representative driver, $APPD_.$ is **average payment per day**, and $DCLR_.$ is **driver's capacity less repayments**. **Effect of sanction** is an index that takes values between zero and one. Its unit is **dimensionless**.

Effect of benefit from violation: this parameter measures how benefit from violation (i.e., monetised value of violations to drivers) affects driver behaviour. It estimates this impact by comparing the monetised benefit as a ratio to drivers' income capacity. It is assumed that the more the value of this ratio, the higher the effect of this benefit and vice versa. The equation is given as

$$EBF_t = \max_0 (\min_1 \frac{BFV_t}{DCLR_t}) \quad (24)$$

where $EBF_.$ is **effect of benefit from violation** of a representative driver, $BFV_.$ is **benefit from violation**, and $DCLR_.$ is **driver's capacity less repayments**. It takes values between zero and one too and its unit is **dimensionless**.

Benefit from violation: This is the estimated total monetary benefit a driver derives from committing violation in a day. It is given by

$$BFV_t = VF_t * VUE \quad (25)$$

where BFV is **benefit from violation**, VF is **violation frequency**, and VUE is **violation utility effect**. Its unit is **NGN/(Week*day*driver)**.

Other variables appearing in the figure whose equations are not provided above are shown in table 10.6.

Table 10.6: Table of constants and shadow variables for deterrence effect[43]

Other parameters	Value	Meaning	Unit
Constants			
Initial tendency	0.45	It is assumed that the drivers had a relatively high violation tendency even prior to the start of the trade. This parameter represents the value of violation tendency (for private motorcycle drivers) before commercial motorcycle started. Similar formulation was adopted by Mehmood (2010, p.429) who put the initial condition at 0.3 for his "index of drivers' attitude"	Dmnl
Full tendency	1	This is used to indicate that **tendency to violate** is an index between 0 and 1 and to define the maximum value it can take	Dmnl

[43] See appendix 2 for more equations

Other parameters	Value	Meaning	Unit
Unit time	1	This is the time span at which the rate of change in **tendency to violate** is measured	week
Violation utility	140	This is used to provide some monetary quantity to the benefits derivable from violations	*NGN/ violation*
Shadow variables			
Variable	**Reference section**		
Driver's capacity less repayments	Treated in section 10.7.1.2		
Total violations	Treated in section 10.8.2		
Violating population	Treated in section 10.6.2.2		
Detectable violation frequency	Treated in section 10.8.2		
Total drivers	Treated in section 10.7.1.1		
Violation utility factor	Treated in section 10.6.2		
Undetectable violation frequency	Treated in section 10.8.2		

In this table, the value of **violation utility** used is very high: it is the equivalence of one hour of work of a commercial motorcycle driver. As (Garoupa, 2003, p.9) notes, violators are limited in rationality more so as "people seem to exaggerate a small or zero probability and have difficulty in processing probabilistic losses" and that "individual prefer more to less income" (Garoupa, 2003, p.8). Based on this, it is possible to explain why violation is prized so high. Notwithstanding, it is important to note that not all violations offer monetary reward. They are, however, monetised for convenience of computation.

10.6.2.2 Prosecution and its associated factors

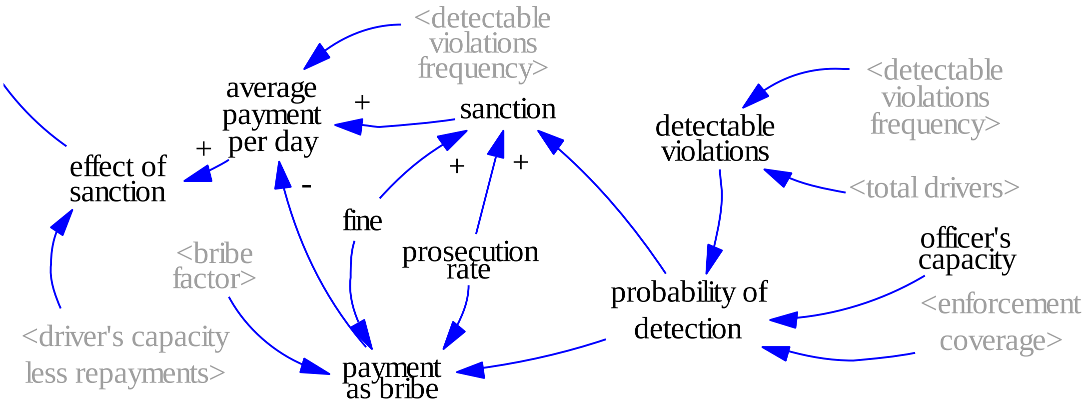

Figure 10.12: SFD for prosecution and its associated parameters

This part of the model shows how the parameter: **effect of sanction** shown in figure 10.11 and discussed in section 10.6.2.1 is generated. It shows that it is a function of **probability of detection**, **prosecution rate,** and **fine**, amidst other things. The SFD representing this part is shown below

Probability of detection: is a measure of the likelihood of a violation committed by a driver being caught by an officer. Polinsky and Shavell (1999, p.6) noted that "fine and the probability of apprehension" are usually chosen to maximise benefit to the society. In this model, the value of the probability of detection has been chosen to range from 0 to 1 depending on the level of violations and **enforcement coverage**. Equation for **probability of detection** is given as

$$POD_t = \begin{cases} POD_{LKP} ; \frac{DV_t}{EC_t * OC}, \ EC_t * OC \geq DV_t \\ POD_{LKP}; \frac{EC_t * OC}{DV_t}, EC_t * OC < DV_t \end{cases} \tag{26}$$

where POD is the **probability of detection**, EC is the **enforcement coverage** of officers, OC is **officer's capacity**, meant to estimate the number of violations an officer can deal with in a typical day, and DV is the number of **detectable violations**. The number of violations an officer can deal with is not known. The heuristic relationship is used to make up for this. OC is however included for dimensional consistency. POD_{LKP} is a heuristic relation used to retain the values between zero and one. It follows from the findings of Elliot and Broughton (2004) (see also (de Waard and Rooijers, 1994)). Similar relationship is used in a related study too (Mehmood, 2010). This function is shown below. The unit of measurement of **probability of detection** is **dimensionless**.

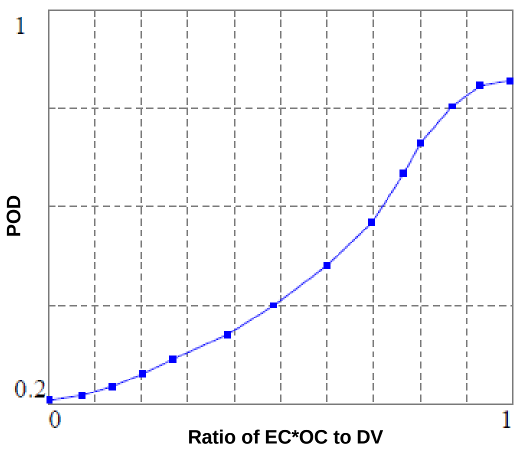

Figure 10.13: Heuristic function for probability of detection

(POD, EC, OC, and DV are define in equation 26)

Detectable violations: As previously noted, a distinction is made between **detectable violations** and **undetectable violations**. **Detectable violations** can be easily enforced but **undetectable violations** are difficult to enforce as there are no ready or clear evidence about them due to, for example, unavailability of automatic traffic monitors such as speed cameras. It is shown here that what enforcement operation can focus, enforce and prosecute are **detectable violations**. **Detectable violation** is given as the product of the frequency of violation and total number of drivers, i.e.

$$DV_t = \max_1 DVF_t * TD_t \tag{27}$$

$$VPL_t = TTV_t * TD_t \tag{28}$$

where DV is **detectable violations**. Its unit of measurement is **violation/(week*day)**. DVF is the **detectable violation frequency**, the frequency of committing violations by a representative driver, and VPL is **violating population**, a hypothetical estimate for the percentage of drivers who would contemplate violation. While this might not be real, this measure is used to estimate the changing violation pattern in the system. TTV_t is **tendency to violate**, and TD is **total drivers**. Its unit of measurement is **driver**.

Prosecution rate: is the ratio of violations prosecuted to the total number of detected violations. The index of corruption (CPI)[44] provided by Transparency International available online provides a guide for the value chosen. The value of 0.275 is used in this model. The unit is **dimensionless**.

Average payment per day: supposing each violating driver had a frequency of violation, the hypothetical cost of violation to a violating driver is what is described by average payment per day. It is given by

$$APPD_t = DVF_t * (S_t + PAB_t) \tag{29}$$

where $APPD$ is **average payment per day**, DVF is **detectable violation frequency**, PAB is **payment as bribe**, and S is **sanction**. The unit of measurement is **NGN/(day*Week*driver)[45]**.

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[44] CPI – corruption perception index. The website http://www.transparency.org/cpi2012/results shows Nigeria's CPI to range between 0.22 and 0.31 for the year 2012 (the year for data collection)

[45] NGN means Nigerian Naira

Sanction: this is the hypothetical average amount of money a violator pays by law for committing a violation (Polinsky and Shavell, 2001). It depends on the probability of detection in the system (Polinsky and Shavel, 2001) and is given as

$$S_t = \max_0 PR * F * POD_t \qquad (30)$$

where S is **sanction**, F is fine, $POD_.$ is **probability of detection**, and $PR_.$ is **prosecution rate**. The unit of measurement is **NGN/violation**.

Payment as bribe: is the hypothetical average amount of money a typical violating driver pays out to officers as bribe for being caught for a violation. Its equation is formed to take account of possible changes in the prosecution rate. It is given as

$$PAB_t = \begin{cases} \max_0 BF * (1 - PR_t) * F_t * POD_t, & PR_t < 1 \\ 0, PR_t \geq 1 \end{cases} \qquad (31)$$

where PAB denotes **payment as bribe** for a violation, BF is the **bribe factor**, also called "bargaining power of the enforcer" by Polinsky and Shavell (2001, p.4), PR is the **prosecution rate**, F is the average legal **fine** being charged when caught for a violation, and POD is the **probability of detection** of a violation. The unit for **payment as bribe** is **NGN/violation**.

Table 10.7 shows some variables which appear in figure 10.12 but their equations are not provided. It also gives more information about them.

Table 10.7: Table of constants and shadow variables for prosecution and its associated parameters' representation

Other parameters	**Value**	**Meaning**	**Unit**
Constants			
Fine	3000	This is the estimated amount of money that is legally charged for a violation. According the Arosanyin et al. (2012), the value of fine ranges from N2000 to N50, 000 in Nigeria. Most offences are however in the range of 2,000. The value of 3000 fits the model most	NGN/ violation
Officer's capacity	1	This is similar to the number of violations an officer is able to deal with in a typical day. It is set at a unity for dimensional consistency rather than ignoring it since its actual value is not known. The use of heuristic POD_{LKP} is intended to take care of this unknown	violation/ (officer* day*Week)
Shadow variables			
Variable	**Reference section**		
Effect of sanction	Treated in section 10.6.2.1		

Detectable violation frequency	Treated in section 10.8.2
Enforcement coverage	Treated in section 10.6.1.1
Total drivers	Treated in section 10.7.1.1
Driver's capacity less repayment	Treated in section 10.7.1.2
Bribe factor	Treated in section 10.6.3

10.6.3 Payment of rent module

This section treats officers' benefit from rent paid by the driver and how this benefits influences officers. It represents the decision rule for enforcement officers' engagement in overtime service (for example, mounting illegal police posts). It shows that what individual officers benefit from bribe paid by drivers encourages the officer to continue in overtime service if the amount increases, and vice versa. Officers can also try to maintain the system in equilibrium. A simplified structure is shown below:

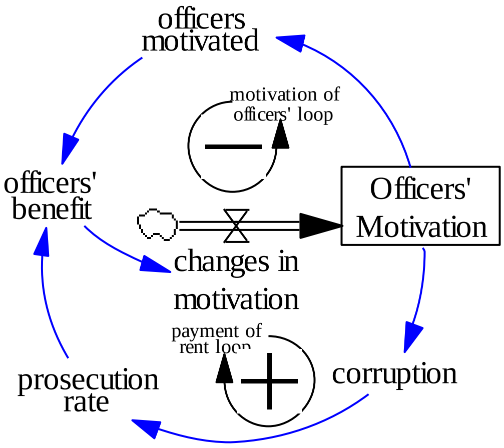

Figure 10.14: Simplified SFD of payment of rent and its effect loops

Figure 10.14 shows that when officers get motivated from the rent they receive from drivers, two things happen: more officers are attracted to bribery and/or officers already benefiting want to continue the corrupt practices and; officers are willing to reduce their charge (**bribe factor**) so as to keep the system in equilibrium. This description is represented in figure 10.15 below.

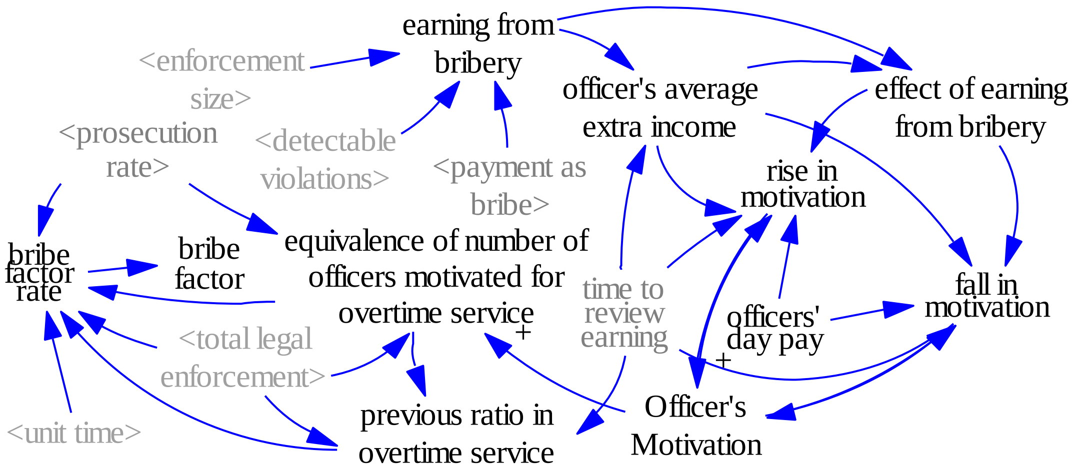

Figure 10.15: SFD for payment of rent and its effect loops

The equations for this representation are as follow:

Officer's Motivation: this is the willingness of an enforcement officer to render extra services (particularly by operating illegal/unapproved police posts). It is treated as a variable with cumulating effect (a stock) as it is related to behaviour which builds up over time. In this model, it is given an initial value that is equal to a measure of the level of country's corruption **prosecution rate**. This is because illegal police posts dates back past the emergence of commercial motorcycles. **Officer's Motivation** has the unit **dimensionless** and its equation is given by

$$OM_t = OM_{t(t-1)} + \sum . CIM_t;\ OM_{t(0)} = PR \qquad (32)$$

where OM is **officer's motivation**, the motivation a typical officer has towards engaging in additional hours of unofficial traffic monitoring. CIM is the summation of change in officer's motivation, called **change in motivation**. It is described below.

Change in motivation: this parameter estimates changes in the willingness of an officer to participate in overtime service in response to changes in what he might earn from overtime service. The understanding is that the basis for engagement in overtime service is for the purpose of collecting bribe. **Change in motivation**, denoted by CIM_t is the sum of two variables: RIM, denoting **rise in motivation**, and FIM, denoted **fall in motivation**. It is given by

$$CIM_t = \begin{cases} RIM = \frac{\left(\left(1-OM_{t(t-1)}\right)*OM_{t(t-1)}*OAEI*EEB_{t(t-1)}\right)}{TTRE*ODP}, OM_t > 0; EEB_{t(t-1)} > 0 \\ + \\ FIM = \begin{cases} \frac{\left(\left(\left(OM_{t(t-1)}\right)*OM_{t(t-1)}*OAEI*EEB_{t(t-1)}\right)\right.}{TTRE*ODP}, OM_t > 0; EEB_{t(t-1)} < 0 \\ 0 \end{cases} \end{cases}$$

(33)

where $OM_{.}$ is **officer’s motivation**, the motivation an officer has towards overtime service at the time, and $EEB_{.}$, the **effect of earning from bribery** is the effect the changes (in what an officer earns during overtime service from bribery) have on his willingness to continue to participate. $TTRE_{.}$ is **time to review earning,** $OAEI_{.}$ is **officer's average extra income**, and ODP is **officer’s day pay**. The unit of **change in motivation** is given as **1/Week**.

Equivalence of number of officers motivated for overtime service: this represent the approximate number of enforcement officers engaging in overtime services (by operating illegal/unapproved police posts) with a view to arresting violators for the purpose of collecting bribe. This does not mean additional officers in practice; it can represent full officers’ equivalence of the number of extra hours officers are putting into overtime service. It is given by

$$EMOS_t = (1 - PR) * TLE_t * \min_1(\max_0 OM_t) \tag{34}$$

where $EMOS_t$ is **equivalence of number of officers motivated for overtime service** at a time. Its unit is given as **officer**. $TLE_{.}$ is the **total legal enforcement** at that time, $PR_{.}$ is the **prosecution rate**, and $OM_{.}$ is **officer’s motivation**.

Officer's average extra income this is the average amount an officer makes by engaging in over-time duties with the intention to collect bribe. This average is used by the officers for periodic review about their participation in overtime service in the bid to decide whether to continue or not. It is a measure of the average of past earnings within the review period and is given by

$$OAEI_t = \sum_{t(t-TTRE)}^{t} \frac{EFB_{t.}}{TTRE} \tag{35}$$

where $OAEI_{.}$ is **officer’s average extra income**, $EFB_{.}$ is **earning from bribery**, and $TTRE_{.}$ is **time to review earning**. The unit of measurement is **NGN/(Week*officer*day)**.

Earning from bribery this reflects the average amount an officer makes by engaging in over-time duties with the intention to collect bribe. It is given by

$$EFB_t = PAB_t * DV_t * \frac{1}{ES_t} \tag{36}$$

where $EFB_{.}$ is **earning from bribery**, $PAB_{.}$ is **payment as bribe**, and $DV_{.}$ is **detectable violations**, and $ES_{.}$ is **enforcement size**. Its unit of measurement is **NGN/(officer*Week*day)**.

Effect of earning from bribery: this is the outcome of the periodic review an officer conducts on whether to continue to participate in overtime service or not. This outcome affects his motivation. It is given by:

$$EEB_{j,t} = \min_{0.9}\left((EFB_t - OAEI_t) * \frac{1}{OAEI_t}\right) \quad (37)$$

where $EEB_{.}$ is **effect of earning from bribery**, $EFB_{.}$ is **earning from bribery**, and $OAEI_{.}$ is **officer's average extra income**. The unit of measurement is **dimensionless**.

Other parameters appearing in figure 10.15 whose equations are not provided are shown in table 10.8.

Table 10.8: Table of constants and shadow variables for payment of rent and its effect representation[46]

Other parameters	Value	Meaning	Unit
Constants			
Time to review earning	4	Since salaries are paid monthly, the decision of an enforcement officer to review income might be monthly since he prepares his budget when salaries are paid	week
Officers' day pay	1200	This is an arbitrary value used to estimate an officer's day salary	
Shadow variables			
Variable		**Reference section**	
Detectable violations		Treated in section 10.6.2.2	
Prosecution rate		Treated in section 10.6.2.2	
Total legal enforcement		Treated in section 10.6.1.1	
Unit time		Treated in section 10.6.2.1	
Payments as bribe		Treated in section 10.6.2.2	
Enforcement size		Treated in section 10.6.1.1	

10.7 Stock and flow model equations for drivers' and work characteristics theme

As shown in section 10.5, the remaining six loops[47] are combined together and divided into two sections for the presentation of equations. This is due to the

[46] See appendix 2 for more equations

convenience merging them together offers (e.g., where a single parameter covers the themes of multiple loops). The two sections are: **drivers' population growth and ownership structure** module and; **competition, ownership and strenuous working condition** module. The SFDs covered are shown in the oval shapes C, E, and F in figure 10.3. These are presented below.

10.7.1 Drivers' population growth and ownership structure module

This section mainly treats the two loops[48]: **drivers' population growth** loop and **expensive ownership options** loop. In the following discussion, it is shown that these two loops are related. First, the loop of **drivers' population growth** can be formalised as shown figure 10.16 below as a stock of **drivers** with the flow: **growth rate**.

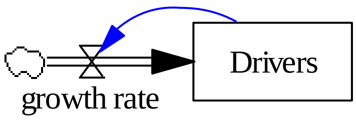

Figure 10.16: Simplified Drivers' population growth SFD

However, the data provides additional information about drivers' experience, ownership, and risk characteristics (see figures 9.6 and 9.7, pages 180 and 181). This is used to extend figure 10.16 and divide the drivers into three groups. These three groups reflect drivers' experience and vehicle ownership structure of the drivers. They are also used to capture the variation in drivers' risk characteristics (**effect of maturity**) as is found in the literature (Adisa, 2010). These characteristics are reflected in monetary terms in the model and used to generate the pressures in the system. They are discussed under two units as: **driver groups** and **money characteristics** and presented below.

10.7.1.1 Driver groups

It is shown that many of the new drivers acquire their motorcycles through means that require exorbitant repayments (expensive motorcycle-acquisition options or **expensive repayment options**). This puts them under pressure from their start of the trade. This pressure quickly develops into a habit which they continue to maintain even after completing the repayment, usually within a year. In addition, this pressure makes drivers see the trade as transient and they initiate/join savings

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[47] Notwithstanding, the loop of trade is strenuous is further extended in section 10.8.

[48] It is also used to treat training effect in the model. This is discussed later.

schemes with the intent to raise capital and switch to other trades. But savings schemes increase their pressure as it further increases the individual drivers' targeted daily income (and so increase the average **target income** in the system). There however comes a time when drivers are more relaxed, have now settled down to the trade and are not strongly intending to switch trade again. At this time the pressure starts to fall down. This description divides the drivers into three categories. These are: drivers who have just come in new into the trade, many of which have huge loan to pay but can only earn little because they are new in the trade. These are named **new entrant drivers**. Another group is those who have been working under payment pressure but have finished paying and become motorcycle owners. This group has the feeling that it is good to switch from the trade because it is strenuous – so they make huge savings to raise capital for other trades. They are named **ambivalent drivers**. The last group is the group of drivers who are experienced; they have not been able to switch to other trades. They have also let off working pressure (**earning pressure**) over the years. These are called **established drivers**. The part of figure 10.17 showing the stock of carrying capacity represents the city growth capacity for drivers. This carrying capacity is an estimation based on the current drivers' population to current city population. Finally, training loop is reflected as related to the changing population pattern of drivers and is covered under this module. All the above are shown in figure 10.17 below. Equations for the SFD follow thereafter.

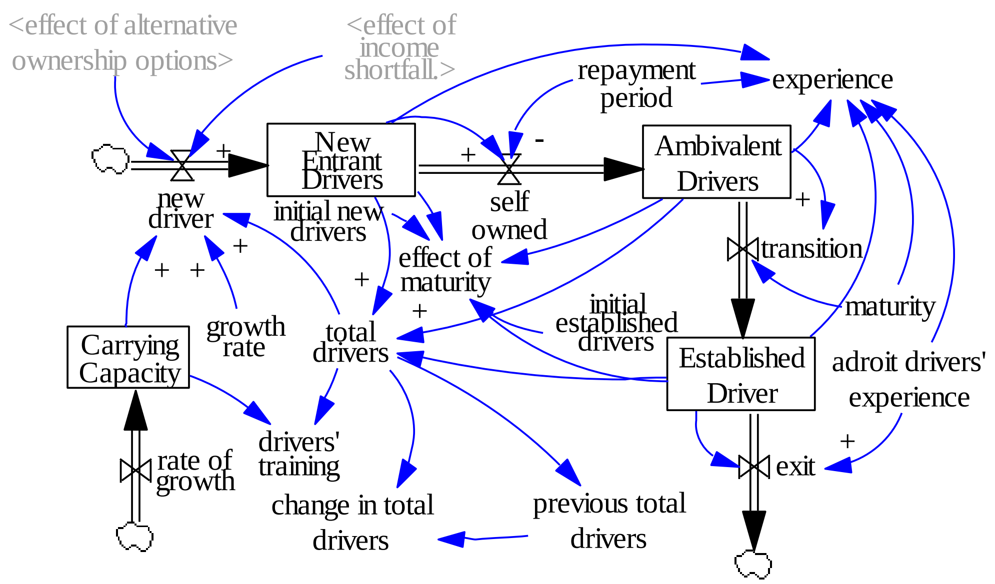


Figure 10.17: Drivers' population SFD with extension showing drivers' groupings

New entrant drivers is the population of drivers who are classified as new in the commercial motorcycle trade. These drivers also acquire their motorcycle through various options, including options that require expensive repayments. Mathematically, it is represented as

$$NED_t = NED_{t(t-1)} + \sum(ND_t - SO_t);\ NED_0 = 20 \qquad (38)$$

where $NED_.$ is **new entrant drivers**. Its dimension is given by **driver**. A value of 20 is used to initiate the model. The data obtained during the fieldwork indicates that there could have been about 100 drivers in 1996 most of whom were owner operators. These 100 drivers are divided into two: 20 and 80 with 20 classified as **new entrant drivers** and 80 classified as **established drivers**. $(ND_t - SO_t)$ is change in new entrant drivers - the difference between **new driver**(s) joining the trade and drivers leaving the group. Drivers gain some experience within one year and leave the stock of **new entrant drivers** to join the stock of ambivalent drivers. ND is **new driver**, and SO is **self-owned** drivers.

New drivers are added each time period and the number of new drivers who join each time is given by

$$ND_t = (1 - EIS_t) * (EAOO_t) * GR_. * TD_t * \left(1 - \frac{TD_t}{CC_t}\right)_. \qquad (39)$$

$ND_.$ has the unit, **driver/week**. EIS is **effect of income shortfall** on the rate at which new drivers join the trade. This effect is caused by shortfall in income that might arise if drivers are making less than their targets. $EAOO$ is **effect of alternative ownership options**. This is the variable that shows how the availability of quick, though expensive, motorcycle-acquisition options affects the number of new drivers. $GR_.$ is **growth rate**. It is a constant value given as 0.02 in this model. It is the value used to represent the trend in the growth of drivers' population. $TD_.$ is **total drivers**. It is the total number of drivers within the system - the sum of **new entrant drivers**, **ambivalent drivers**, and **established drivers**. $CC_.$ is **carrying capacity**. It is the hypothesised maximum number of drivers that the study location can accommodate. To estimate this variable (i.e., **carrying capacity**) an assumption is made about the current number of drivers in relation to the **carrying capacity**: it is taken that the population of drivers at the time of data collection was about the maximum the study location could accommodate at that time. This assumption is based on the fieldwork data that showed that the population rose from 100 to 2000 in 4 years but has not gone beyond 5,000 eleven years after. Such growth is treated as goal-seeking pattern of growth in dynamic systems. This goal is what is named **carrying capacity** in this model. In addition, **carrying capacity** is presented as a growing variable. This is due to the characteristic of the study area as described in section 6.4 which shows that the city doubled in developed area within the simulation period of this model. It was therefore considered better to adopt a growing **carrying capacity** rather than a fixed **carrying capacity** to account for the significant change in city population. The initial value and rate of change for **carrying capacity** are determined to best fit the trend for **total drivers**. Thus **carrying capacity**, is given by

$$CC_t = CC_{t(t-1)} + \sum . ROG; \qquad CC_{t(0)} = 3350 \qquad (40)$$

where ROG is **rate of growth** of the **carrying capacity** of the city. $CC_.$, has the unit, **driver**.

Self owned on the other hand removes from the stock (group) of **new entrant driver**. The assumption is that many of those in **new entrant drivers** group do not own their motorcycles (Olubomehin, 2012). However, they usually pay up the motorcycle cost within a year such that those drivers transiting from **new entrant drivers** to **ambivalent drivers** own their motorcycles. Thus **self owned** is the number of people leaving the stock of **new entrant drivers** each time period. It is given by

$$SO_t = \frac{NED_t}{RP} \qquad (41)$$

where SO is **self owned**. Its unit is **driver/Week.** NED is **new entrant drivers**, RP is **repayment period**. **Repayment period** is the estimated average time drivers remain in the stock of **new entrant drivers**. It is derived from the estimate of the time required for any driver who acquires his motorcycle through rent or hire-purchase to complete repayment. An assumption is made that drivers would normally have acquired some experience within a year of practice and would have completed all outstanding repayments too. **Repayment period** is thus made a year.

The second group of drivers is the **ambivalent driver**. This group of drivers has mixed characteristics, showing characteristics of drivers in the first group and those in the third group. Information obtained during data collection stage shows that there is a period of time when drivers target high income for various reasons including diversifying, investing, and the like (because they do not intend to stay long in the trade). At such time, drivers make huge savings for this purpose. This huge savings propels high-risk behaviours. This characteristic is similar to drivers in the first group who set high target income to enable them complete their repayment as quickly as possible. Thus **new entrant driver** and **ambivalent driver** share this characteristic. They are however different in many ways. First, because of experience, **ambivalent drivers** have higher earning capacity than the **new entrant drivers**. They share this characteristic with drivers in the third group, the **established drivers**. Nevertheless, they are different from this third group because those in the third group are more mature, they no longer set high target income; they are more satisfied with whatever they earn than the two other groups (though they really earn well). All these distinctions were extracted from the fieldwork data and therefore necessitate separating **ambivalent drivers** to a different group from the first and the last group. In this section, **ambivalent drivers** are taken as drivers between the ages of one year and six years and are represented by the following equation

$$AD_t = AD_{t(t-1)} + \sum .(SO_t - T_t);\ AD_{t(0)} = 0 \qquad (42)$$

where AD is **ambivalent drivers**. Its unit is **driver**. $(SO_t - T_t)$ is change in **ambivalent**. SO is **self-owned** (driver), and T is **transition**. **Transition** is the number of drivers maturing from the stock of **ambivalent drivers** to **established drivers**. It is given by the equation:

$$T_t = \frac{AD_t}{M} \qquad (43)$$

M is **maturity**. **Maturity** is the approximate life span of drivers in the stock of **ambivalent drivers**. It has the value of five years. The unit of **transition** is **driver/Week**.

Established drivers: The last group of drivers is **established drivers**. As previously mentioned, a time comes when drivers are no longer under the pressure of target earning. This drivers are more relaxed; they use commercial motorcycle stops rather than hunting for passengers all around and they are more safe in their driving, exhibiting less aberrant behaviours (Adisa, 2010). Notwithstanding, they still have high income. In this model, the two sources of change in **established drivers** are **maturity** and **exit**. **Maturity** as previously described is the time it takes drivers to leave the stock of **ambivalent drivers** and come into the stock of **established drivers**. **Exit** is a parameter that represents the average number of drivers leaving the **established drivers** group. **Established driver** is computed as

$$ED_t = ED_{t(t-1)} + \sum .(T_t - E_t)\ ;\ ED_{t(0)} = 80 \qquad (44)$$

where ED is **established drivers.** Its unit is **driver**. $(T_t - E_t)$ is change in **established drivers**. T is **transition,** E is **exit**. **Exit** is the ratio of **established drivers** to **adroit drivers' experience**. It is given by:

$$E_t = \frac{ED_t}{ADE} \quad (45)$$

Its unit is given by **driver/Week.**

Finally, as pointed out earlier, figures 9.6 and 9.7 (pages 180 and 181) provide an extension to drivers' characteristics. Training deficiency is noted in figure 9.6 while competition effect is noted in figure 7. Data indicates that there were more trained drivers earlier at the inception of the trade but there are fewer now, meaning the growth in population is inversely proportional to the percentage of trained drivers. Similarly, competition can be represented as inversely proportional to driver's population growth. The level of drivers' training is shown here while competition is shown in section 10.7.2.1. Their descriptions are however formalised below:

The level of drivers' training is given as

$$DT_t = 1 - \frac{TD_t}{CC_t} \quad (46)$$

where DT is **drivers' training**, TD is **total drivers**, and CC is **carrying capacity**. **Drivers' training** is **dimensionless**.

Other variables appearing in figure 10.17 whose equations are not provided in this section are shown in table 10.9.

Table 10.9: Table of constants and shadow variables for drivers' groupings representation[49]

Other parameters	Value	Meaning	Unit
Constants [50]			
Growth rate	0.02	Growth factor for **New Entrant Driver**. It was obtained by trying several runs to replicate the growth trend for total drivers	1/week
Repayment period	52	This is the estimated length of time it takes a driver to move from the stock of **New Entrant Drivers** to **Ambivalent Drivers**. It is the approximate time drivers require to pay up the cost of their	week

[49] See appendix 2 for more equations

[50] In this table, the values of **repayment period**, **maturity** and **adroit driver's experience** are estimated from drivers' experience reported in the literature. The **initial new drivers** and **initial experienced drivers** sum up to the estimate provided by respondents during data collection

Other parameters	Value	Meaning	Unit
		motorcycles	
Maturity	260	This is the estimated length of time it takes a driver to move from the stock of Ambivalent Drivers to Established Drivers. It also implies the period when a driver uses the trade for social and economic enhancement – to raise capital to switch trade, to own a home and/or raise money for other personal projects.	week
Adroit driver's experience	208	This is the estimated length of time a driver spends in the system as a mature driver. It also represents the average time for which drivers are no longer under any pressure to make a **target income**.	week
Rate of growth	2.4615	The estimated rate for city population growth relative to year 2011 drivers' population. It explains the rate of change of the capacity of the city in terms of the number of drivers it can accommodate profitably. It is treated as a function of city population. It is obtained by estimating the ratio of the city population to drivers' population for the year 2011 and extrapolating this ratio backward to the start of simulation.	Dmnl
Initial new drivers	20	This model assumes that majority of those who started the trade were experienced owners who worked on part time but with a small percentage coming to join as new entrants drivers	driver
Initial established drivers	80	This model assumes that majority of those who started the trade were experienced owners who worked on part time.	driver
Shadow variables			
Variable		**Reference section**	
Effect of alternative ownership options		Treated in section 10.7.1.2	
Effect of income shortfall		Treated in section 10.7.2.1	

10.7.1.2 Money characteristics

This is the second part of **drivers' population growth and ownership structure** module introduced in section 10.7.1. The effect of drivers' motorcycle-acquisition method and drivers' income capacities is formalised here. This is shown in figure 10.18.

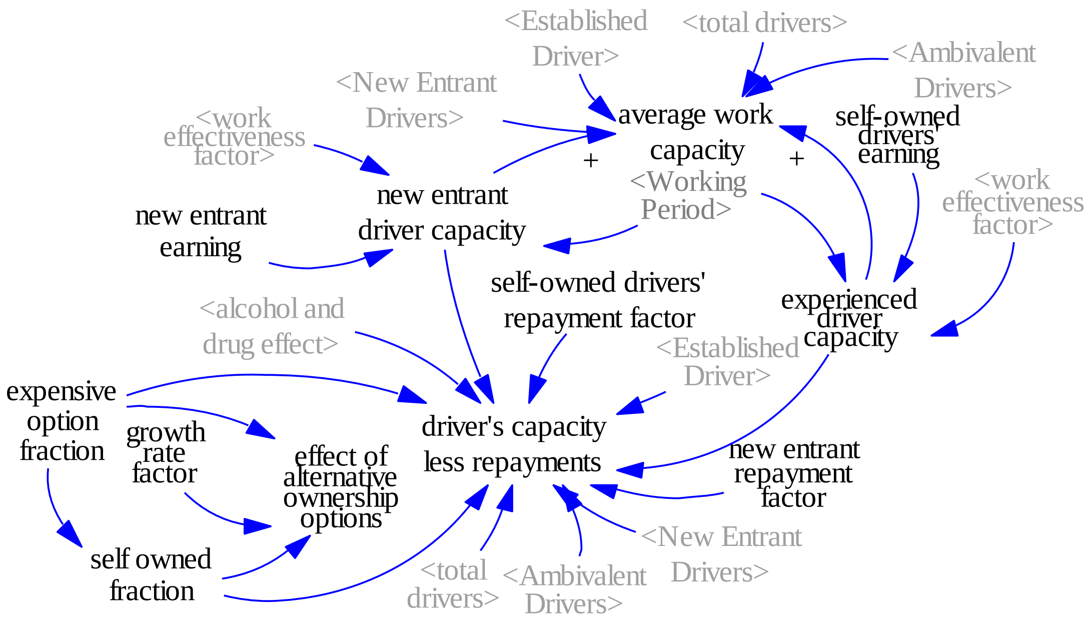


Figure 10.18: SFD of drivers' money characteristics

In line with the literature, figure 10.18 shows that drivers have two income characteristics (**new entrant drivers' capacity** and **experienced drivers' capacity**) and two cost characteristics (**new entrant drivers' repayment factor** and **self-owned drivers' repayment factor**). The income characteristics vary because new drivers are novice and so do not earn as much as **ambivalent drivers** and **established drivers** who are more experienced on the job (Fasakin, 2001). The cost characteristics reflect the fact that new drivers mostly take hire-purchase or rented motorcycles and are required to pay back up to half of their income to cover the motorcycle cost. Most however become owners by the end of one year. On the other hand, **established drivers** have about three years or more between the replacement times of their motorcycles[51]. How these affect the system is presented later in the model. The following equations estimate drivers' earning ability based on different drivers' groupings. They also show how the repayments affect these earning abilities.

Average work capacity is used to estimate the average of drivers' earning if there were no repayments to be made. It depends on the work capacity of the three groups of drivers. It is given by this formulation:

$$AWC_t = \frac{NED_t * NEDC_t + EDC_t * (AD_t + ED_t)}{TD_t} \qquad (47)$$

[51] This is obtained from the estimate of the average age of commercial motorcycles in use (Oni et al., 2011)

where AWC is the **average work capacity** of a representative driver, and has the unit **NGN/(day*week*driver)**. AD is **ambivalent drivers**, ED is **established drivers**. $NEDC$, the **new entrant driver capacity** is the possible amount of money a typical **new entrant driver** might be able to make, being inexperienced, and EDC, the **experienced driver's capacity** is the possible amount of money a typical driver who is no longer new in the system might be able to make. Both $NEDC$, and EDC, depend on drivers' earning and time put into operation at that time and are formulated as

$$NEDC_t = WP_t + NEE_t * WEF_t \quad (48)$$

and,

$$EDC_t = WP_t * SDE_t * WEF_t \quad (49)$$

respectively, where WP is **working period**, NEE is **new entrant earning** for a driver, WEF, is **work effectiveness factor**, and SDE is **self-owned driver's earning**. Both $NEDC$, and EDC have the unit: **NGN/(week*day*driver)**. **Working period** (WP) represents the number of hours of the day drivers are working for on the average. It is shown to have grown from a part time commitment to as much as about 14 hours at a day in this model. Arosanyin et al. (2013) found about 13 hours a day services in a study. NEE, and SDE are average hourly drivers' earning per day. The values for these parameters were computed based on average eight hour earning (less operating cost) for a driver obtained in Mahlstein (2009) and factored based on Ogunrinola's (2011) comparison of monthly income between drivers who are relatively new and those who are more experienced. NEE, has a value of NGN110 while SDE has a value of NGN140. WEF is a function with lookup that discounts the effect of long hours of working. WEF is used to indicate that the longer a driver works for the less effective the total number of hours spent working is.

Drivers' capacity less repayments: This parameter is used to show the difference between driver's capacity when and when not having repayments by bringing in the cost of repayment. The **driver's capacity less repayments** is given by

$$DCLR_t = \left\{\langle[(1 - SDRF) * SOF + EOF * (1 - NERF)] * NEDC_t * NED_t + (1 - SDRF) * EDC_t * [AD_t + ED_t]\rangle * \frac{1}{TD_t}\right\} * (1 + AADE_t) \quad (50)$$

where $DCLR$ is the **driver's capacity less repayments**. $NERF$ is **new entrant repayment factor**. This is taken to be the fraction of earning paid as rent. This is shown to be about 50% of their net earnings (Cerevo, 2000). SOF is **self owned fraction**, the fraction of the new entrant drivers who do not take expensive motorcycle acquisition. EOF is **expensive option fraction,** the fraction of the new entrant drivers who take expensive motorcycle acquisition. $NEDC$ is **new entrant driver capacity**. NED is **new entrant drivers**. $SDRF$ is **self-owned drivers' repayment factor** and is used to provide for driver's need to replace the motorcycle after a period of time. It is therefore given a lower value of 10%. EDC is **established driver capacity**, ED is **established drivers**, TD **total drivers**, and $AADE$ **alcohol and drug effect**. **Alcohol and drug effect** is included here as indicated by the data and literature: Olubomehin (2012) notes that drivers use alcohol to combat the effect of harsh weather condition under which they work. The unit of average drivers' income is **NGN/(week*day*driver)**.

Other parameters appearing in figure 10.18 whose equations are not provided in this section are shown in table 10.10[52].

Table 10.10: Table of constants and shadow variables for money characteristics representation[53]

Other parameters	Value	Meaning	Unit
Constants			
Expensive option fraction	0.5	Percentage of drivers who join commercial motorcycle trade by taking motorcycles which requires them to make expensive repayment (e.g., renting a motorcycle or taking hire-purchase)	Dmnl
New entrant earning	110	This is the estimated average income per hour for a new-entrant driver. It is chosen based on the literature	NGN/ (Week*hrs *driver)
Self-owned drivers' repayment factor	0.1	This factor to cater for savings towards motorcycle replacement by drivers. An estimate of three years replacement period is chosen to arrive at this value	Dmnl
New entrant repayment factor	0.5	This parameter caters for **new-entrant drivers'** repayment cost towards motorcycle-acquisition (for those of them who take expensive ownership option). An estimate of a year repayment period is chosen to arrive at this value	Dmnl
Self-owned	140	This is the estimated average income per hour for drivers	NGN/

[52] See appendix 2 for additional equations

[53] In the table, **expensive option fraction**, **new entrant earning**, and **self-owned drivers' earning** are estimates based on the literature. **Self-owned drivers' repayment factor** and **new entrant repayment factor** are approximations based on the cost of motorcycle purchase as given by respondents during data collection.

Other parameters	Value	Meaning	Unit
drivers' earning		who have crossed the initial stage of **new-entrant drivers**. It is chosen based on the literature	(Week*hrs *driver)
Growth rate factor	0.25	This is used to obtain a minimum ratio for the **effect of expensive ownership options** on the rate at which new drivers join commercial motorcycle trade.	Dmnl

Shadow variables	
Variable	**Reference section**
Work effectiveness factor	Treated in section 10.8.2
New Entrant Drivers	Treated in section 10.7.1.1
Established Driver	Treated in section 10.7.1.1
Total drivers	Treated in section 10.7.1.1
Ambivalent Drivers	Treated in section 10.7.1.1
Working Period	Treated in section 10.8.1
Alcohol and drug effect	Treated in section 10.8.2

10.7.2 Competition, ownership and strenuous working condition module

In this section, the completing part of ownership structure[54], competition, and strenuous working condition is formalised in the model. How drivers' **target income** and its effect are modelled is also shown here. It is shown that the difference between the **target income** and **drivers' income** leads to a shortfall which cumulates. This stock of shortfall is called **effect of shortfall**. **Effect of shortfall** leads to **earning pressure** and some other consequences discussed later. The SFD is shown in figure 10.19

[54] Section 10.7.1 only introduced ownership structure and not the complete loop. The loop of ownership structure is completed in the section.

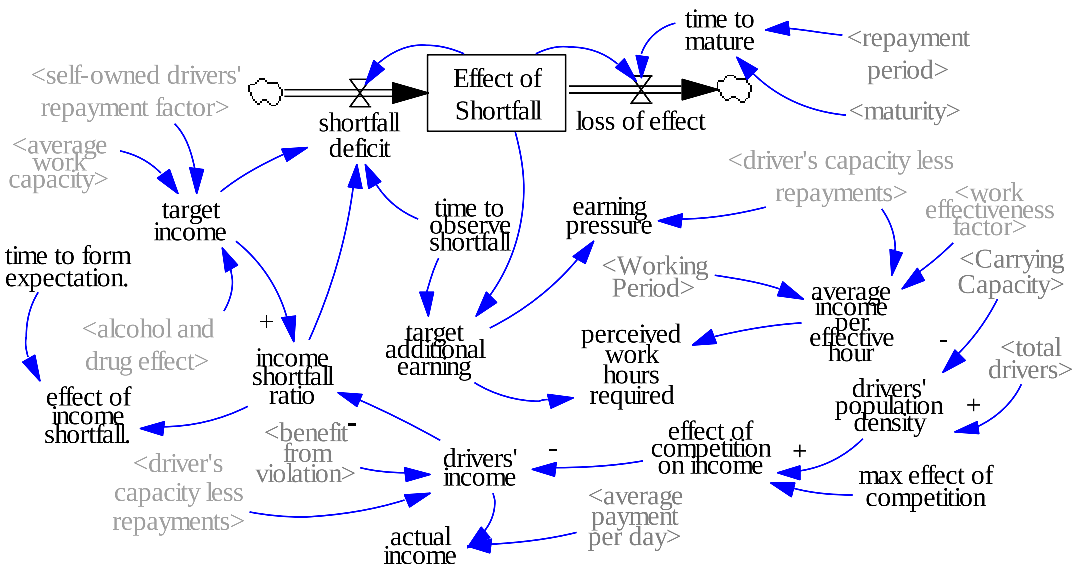


Figure 10.19: SFD of strenuous working condition and its effect

Figure 10.19 has been described under section 10.7.1.1 for drivers' groups but will be repeated here for clarity: **expensive ownership options** propel drivers to set a high **target income**. Thus a driver sets a target amount which he strives to meet up with each day. This striving eventually develops into a habit (represented by **effect of shortfall** in this model) as he works under the pressure of reaching that target from day to day. This pressure is called e**arning pressure**. Habits are however difficult to change and so when there is no longer any pressure, he still continues to work as if under pressure. This pressure makes a driver to think that the trade is strenuous and want to switch to less difficult trade (i.e., "…not a lifetime trade" loop). The driver would then initiate a savings scheme to implement this plan. But this saving scheme would further lead to an increase in his **target income** and raise the pressure further or at least sustain the existing pressure. This model indicates that it sustains the existing pressure. This condition, added to the **effect of competition on income** is what is shown in figure 10.19. The equations for variables in figure 10.19 are shown below.

Target income: based on the characteristics of different groups of drivers described in section 10.7.1.1, the parameter, **target income** is derived. This **target income** depends on drivers' working ability (i.e., earning capacity), drivers' repayments, and drivers' anticipated income. The equation for **target income** is shown below:

$$TI_t = [(1 - SDRF) * AWC_t * (1 + AADE)] \qquad (51)$$

where TI is **target income**. Its unit of measurement is **NGN/(day*Week*driver)**. $SDRF$ is **self-owned drivers' repayment factor**, AWC is **average work capacity**, and $AADE$ is **alcohol and drug effect.** Drivers look forward to owning their motorcycles and making full profit without having to make repayments. A driver on rent or hire-purchase is therefore under persistent pressure to pay his rent as well as make close to the system average. It will be shown later how this pressure drives the behaviour of drivers. This equation reflects that, earning capacity, notwithstanding, the **new entrant drivers** too have high income expectation. The equation also shows that all driver groups benefit from **alcohol and drug effect**.

Drivers' income: this is the daily amount of money that comes into driver's pocket. It is different from **driver's capacity less repayments** and **average work capacity** which are drivers' potentials. The actual amount of income is affected by the influence of competition and the benefit from violation. What he pays out for violation is however not deducted from this amount. It is therefore given as

$$DI_t = \max_0(BFV_t + DCLR_t(1 - ECI_t)) \quad (52)$$

where DI is **drivers' income**, BFV is **benefit from violation**, $DCLR$ is **driver's capacity less repayments**, ECI is **effect of competition on income**. It was not possible to obtain information about the level of competition on the operation of commercial motorcycles during data collection, though this was mentioned. It is nevertheless formalised and how this is done is presented later in this section .The dimension of **drivers' income** is **NGN/(day*Week*driver)**.

Income shortfall ratio: this ratio compares the **target income** of a representative driver to his income (**drivers' income**) to show if and what the amount of shortfall is. Its equation is given as

$$ISR_t = \max_0 \frac{TI_t - DI_t}{TI_t} \quad (53)$$

where ISR is **income shortfall ratio**, TI is **target income**, DI is **drivers' income**. **Income shortfall ratio** is **dimensionless**. **Income shortfall ratio** is the variable used to obtain the pressure in the system. This pressure in the system is estimated using **effect of shortfall** and is presented below.

Effect of shortfall this parameter covers two descriptions. The first is that drivers get used to the pressure they work under. Thus the **effect of shortfall** cumulates and persists. When a driver works under a certain condition, he becomes used to it so that when the pressure goes down, he still continues to work as if he had the pressure on. This pressure, nevertheless, falls naturally over time.

However, if the pressure rises further, he strives to meet up and starts to operate/ work at the new pressure level. In addition, this pressure makes the trade look difficult and causes drivers to want to raise funds and switch to an alternative trade. So drivers continue to work hard even when there is no repayment to be made any longer, sustaining the initial high pressure introduced due to expensive repayments and other factors. This keeps their **target income** high. This second description covers in the " …not a lifetime trade" loop shown in figure 9.9. The equation is shown below

$$EOS_t = EOS_{t(t-1)} + \sum(SD_t - LOE_t) \tag{54}$$

where EOS is **effect of shortfall** for a representative driver, $(SD_t - LOE_t)$ is the change in the **effect of shortfall** for a representative driver. This is the difference between **shortfall deficit** and **loss of effect**. The unit for **effect of shortfall** is **NGN/(day*driver)**.

Shortfall deficit is the flow into the stock of **effect of shortfall** in the system. It converts the variable: **income shortfall ratio** to monetary value. Its equation is given by

$$SD_t = \begin{cases} (ISR_t * TI_t * TTOS - EOS_t) * \frac{1}{TTOS}\,; (ISR_t * TI_t * TTOS - EOS_t) \geq 0 \\ otherwise \\ 0 \end{cases} \tag{55}$$

where SD is **shortfall deficit**, ISR is **income shortfall ratio**, TI is **target income**, EOS is **effect of shortfall**, and $TTOS$ is **time to observe shortfall**. The unit for **shortfall deficit** is **NGN/(Week*day*driver)**.

Target additional earning: this is the value of **effect of shortfall** as viewed by the driver. It estimates the amount of money a driver earns less than what he would have wanted to earn each unit time. This amount is what he desires to make up for. The variable is used to show that drivers review their earning and the outcome of the review influences their driving behaviour. Its equation is given as

$$TAE_t = \frac{EOS_t}{TTOS} \tag{56}$$

where TAE is **target additional earning**, EOS is **effect of shortfall**, and $TTOS$ is **time to observe shortfall**. The unit for **target additional earning** is **NGN/(Week*day*driver)**.

Earning pressure: this is a variable that takes the effect of the pressure from shortfall to driver behaviour. Its value is measured as a ratio of what additional money the driver is targeting to system's **drivers' capacity less repayment**. It is given by

$$EP_t = \frac{TAE_t}{DCLR_t} \qquad (57)$$

where EP is **earning pressure**, TAE is **target additional earning**, and $DCLR$ is **driver's capacity less repayments**. The unit for **earning pressure** is **dimensionless**.

Loss of effect: As previously noted in section 10.7.1.1, the pressure under which drivers work eventually goes down after some time. This parameter captures the process. It is used to show the rate at which this pressure goes down and is given by

$$LOE_t = \frac{EOS_t}{TTM} \qquad (58)$$

where LOE is **loss of effect**, EOS is e**ffect of shortfall**, and TTM is **time to mature**. The unit for **loss of effect** is **NGN/(Week*day*driver)**.

The effect of competition is represented in this model as a factor that affects **drivers' income.** This is shown as a ratio of the density of drivers multiplied by a factor (30% is used). This is intended to mean that even when drivers' density is "1", competition effect is at most 0.3. This value is based on the literature that suggests values as much as 20% (Mahlstein, 2009).

$$ECI_t = DPD_t * MEC \qquad (59)$$

where ECI **effect of competition on income**, DPD is **drivers' population density**, MEC is **maximum effect of competition**. **Drivers' population density** is a measure of the ratio of **total drivers** to the system's **carrying capacity** and is given by

$$DPD_t = \frac{TD_t}{CC_t} \qquad (60)$$

where DPD is **drivers' population density**, TD is **total drivers**, and CC is **carrying capacity**.

Perceived work hours required: this parameter demonstrates the decision process of the driver. A driver with pressure from shortfall sets a hypothetical **target additional earning** which he desires to make each day to increase his previous earning. This parameter assumes that the driver assesses this outstanding amount in terms of the number of working hours he requires to make the amount. Its equation is given as:

$$PWHR_t = \frac{TAE_t}{AIEH_t} \tag{61}$$

where $PWHR$ is **perceived work hours required**, TAE is **target additional earning**, and $AIEH$ is **average income per effective hour**. The unit of measurement is **hrs/day**.

Other variables in figure 10.19 whose equations are not provided above are shown in table 10.11.

Table 10.11: Table of constants and shadow variables for strenuous working condition and its effect[55]

Other parameters	Value	Meaning	Unit
Constants			
Max effect of competition	0.3	This is introduced to limit the effect of competition. The literature shows that this effect has been as much as 20% of driver's earning (Mahlstein, 2009). It is set at 30% so that the actual effect in the model does not exceed 30%.	Dmnl
Time to form expectation	13	It is assumed that prospective drivers cannot be easily dissuaded from joining the trade. So they require as much as three months of continuous poor earning from the trade to consider a rethink about joining the trade	week
Time to observe shortfall	1	Drivers would normally review their income in each representative day week	week
Shadow variables			
Variable		**Reference section**	
Average payment per day		Treated in section 10.6.2.2	
Average work capacity		Treated in section 10.7.1.2	
Benefit from violation		Treated in section 10.6.2.1	
Carrying Capacity		Treated in section 10.7.1.1	
Driver's capacity less repayments		Treated in section 10.7.1.2	
Maturity		Treated in section 10. 7.1.1	
Alcohol and drug effect		Treated in section 10. 8.2	
Repayment period		Treated in section 10. 7.1.1	
Self-owned drivers' repayment factor		Treated in section 10. 7.1.2	
Total drivers		Treated in section 10. 7.1.1	
Work effectiveness factor		Treated in section 10.8.2	
Working Period		Treated in section 10.8.1	

[55] See appendix 2 for more equations

10.8 Effect of drivers' and work characteristics model structure

How drivers' **target income** and its effect are modelled has been shown in section 10.7.2. What is shown here are the responses to this effect. They include increased working period, fatigue, alcohol use, and aberrant behaviour (violations). The SFDs treated here are in the oval shape "G" in figure 10.3. First, drivers' work reponse to the effect of **target income** is shown. This is followed by drivers' violation response.

10.8.1 Drivers' work response to strenuous working condition module

The decision rule guiding drivers' decision to work more is described by figure 10.20 below. It is shown that a representative driver has a limit to the number of hours he can work in a day (represented by **work capacity**). This capacity can be increased by constantly working more (i.e., increase **working period**). The model shows that working more for a certain amount of time regularly over 13 weeks increases driver's **work capacity** (i.e., more **working period** over 13 weeks raises **work capacity**). However, working more meaning going beyond the drivers' capacity and this often causes breakdown. This breakdown is represented by the variable **work capacity limit per time**. Subsequently, it is shown that the attempt to avoid this breakdown is part of what leads to the use of alcohol and other drugs as found in the data. The equations for this part of the model follow figure 10.20 below.

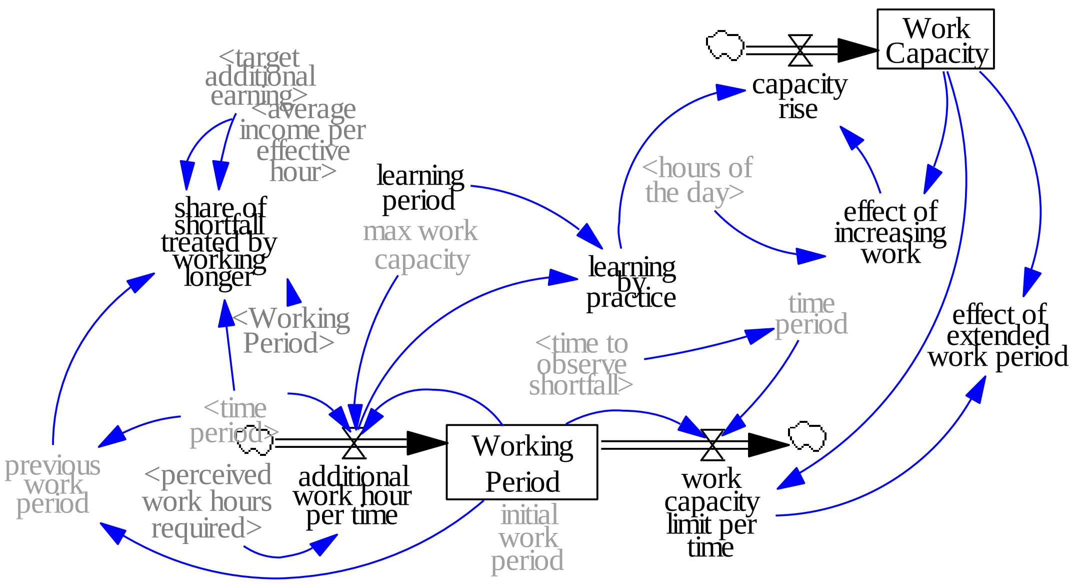


Figure 10.20: SFD of drivers' work response to strenuous working condition

Working period: this is the average number of hours a representative driver puts into operation/service per day. Usually, when the driver decides on the number of additional hours he wants to put to work (i.e., **perceived work hours required**), he increases his **working period** by that amount and starts to operate at a new **working period**. However, if the additional working period exceeds his ability (referred to as **Work Capacity** in this model), this might result in breakdown so that the effectively added additional time is less than what the driver actually wishes. This is reflected in the equation below:

$$WP_t = WP_{t(t-1)} + \sum(AWHT_t - WCLT_t);\ WP_{t(0)} = IWP = 6 \tag{62}$$

where WP is **working period** of a representative driver, $\Delta WP_{i,t}$ is the change in **working period** for the driver. The change in working period is given as the difference between $AWHT$ (**additional work hours per time**) and $WCLT$ (**work capacity limit per time**). **Working period** is given an initial value to represent the fact that the trade started as part-time. This initial value, tagged **initial working period** has a value of 6 hours per day. The unit of **working period** is **hrs/day**.

Additional work hour per time is a variable that represents the additional time a driver starts to put into work to meet up with his **target additional earning**. It depends on a number of factors including the current **working period**, the value of **target additional earning**, etc. The equation is shown below

$$AWHT_t = \begin{cases} \min_{\frac{PWHR_t}{TP}}\left(\frac{MWC_t - WP_t}{TP}\right),\ WP_t < MWC_t \\ otherwise \\ 0 \end{cases} \tag{63}$$

where $AWHT$ is **additional work hour per time** for the driver, MWC is the **maximum work capacity**, WP is **working period**, TP is **time period**, the period of time over which additional work is to be done, and $PWHR$ is **perceived work hour required**, the amount of time the drivers thinks he requires to work more and earn enough to offset his pressure. The unit of **additional work hour per time** is **hrs/(day*week)**.

Work capacity limit per time estimates the consequence of overwork in the form of breakdown time and time for recuperating. It is intended to show that drivers may overwork themselves to cover their **target additional earning** and would require time to rest and recover. It therefore depends on driver's **work capacity** and **working period**. The equation is shown below

$$WCLT_t = \max_0 \frac{WP_t - WC_t}{TP} \tag{64}$$

where $WCLT$ is **work capacity limit per time** for the driver, and WC is **work capacity** for the driver, WP is **working period**, TP is **time period**. The unit is **hrs/(day*week)**.

Work capacity is another stock present in the model. It is the average number of hours drivers are working for in a day. It is used to show both the transition of commercial motorcycle trade from part-time job to full time job as it is today as well as to model the implication of the increasing number of hours a driver puts into operation on daily basis. It is particularly useful in comparing **working period** with the drivers' ability (**work capacity**), for formalising one of the reasons for the drink driving, and for providing a trend for drivers' breakdown due to overwork. **Work capacity** is given by

$$WC_t = WC_{t(t-1)} + \sum . CR_t \; ; WC_{t(0)} = IWP = 6 \qquad (65)$$

where $WC_.$ is **work capacity** of the driver, and CR is **capacity rise**. **Work capacity** shares the same initial value with **working period**; its unit is **hrs/day**.

The change in work capacity is given by the parameter **capacity rise**. **Capacity rise** is a variable that measures what a driver is able to get used to within a time period. It is both a function of how much a driver can improve in the number of hours he is working for within a time period as well as current **work capacity**. Its equation is given by

$$CR_{i,t} = LBP_t \times EIW_t \qquad (66)$$

where CR is **capacity rise** for the driver, LBP is **learning by practice** for the driver, and EIW is **effect of increasing work**. The units for **capacity rise** is **hrs/(week*day)**.

Learning by practice helps to capture the fact that for a driver to increase his **work capacity**, he requires practice over time **–** meaning a repetition of the new working period for a space of time. The equation representing this is given by

$$LBP_t = AWHT_{t(t-LP)} \qquad (67)$$

where LBP is **learning by practice** by the driver, and $AWHT$ is **additional work hour per time**, LP is **learning period**. **Learning period** has the value of 13 weeks. The equation shows that **learning by practice** is the value of **additional work hour per time** some 13 weeks before the time (quarter of a year). The unit for **learning by practice** is **hrs/(week*day**).

Effect of increasing work: This variable estimates that maximum number of hours a driver can work in a day. A heuristic function is used to show that as working period tends towards full day, the effectiveness of work reduces to zero. The equation **effect of increasing work** for is given as

$$EIW_t = EIW_{LKP};\ \frac{WC_t}{HOTD} \tag{68}$$

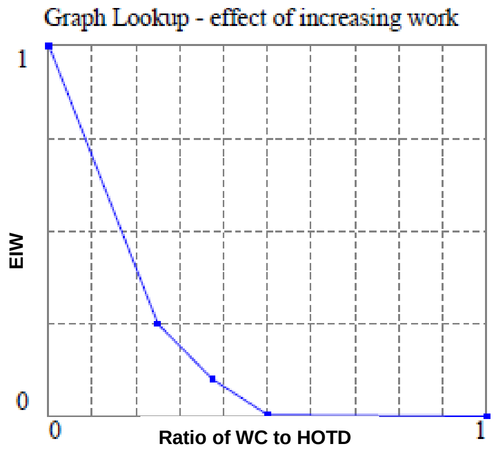


Figure 10.21: Heuristic function relating work capacity to the hours of the day

where EIW is **effect of increasing work,** WC is **work capacity**, $HOTD$ is **hours of the day**, and EIW_{LKP} is **effect of increasing work lookup function** shown above.

Share of shortfall treated by working longer: This is a measure of the percentage of shortfall effect (**target additional earning**) that a driver fulfils by working more. It is given by

$$SSTW_t = \min_{0.9} \begin{cases} AIEH_t * \frac{(WP_t - PWP_t)}{TAE_t * TP} * TI_t \ ; WP_t - PWP_t > 0 \\ \text{otherwise} \\ 0 \end{cases} \tag{69}$$

where $SSTW$ is **share of shortfall treated by working longer**. Its unit of measurement is **1/Week**. WP is **working period**, PWP is **previous work period**, $AIEH$ is **average income per effective hour**, TP is **time period**, and TAE is **target additional earning**.

Previous work period is given by

$$PWP_t = WP_{t(t-1)} \tag{70}$$

where WP is **work period**. Its unit is **hrs/day**.

Effect of extended work period this parameter estimates drivers' break-down problem due to overwork. It is given as the ratio of break-down/ recovery time to driver's work capacity at that time and is expressed mathematically as

$$EEWP_{i,t} = \left(\frac{WCLT_t}{WC_t}\right) \tag{71}$$

where $EEWP$ is **effect of extended work period** for a driver, $WCLT$ is the **work capacity limit per time** for the driver, and WC is **work capacity** of the driver. The unit for **effect of extended work period** is **1/week**.

Other parameters appearing in figure 10.21 whose equations are not provided above are shown in table 10.12.

Table 10.12: Table of constants and shadow variables for drivers' work response to pressure representation

Other parameters	Value	Meaning	Unit
Constants			
Initial work period	6	The number of hours that drivers were working for at the start of the simulation. Since the qualitative data shows that working pattern was part-time, this value is used to represent part-time service	hrs/day
Max work capacity	14	An arbitrary value set to limit the maximum number of hours a representative driver is able to work for in a day. The literature has found as much as 13 hours (Arosanyin et al., 2013)	hrs/day
Time period	1	This is the minimum unit of time considered in the model – a week. For example, it is the length of time over which drivers observe and respond to changes in their daily income	week
Learning period	13	This time period is the average time required for learning and or improving skills. It is given as 13 weeks, a period of three months. It is used to show that it takes time for the body to adjust to a new working pattern	week
Shadow variables			
Variable		**Reference section**	
Target additional earning		Treated in section 10.7.2.1	
Average income per effective hour		Treated in section 10.7.2.1	
Perceived work hours required		Treated in section 10.7.2.1	
Time to observe shortfall		Treated in section 10.7.2.1	
Hours of the day		Treated in section 10.8.2	

10.8.2 Drivers' violation response to strenuous working condition module

This section treats how the pressure resulting from the **effect of shortfall** contributes to violations. It is however important to note that the formalised variables here show that this pressure is just one of the many contributing factors to violations. Other factors that contribute include driver behaviour, represented as **tendency to violate**, **drivers' training**, and many others. These are shown below in figure 10.22. In addition, the use of alcohol and drugs by drivers is formalised and shown in figure 10.23. In the formulation for the use of alcohol and drugs, it is shown that drivers want to minimise their breakdown time (i.e., **work capacity limit per time**). They therefore resort to supporting themselves with taking alcohol and drugs.

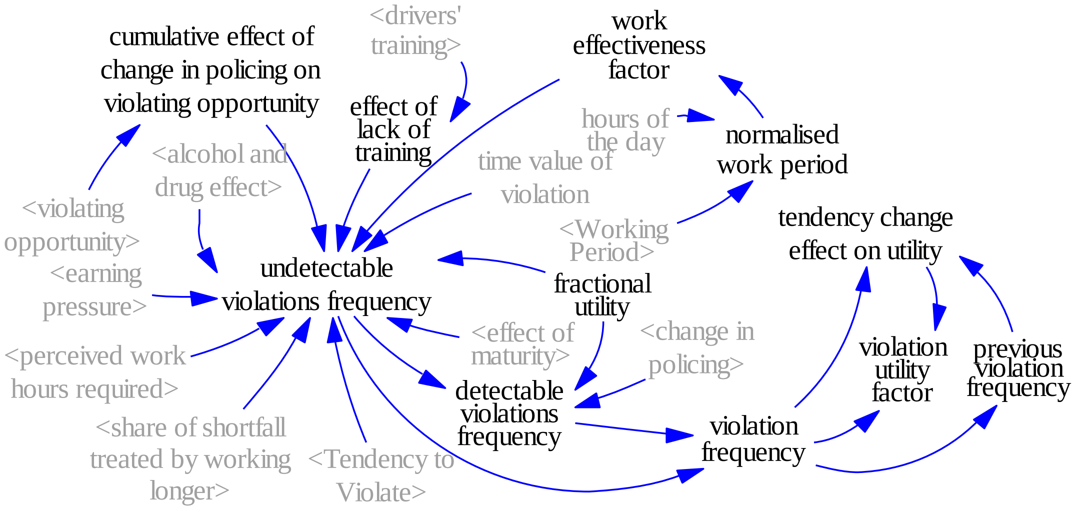


Figure 10.22: SFD for violation components

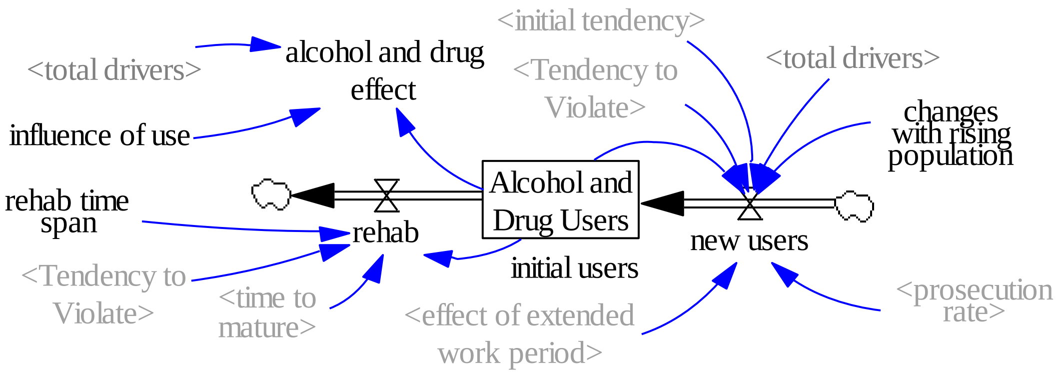


Figure 10.23: SFD for alcohol and drug use components

Undetectable violation frequency: to show that not all violation types can be detected by the enforcement officers, detectable and undetectable violations are differentiated. Officers may not be able to detect offences such as over-speeding as there are no speed cameras, or drink-driving as most officers do not have breathalysers. This variable therefore covers the frequency of this type of violations that cannot be easily detected. Its equation is given by

$UVF_t = (1 - EOMY_t) * (1 - SSTW_t) * TTV_t * \frac{1}{WEF_t} * (1 + EP_t) * (1 + EP_t * ELT_t) *$

$(1 + AADE_t) * (1 - FU) * TVV * CEPV_t * PWR_t$. (72)

Detectable violation frequency: covers the violation types that can be detected by the enforcement officers. Its equation is given by

$DVF_t = \frac{1}{CIP_t * WEF_t} * (1 - EOMY_t) * (1 - SSTW_t) * TTV_t * (1 + EP_t) * (1 + EP_t * ELT_t) *$

$(1 + AADE_t) * FU * TVV * CEPV_t * PWR_t$. (73)

where UVF is **undetectable violation frequency and** DVF is **detectable violation frequency**. Both have the unit **violation/(Week*driver*day)**. $SSTW$ is **share of shortfall treated by working longer**, TTV is **tendency to violate**, WEF is **work effectiveness factor**, EP is **earning pressure**, ELT is **effect of lack of training**, FU is **fractional utility**, TVV is **time value of violation**, CIP is **change in policing**, $CEPV$ is **cumulative effect of change in policing on violating opportunity**, $EOMY$ is **effect of maturity**, $AADE$ is **alcohol and drug effect**, and PWR is **perceived work hours required**.

Work effectiveness factor: This factor shows the effect of reducing efficiency as the number of hours committed to working increases. It is given by

$WEF_t = WEF_{LKP};\ NWP_t$ (74)

$NWP_t = \left(\frac{WP_t}{HOTD}\right)$ (75)

NWP_t is **normalised working period** and is the ratio of **working period (**WP) to the number of **hours of the day** ($HOTD$) (a day has 24 hours), WEF_{LKP} is **work effectiveness factor lookup function**. Thus WEF_t and NWP_t are **dimensionless**. The lookup graph is presented below

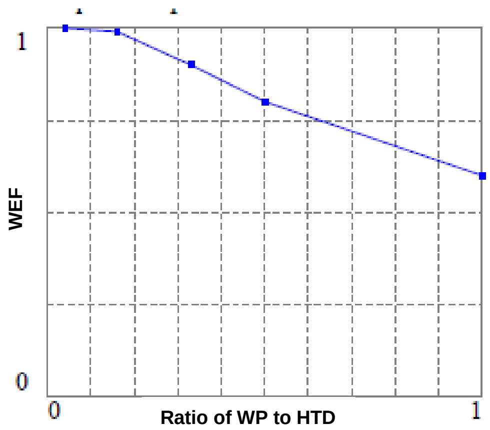


Figure 10.24: Heuristic function estimating the efficiency of working period

Alcohol and drug users: this is treated as a stock and is estimation for the number of drivers using alcohol and drugs. It is an open knowledge in Nigeria that all motorcycle stations have alcohol sale points. It is not unusual to find a huge percentage of commercial motorcycle drivers using alcohol. The use of drugs is however less reported. In this model, this group of users is represented by **alcohol and drug users** and is given by

$$AADU_t = AADU_{t(t-1)} + \sum(NU_t - R_t);\ AADU_{t(0)}=1 \qquad (76)$$

where $AADU_t$ is **alcohol and drug users**, the number of drivers regularly using alcohol. The unit of **alcohol and drug users** is **driver**. $(NU_t - R_t)$ is change in **alcohol and drug users** at any time. This change is equivalent to the difference between the parameters, **new users** and **rehab**. The parameter **rehab** (rehabilitation) indicate the number of drivers dissuaded from using alcohol and drugs and is given by

$$R_t = \left(\frac{(1-TTV_{t)})*AADU_t}{RTS_t} + \frac{AADU_t}{TTM}\right) \qquad (77)$$

where R is **rehab**, meaning rehabilitation, $AADU$ is **alcohol and drug users**, TTV is **tendency to violate,** TTM **is time to mature**, and RTS is **rehab time span**. The unit is **driver/week**

The variable **new users** estimates the number of drivers newly joining the group of regular users of alcohol and drugs. It is a parameter that depends on the **effect of extended working period**, the number of drivers already drinking and the total number of drivers. It is given by the equation

$$NU_t = AADU_{t(t-1)} \times (1-PR) \times \left(1 + EEWP_{t(t-1)}\right) \times \frac{TTV_t}{IT_t} \times \left(1 - \frac{CWRP \times AADU_{t(t-1)}}{TD_t}\right) \qquad (78)$$

where NU_t is **new users**, $EEWP$ is **effect of extended work period**, IT is **initial tendency**, $CWRP$ is **changes with rising population**, and TD is **total drivers**. PR is **prosecution rate**. The parameter **changes with rising population** is a heuristic constant. Its value is given as 1.5. The unit of **new users** is **driver/week**.

Total violations: this is the sum of all violations committed by drivers in the system. It is the sum of detectable and undetectable violations. Detectable and undetectable violations are obtained as violation frequencies per driver. These frequencies are obtained as probable estimate of the number of violations each violating driver commits a day. Total violations is therefore given as

$$TV_t = \max_1 [(DVF_t + UVF_t) * TD_t] \qquad (79)$$

where TV is **total violations**, DVF is the **detectable violation frequency**, the frequency of committing detectable violations by a representative driver, UVF is the **undetectable violation frequency**, and TD is **total drivers**. Its unit of measurement is **violation/(week*day)**.

There are however some variables appearing in figures 10.22 and 10.23 whose equations have not provided. These are listed and described in table 10.13.

Table 10.13: Table of constants and shadow variables for drivers' violation response to pressure representation

Other parameters	Value	Meaning	Unit
		Constants	
Hours of the day	24	The number of hours in a day	hrs/day
Time value of violation	1	This means that a violation is equivalent to about one hour work of a driver, where one hour work is equivalent to violation utility. Note that each work week is measured as the average daily **Working Period**. This high value might be responsible for the difficulty in achieving deterrence	violation/ (hrs*driver)
Fractional utility	0.5	This is the fraction that shows the importance attached to each of the two different types of violations by individual drivers, i.e., detectable and undetectable. Due to lack of data, however, it is assumed that both violation types have the same value to the drivers	Dmnl
Influence of use	0.25	This is used to project how the use of alcohol and drugs affects capacity	Dmnl
Rehab time span[56]	156	This is the length of time required to rehabilitate a driver who is used to drinking and taking drugs (i.e., for the effect of deterrence to dissuade him)	week
Initial users	1	Assumes that only one driver was involved in drink-driving when the mode started. It could indicate that the support from alcohol and drugs was not required when the trade started as most people worked part time then	driver
Changes with rising population	1.5	This is used to generate the pattern of growth in **alcohol and drug Users** population that shows **alcohol and drug users** are about 65% of drivers	Dmnl

[56] **Rehab time span** is a representation for the length of time it might take to discourage the use of alcohol and drugs amidst drivers supposing the decision to discourage its use is reached. This value is intended to show that such process might require time to become successful.

Shadow variables	
Variable	**Reference section**
Change in policing	Treated in section 10.6.1.2
Drivers' training	Treated in section 10.7.1.1
Earning pressure	Treated in section 10.7.2.1
Effect of extended work period	Treated in section 10.8.1
Effect of maturity	Treated in section 10.7.1.1
Initial tendency	Treated in section 10.6.2.1
Perceived work hours required	Treated in section 10.7.2.1
Prosecution rate	Treated in section 10.6.2.2
Share of shortfall treated by working longer	Treated in section 10.8.1
Tendency to Violate	Treated in section 10.6.2.1
Total drivers	Treated in section 10.7.1.1
Violating opportunity	Treated in section 10.6.1.2
Working Period	Treated in section 10.8.1

10.9 Model validation

Following the provisions of sections 10.4 and 10.5, the model presented in sections 10.6 to 10.8 above has been constructed to the best of available information. It is acknowledged however that there are many uncer5tainties with model parameters. In this section and the next, a number of tests are conducted on the model to assess the extent of its validity. In this section, some standard system dynamics tests (Barlas, 1989; Barlas, 1996; Sterman, 2000) are used in the validation exercise conducted on the model developed. These tests include structural assessment, parameter assessment, boundary adequacy, sensitivity, behaviour replication, and extreme conditions tests. First, the behaviours of some model variables are presented in section 10.9.1. Then the dynamic patterns of some variables are discussed in section 10.9.2. This is followed by all the tests listed above in that order. The model developed in this chapter is not intended to predict outcomes. It is rather intended to support the CLD obtained in chapter 9 in helping to understand why things are probably changing the way they do in the actual system.

10.9.1 Model behaviour description

It is important to evaluate the validity of a model using several criteria (Sterman, 2000). For example, the behaviour of a model should be evaluated to see whether it responds in a satisfactory manner or not. This section describes the behaviour of some selected variables in the model. The variables whose behaviours are described here include: **total violations**, **attention to mode**, **public perception about risk in** (commercial motorcycles') **operation**, **enforcement workforce**, **working period**, **alcohol and drug users**. Others shown later include **total drivers**, **drivers' income**, **tendency to violate**, **enforcement coverage**, amidst others. The behaviour of these variables is shown to agree with empirical knowledge about the system. These are presented below.

Total violation

Figure 10.25 shows the graph for **total violations** drivers commit each day. While the exact number of violations committed by the drivers is not known, the useful information from this graph is that the trend has reached a major peak. Olagunju's (2009) work offers some evidence to support this trend.

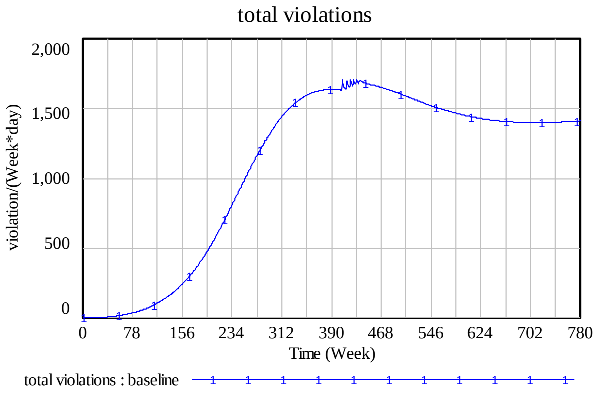


Figure 10.25: Graph for total violations committed by drivers

Attention to mode

Figure 10.26 is intended to show that the attention being given to motorcycles by the police has actually risen as indicated in the data. It is however not as much as the high range speculated by the drivers. Nevertheless, it is useful that this model shows the rise in its trend above the share of commercial motorcycles in traffic.

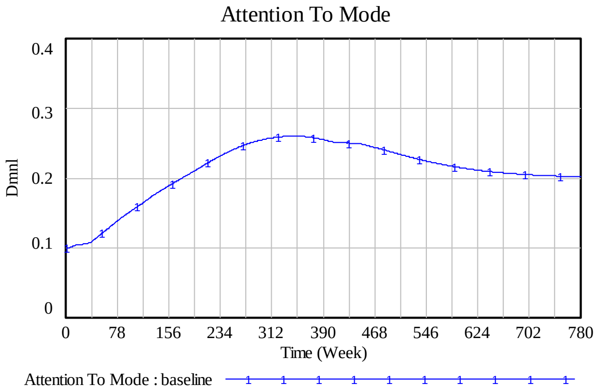


Figure 10.26: Graph for attention officers commit to monitoring motorcycles

Public perception about risk in operation

Figure 10.27 shows that the view of the public about commercial motorcycle risks is still very high. This also agrees with what is generally known about commercial motorcycle operation. The graph also shows that this perception was worse previously but has improved.

Figure 10.27: Graph of public perception about the risky behaviour of drivers

Working period

Figure 10.29 is used to show the increasing pattern of drivers' average working hours per day. This agrees with findings from the literature (Arosanyin et al., 2013) about this high average working hours per day.

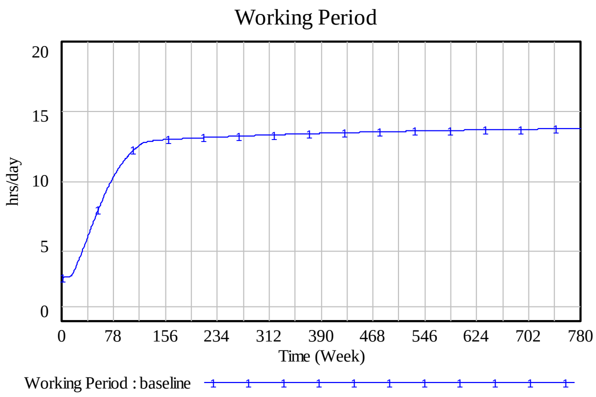


Figure 10.28: Graph for drivers' working hour per day

Enforcement Workforce

Figure 10.28 shows system enforcement capacities. Figure 10.28a shows **enforcement workforce** while figure 10.28b shows **enforcement coverage** for commercial motorcycles. **Enforcement workforce** is used to represent the number of officers fully working in the traffic management unit. It is based on the number obtained during data collection and is an approximation for all the agencies engaged with traffic safety management in the study location. On the other hand, **enforcement coverage** represents the share of the total enforcement capacity (**enforcement size** in this model) which works solely on commercial motorcycle management. While this is not identifiable in practice, it is used to estimate the amount of attention the entire enforcement system is committing to commercial motorcycle operation. One important observation is the shape of the variable. The meaning of the fall after week 390 is related to the floating goal of the enforcement system. Once the enforcement system realised their goal, there was a fall in the level of attention given to commercial motorcycle operations. Figure A3.1 in Appendix 3 shows this more clearly.

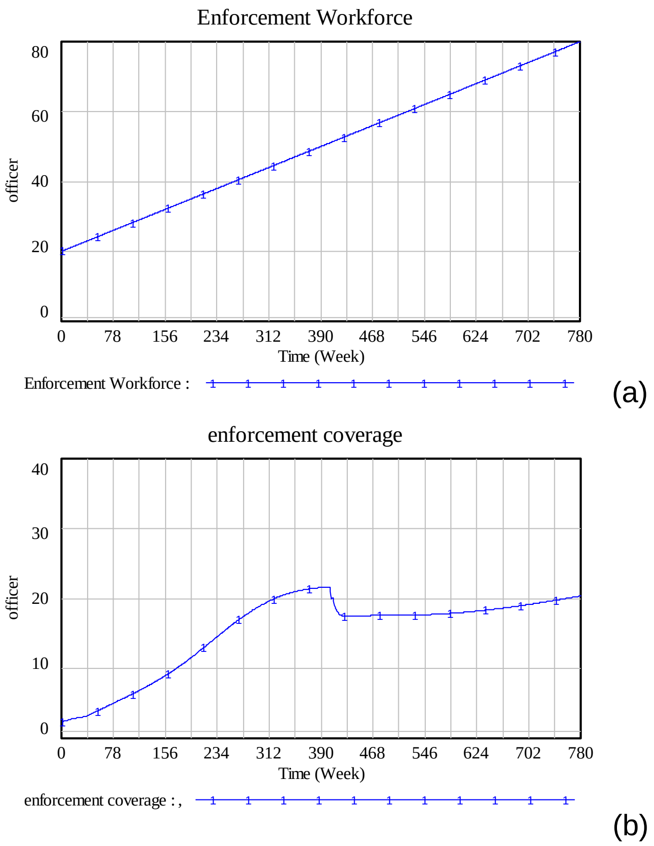


Figure 10.29: Graph for workforce of enforcement agency

Alcohol and drug users

Figure 10.30 is used to show the trend in the use of alcohol and drugs by drivers. This agrees with the data that shows the percentage of users to range between 60% and 90%, though Adisa (2010) found 60% in his studies. What is shown here is 65%.

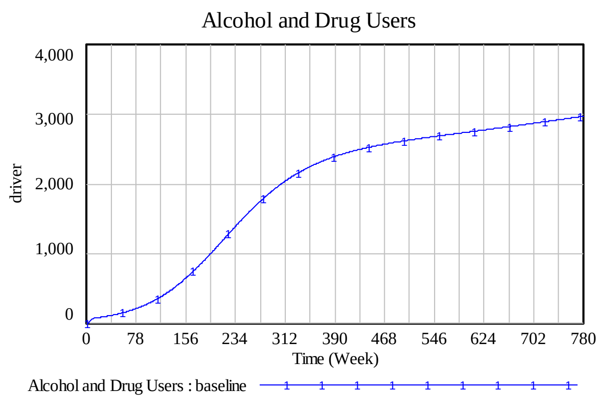


Figure 10.30: Graph for alcohol and drug users

10.9.2 Dynamic patterns in commercial motorcycle operation

There was no historic quantitative data (time series data) about the operation of commercial motorcycle transport. Nevertheless, it was necessary to be guided by some reference behaviour about this transport mode. However, because the dynamic hypothesis for this model was developed during data analysis stage, it was not possible to extract all reference mode graphs from stakeholders. Reference modes were synthesized from the data. Specifically, the data has the following to say about the transport's operation:

> "*Okada transportation is a very good system when started. Everybody enjoys it because it can carry you to the nooks and corners of your houses. Then it's easily available and very fast. But as it goes on now, people abuse it because some riffraff have joined the riders, the commercial riders. They involve themselves in the smoking of Indian hemp (sic)*…" R2I

> "*There are instances when you drive in the night you see an okada man with torchlight he will be riding in the mouth. Is that not stupid? We have seen cases where okada had an accident and the touch-light entered his mouth. He put it in the mouth... damaged all the buccal cavity(sic)*" R2I

> "*But actually, it's like there has been a reduction in the frequency of accident since we started our monthly meeting*." R6FG1

> "*And if you observe accident trend on the street generally now, you find out that frequency is reducing. Such that the meeting we hold every month, they hear this thing*." R3FG1

The inference from the quotes above adopted by the researcher is that commercial motorcycle drivers had less aberrant behaviours when they started. Along the line, as the number of drivers increased and more people joined, the drivers became risky and the trend rose. Now, it is no longer increasing. This is shown in figure 10.31 below.

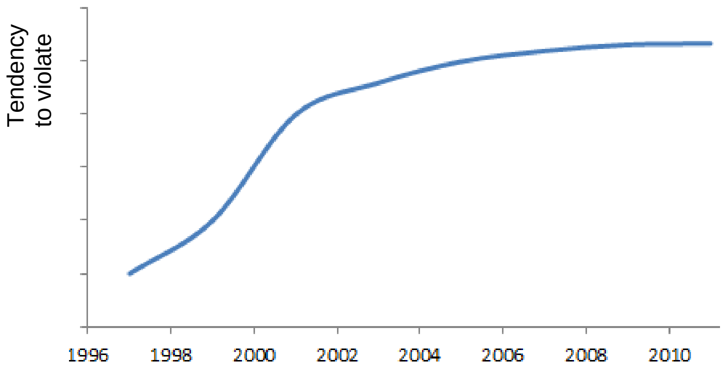


Figure 10.31: Reference mode for tendency to violate

Figure 10.31 above represents the reference mode for parameter: **tendency to violate**. It shows a rapid earlier rise which is now at its peak. This reference mode is assumed to show that the index representing driver behaviour might have reached the peak and might not be getting worse.

Similarly, from the quotes below, the drivers also noted that there were about a 100 drivers in the year 1996, 2000 drivers in year 2000 and 5000 drivers in year 2011. This gives the indication of a growth pattern shown in figure 10.32. The supporting quotes include:

> "*Could they be up to 400? They were so few they could be counted... Okada rider in Ado when I started could not be more than 100… By the year 2000, the number has risen. They should be about 2000 then*." R2FG1
>
> "*So for this reason, as they are more interested in making money, since when we call for a meeting, we would expect 5000+ in attendance but only 2000 people/riders would come*." R4FG1

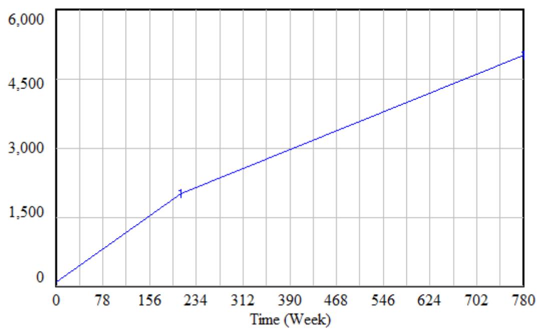


Figure 10.32: Reference mode for drivers' population growth

These two graphs were part of the guides for the model development exercise. How well the model matches these reference modes is discussed in section 10.9.7.

10.9.3 Structural assessment test

According to Sterman (2000), the structural assessment test is required to find out whether the model is consistent with knowledge of the real system relevant to the purpose. It checks for the appropriateness of the level of aggregation in the model. It also finds out if the model conforms to the basic laws of physics such as conservation laws and if the decision rules adopted capture the behaviour of the actors in the real system. As suggested by Sterman (2000), the use of stock and flow maps, direct inspection of model equation, and the collection of information about the system characteristics using methods such as interview, direct observation, as well as archival materials can address this test. Sections 7.3, 8.6 and 9.3 report how these steps were taken. For example, the system structure emerged from a rigorous analyses of the qualitative data obtained from a primary source and validated using secondary information from the literature (as shown in section 9.3). In addition, some of the descriptions modelled were obtained from the literature. For example, the deterrence effect of sanction was developed based on the theory of deterrence of crime described in Polinsky and Shavel (2001). Moreover, the model structure is very similar Mehmood (2010) traffic law violation model. It is however superior to Mehmood's model because actual local conditions are used in many instances where Mehmood used heuristic relationships. Mehmood's structural framework is shown in figure 10.33 below.

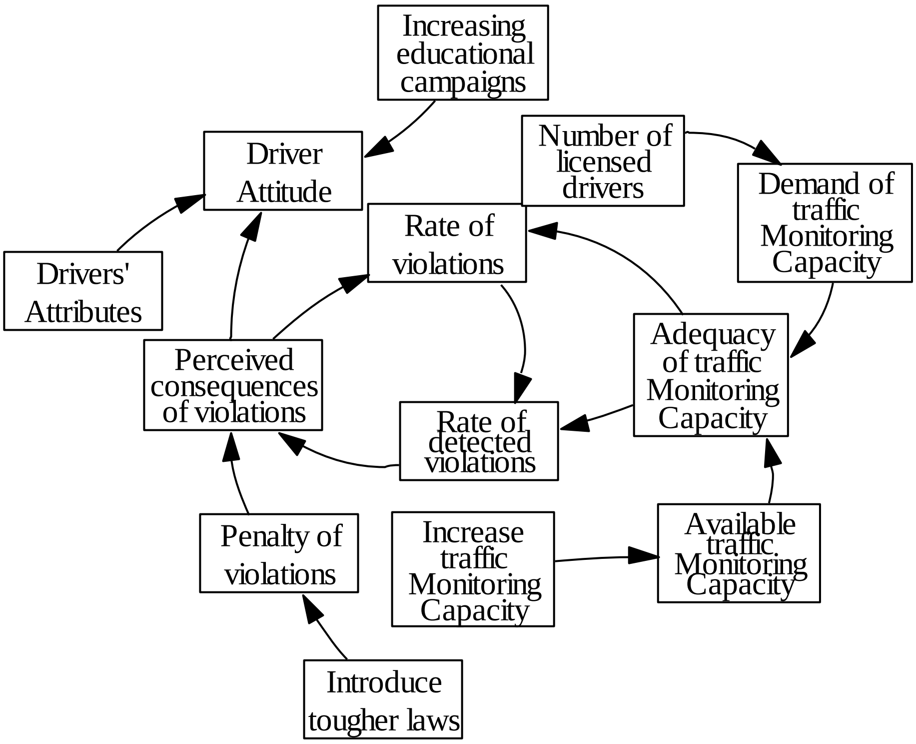


Figure 10.33: Mehmood's (2010, p.428) "logical framework" for violations' model

10.9.4 Parameter assessment test

This test finds out whether the parameters used in the model have values consistent with relevant descriptive and numerical knowledge of the system. Sections 10.6 to 10.8 include tables of the constants in the model, the values given these constants as well as what these constants represent. As can be seen on the tables all parameters have real world meaning and take realistic values.

10.9.5 Boundary adequacy test

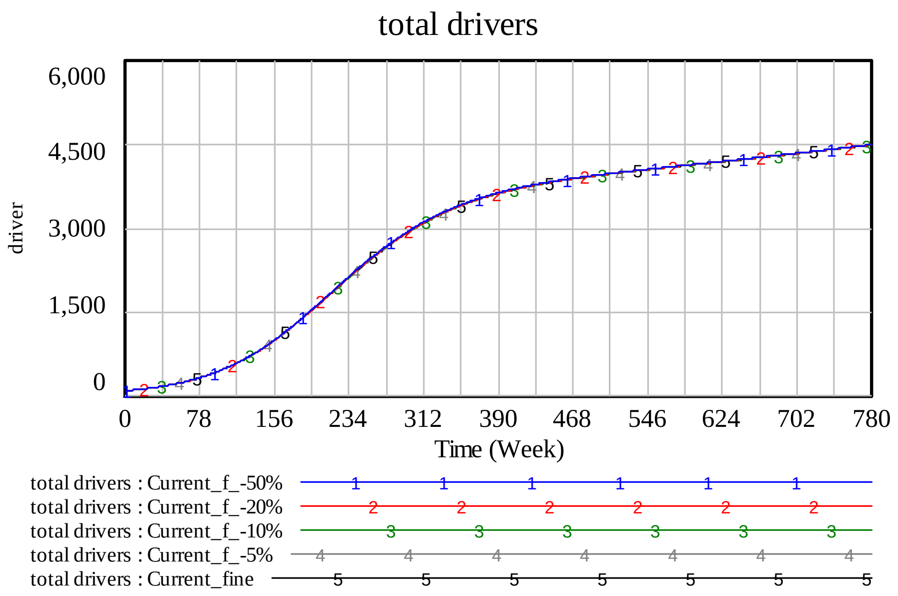
This test helps to check if important themes for addressing the problem are endogenous to the model. The extensive data collection and rigorous analysis of data helped to define system boundaries. Almost all the factors in the CLD were adopted in the stock and flow model as endogenous so as to ensure that the behaviour within the model is generated from its structure and not due to external influences. These steps help to fulfil boundary adequacy requirements.

10.9.6 Sensitivity test

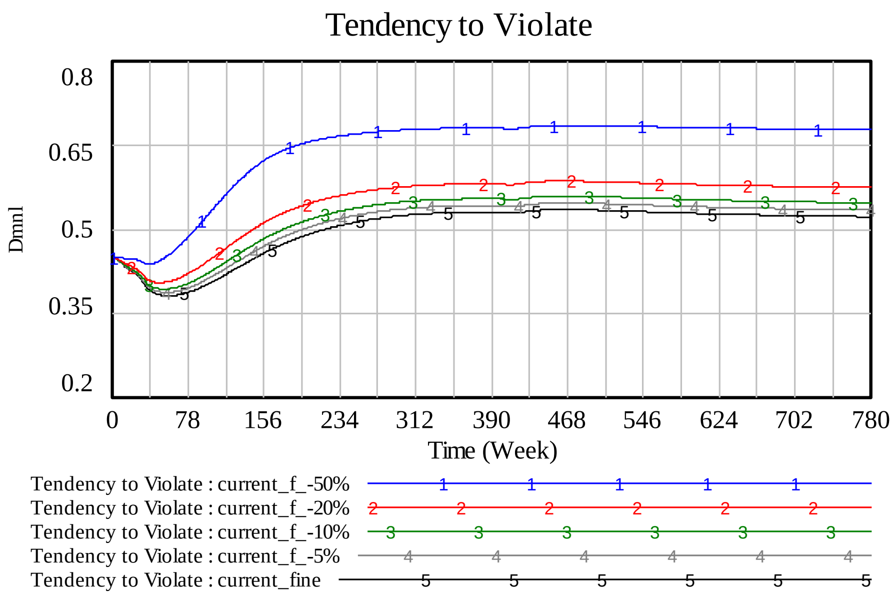
The sensitivity test conducted for this model is done for some constants. Sensitivity testing is the process of changing the assumptions about the values of the constants in the model and examining the resulting output. They are required to identify the parameters to which the model is highly sensitive and ask if these sensitivity would make sense in the real system (Vlachos et al., 2007). This test is conducted for a broad variation in the values of some parameters in the model. The outcome shows that the sensitivity of these parameters generally makes sense and confirms that the model is robust. Some of the tests are discussed below.

10.9.6.1 Sensitivity of the parameter: fine

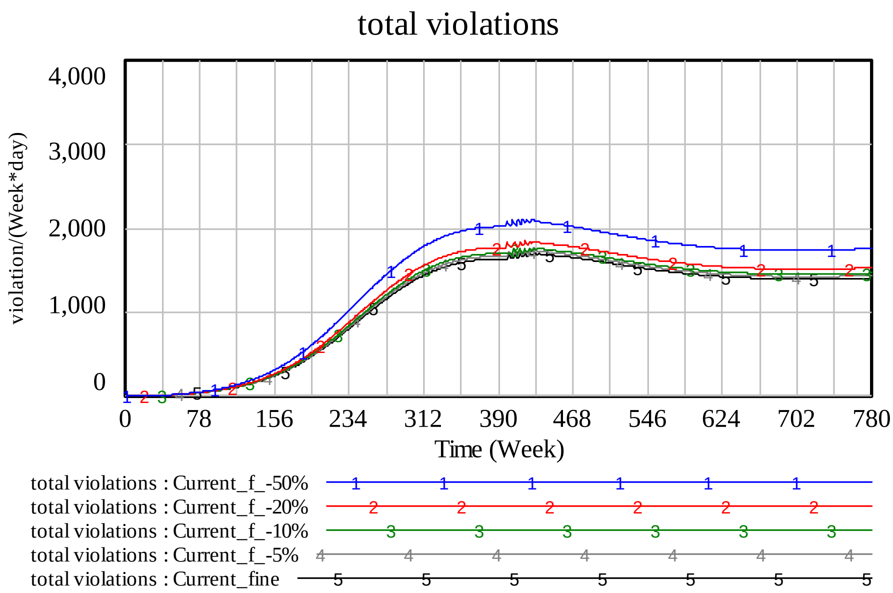
Figures 10.34 and 10.35 show that the parameter **fine** is sensitive in the model. An increase in **fine** would reduce drivers' **tendency to violate** and **total violations** and vice versa. Higher value of **fine** might also reduce the required **enforcement coverage**. As Barlas (1996, p.191) puts it, behaviour sensitivity test involves "asking if the real system would exhibit similar high sensitivity to the corresponding parameter." This behaviour agrees with what could be the case in the real world. This parameter therefore looks appropriate.



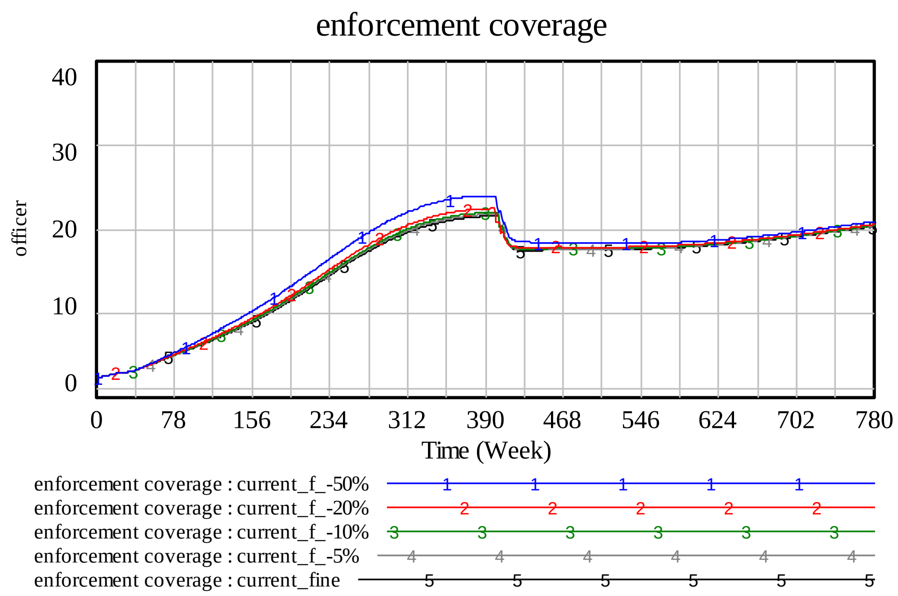
(a): **Total drivers'** population under different values of **fine** (Reduction in the value of **fine** does not affect **total drivers**' growth pattern)



(b): Trend of **tendency to violate** under different values of **fine** (Reduction in the value of fine increases drivers' **tendency to violate**)

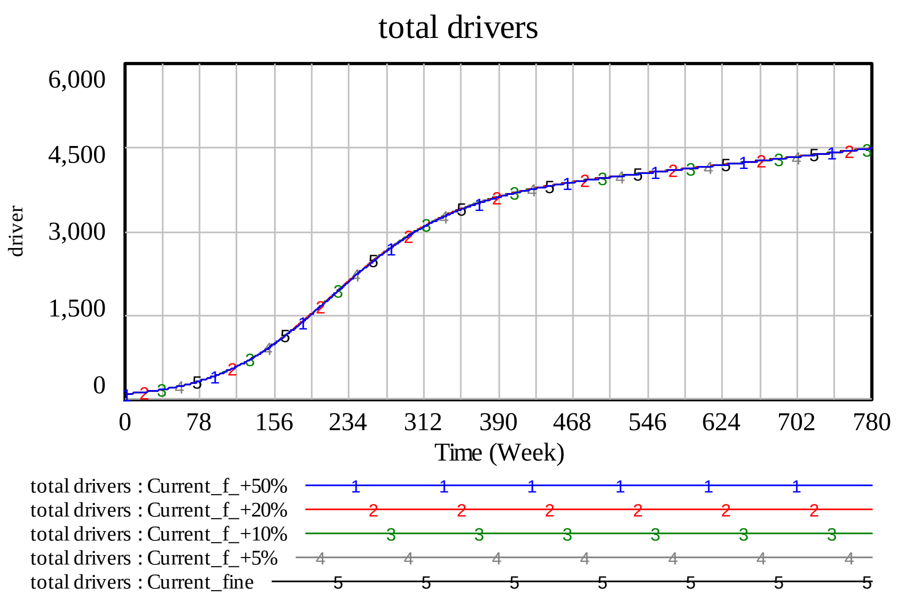


(c): **Total violations** trend under different values of **fine** (Reduction in the value of **fine** increases **total violations** committed by drivers)

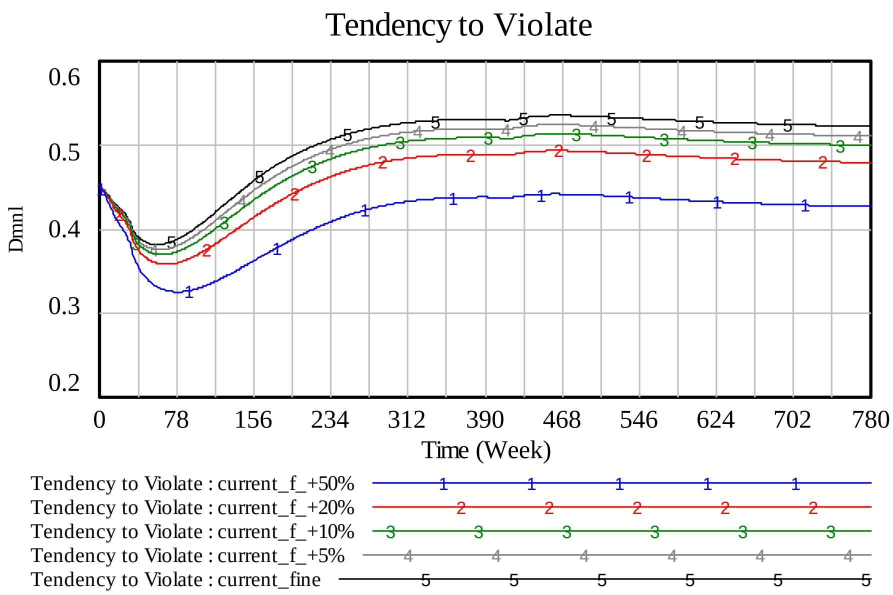


(d): **Enforcement coverage** trend under different values of **fine** (Reduction in the value of fine could increase **enforcement coverage** growth pattern)

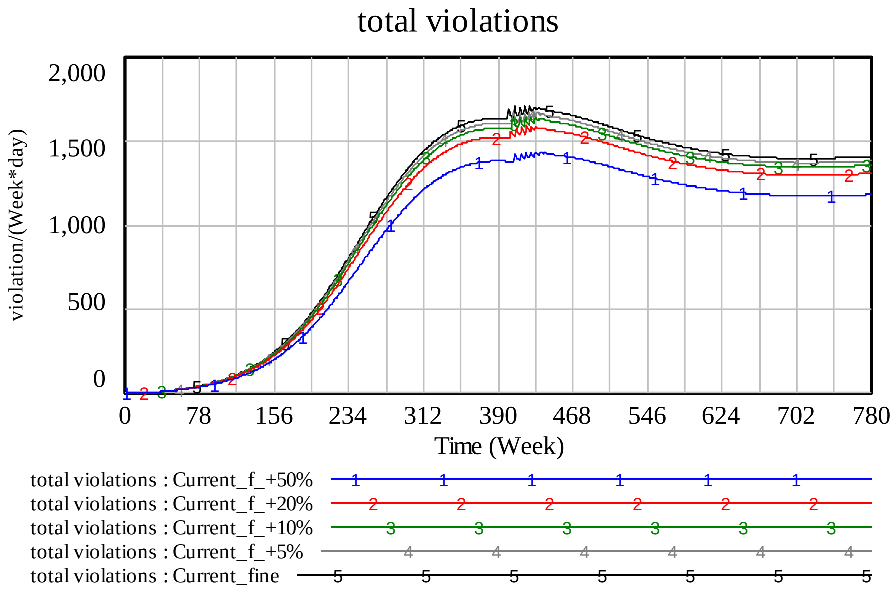
Figure 10.34: Sensitivity to lower fine at 0% 5%, 10%, 20%, and 50% less than N3000



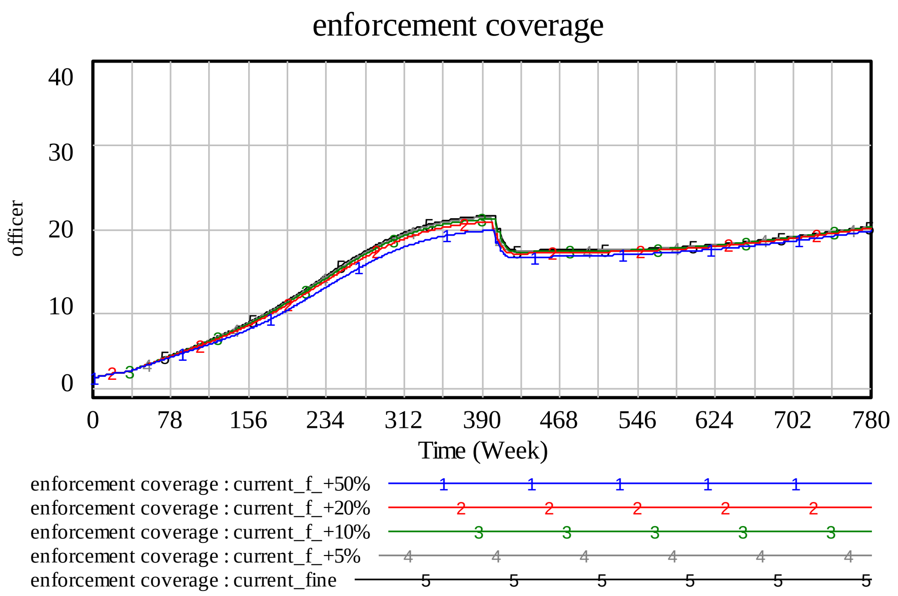
(a): **Total drivers'** population under different values of **fine** (Increasing the value of **fine** does not affect **total drivers**' growth pattern)



(b): Trend of **tendency to violate** under different values of **fine** (Increasing the value of **fine** reduces drivers' **tendency to violate)**

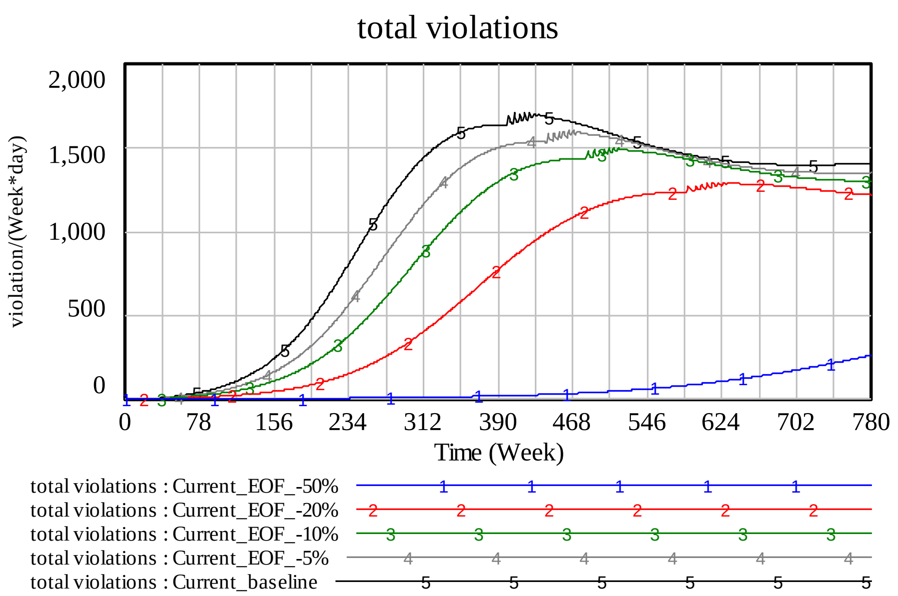


(c): **Total violations** trend under different values of **fine** (Increasing the value of fine reduces **total violations committed by** drivers

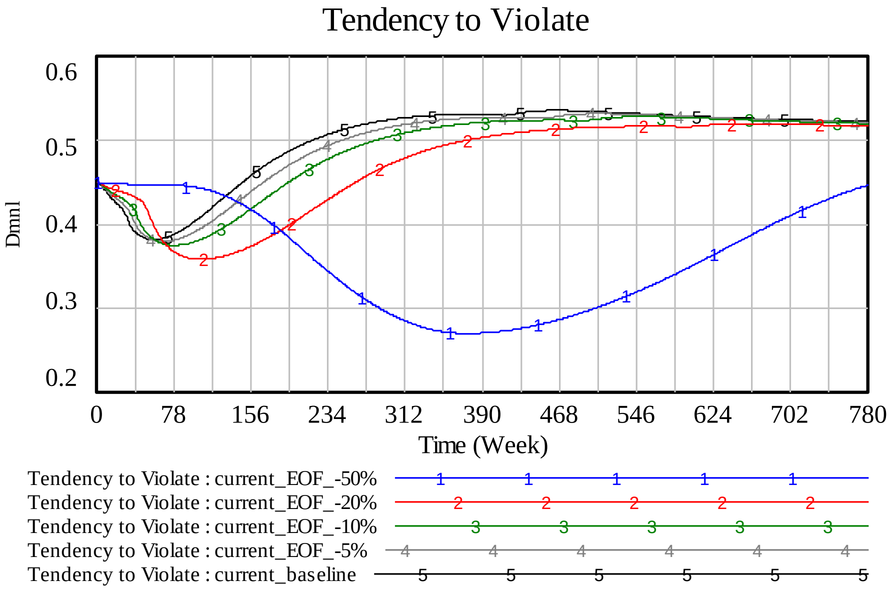


(d): **Enforcement coverage** trend under different values of **fine** (Reduction in the value of fine could increase **enforcement coverage** required)

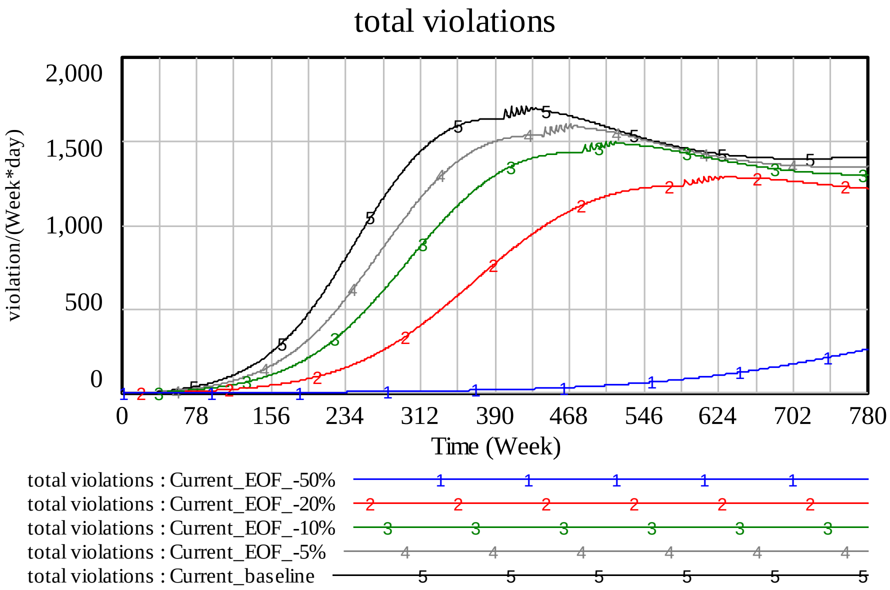
Figure 10.35: Sensitivity test for higher fine at 0% 5%, 10%, 20%, and 50% more than N3000



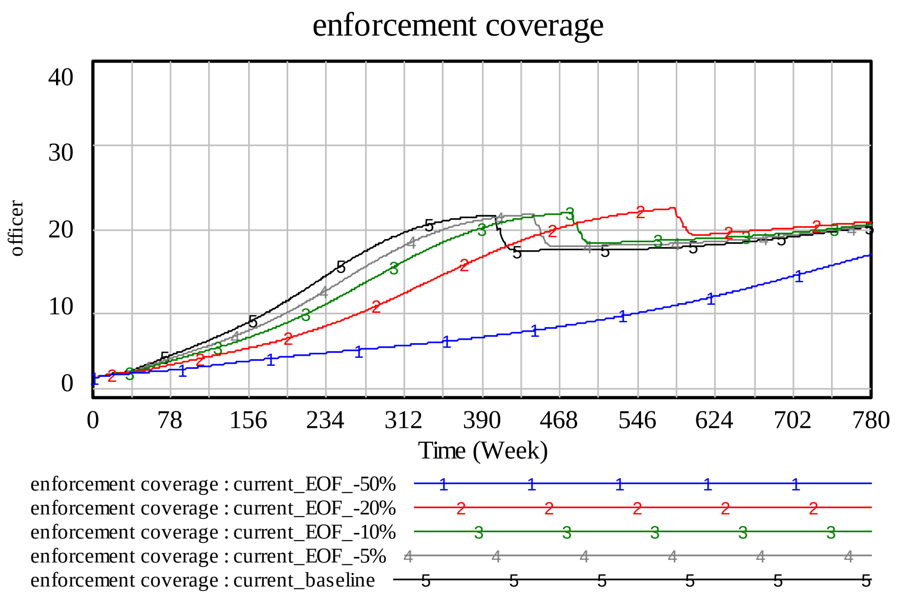
(a): **Total drivers'** population under different values of **expensive option fraction** (The graph shows that this parameter affects drivers' population in the system at any time)



(b): Trend of **tendency to violate** under different values of **expensive option fraction** (The similar trend of drivers' **tendency to violate** is observable with the time and intensity of initial dip farther and deeper as **expensive option fraction** reduces)



(c): **Total violations** trend under different values of **expensive option fraction** (How many violations are committed is related to drivers' population and might be related to **expensive option fraction** too)

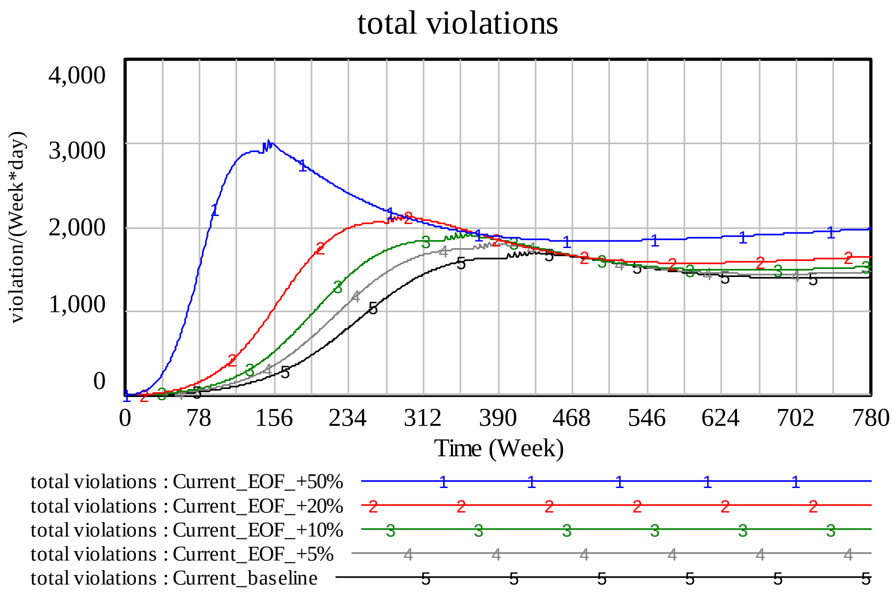


(d): **Enforcement coverage** trend under different values of **expensive option fraction** (Reduction in **expensive option fraction** tend to delay requirement for **enforcement coverage**)

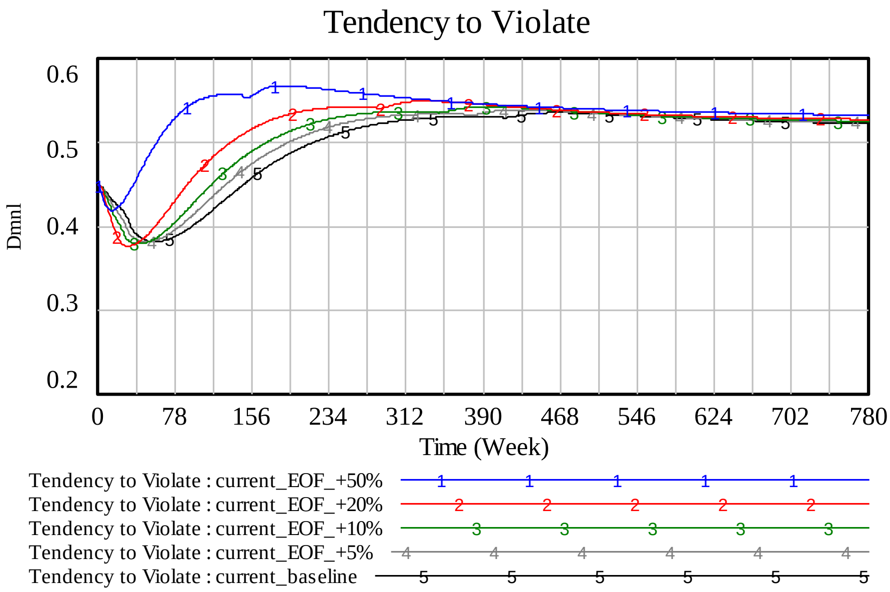
Figure 10.36: Sensitivity test for lower expensive option fraction at 5%, 10% 20%, and 50% below the 0.5 index

10.9.6.2 Sensitivity of the parameter: expensive option fraction

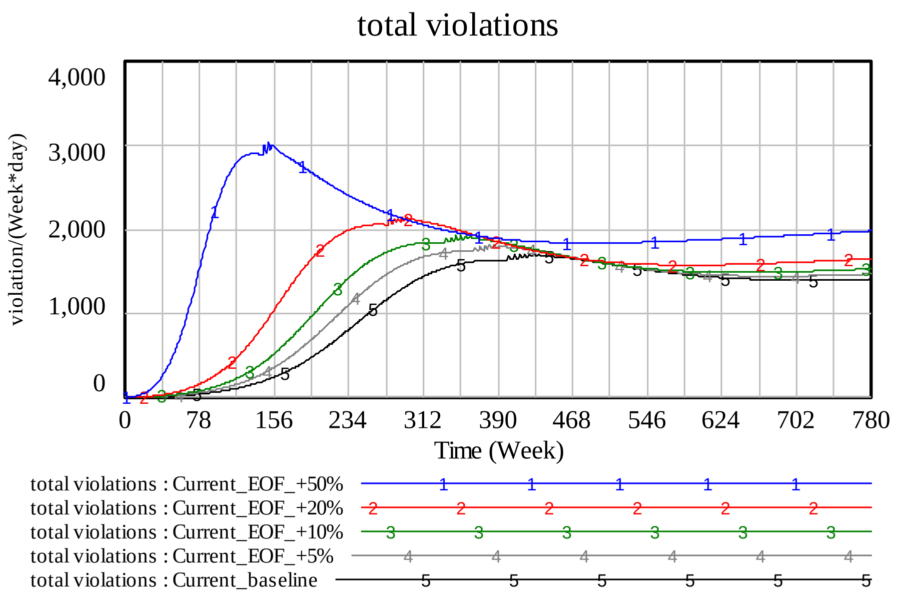
Figures 10.36 and 10.37 indicate the sensitivity of the parameter **expensive option fraction** to the model. The **expensive option fraction** is the parameter that determines the number of drivers who acquire their motorcycles by hire-purchase or rent. This result indicates that this parameter is very important in the model. This is because it is tied to drivers' population which affects everything else in the system. It shows that the pattern of development of variables' trend is similar for higher or lower value of **expensive option fraction**. Lower values however delay the development of these patterns for the variables. It also limits the maximum number of **total violations** attainable but increases the **enforcement capacity** required to combat it. The reverse happens for higher values of **expensive option fraction**. Moreover, graphs of **enforcement coverage** indicate that the earlier the enforcement system intervenes, the less **enforcement coverage** is required to restore the system. This agrees with *The Rapid Response to 911* which is one of the eight major hypotheses about policing and crime:, described by Sherman et al. (2003, p.227). Finally, these results also show that the correct value of the parameter is essential to model calibration.



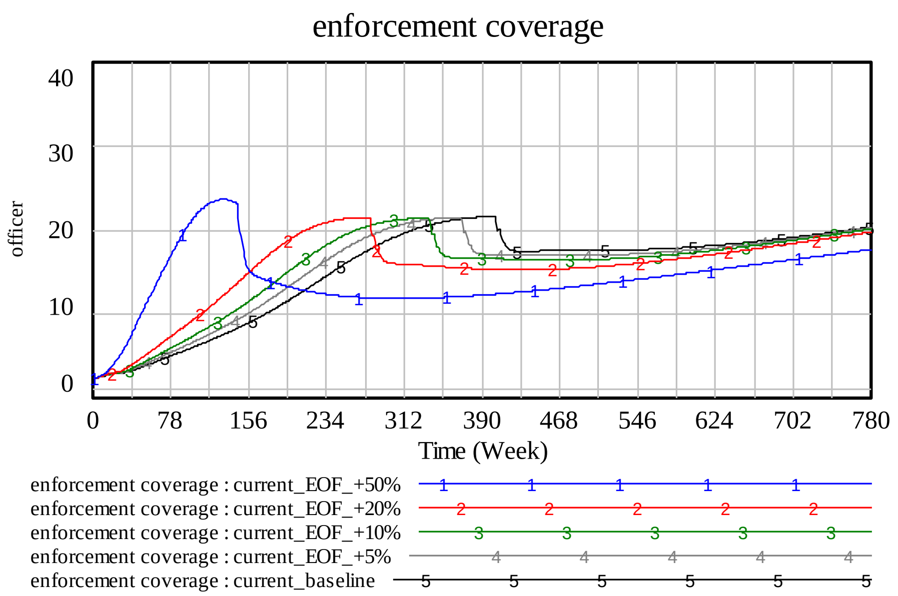
(a): **Total drivers'** population under increasing values **expensive ownership fraction** (The parameter affects drivers' population in the system at any time)



(b): Trend of **tendency to violate** under different values of **expensive option fraction** (Higher values of **expensive option fraction** would make drivers' **tendency to violate** worse)



(c): **Total violations** trend under different values of **expensive option fraction** (Highest number of violations is more quickly attained as **expensive option fraction** value increases)

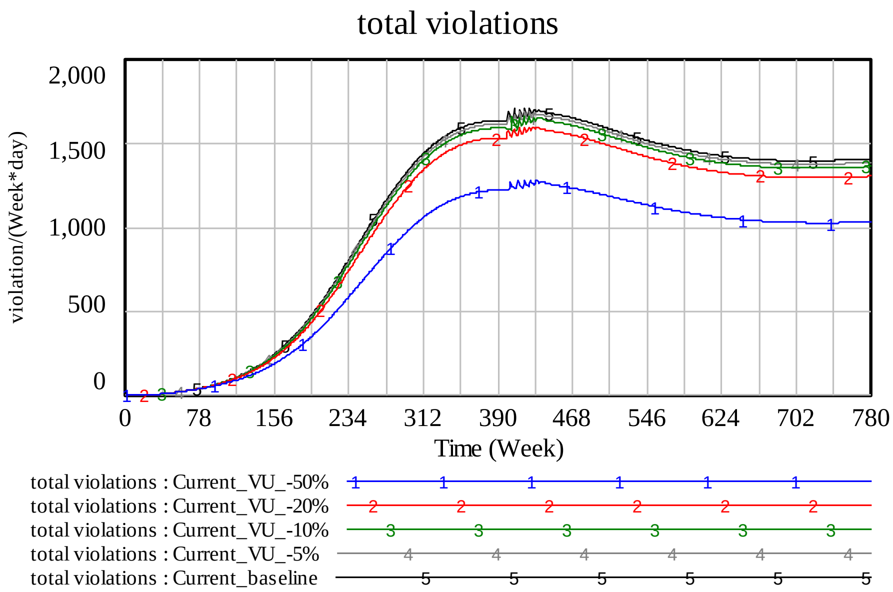


(d): **Enforcement coverage** trend under increasing values of **expensive option fraction** (Higher **expensive option fraction** tend to necessitate earlier requirement for increased **enforcement coverage)**

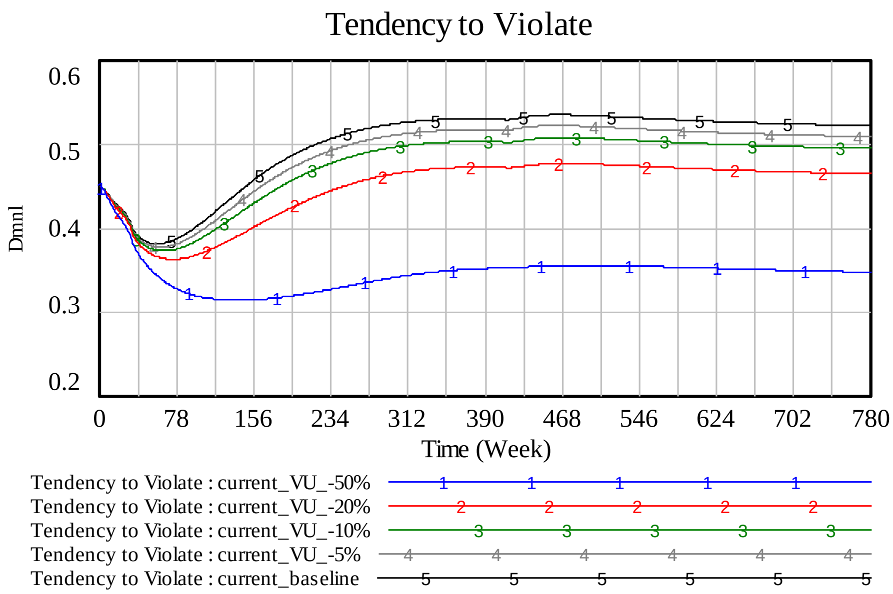
Figure 10.37:Sensitivity test for higher expensive option fraction at 5% 10%, 20%, and 50% higher than the 0.5 index

10.9.6.3 Sensitivity of the parameter: violation utility

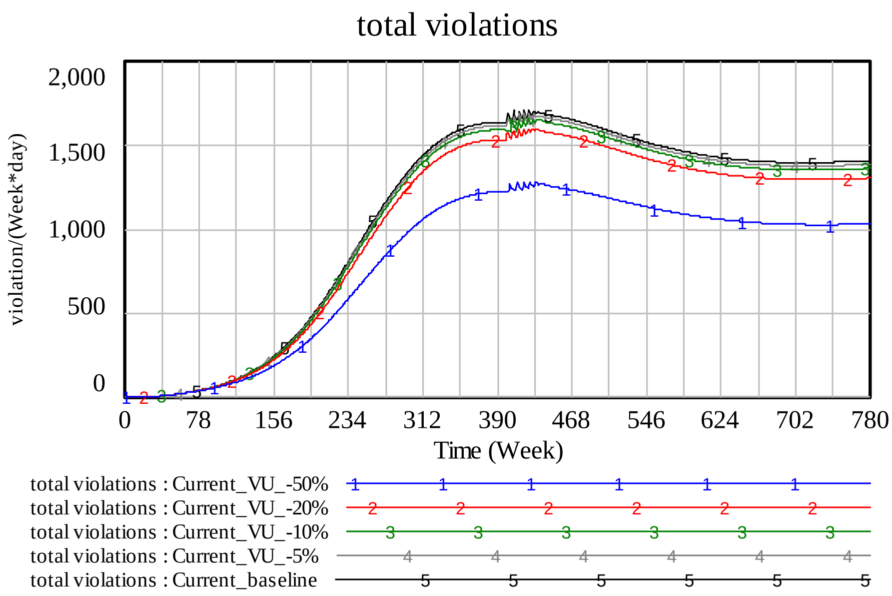
Similarly, figures 10.38 and 10.39 show the sensitivity analysis for the parameter **violation utility**. This analysis shows that the model is more sensitive to lower values of **violation utility** and less sensitive to higher values for the range considered here. This agrees with what could be expected in the real system.



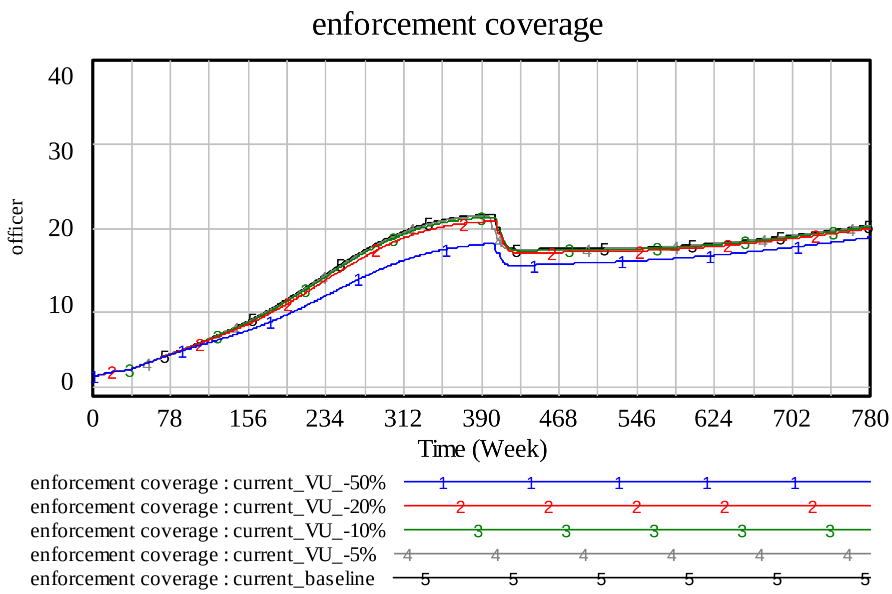
(a): **Total drivers'** population under reducing values **violation utility** (This parameter does not affect drivers' population)



(b): Trend of **tendency to violate** under different values of **violation utility** (Reduction in **violation utility** reduces drivers' **tendency to violate)**

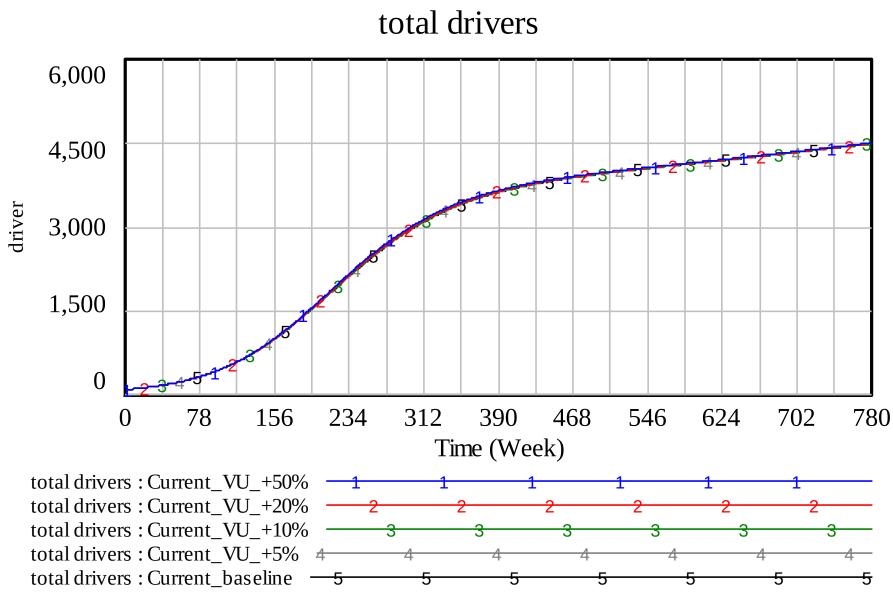


(c): **Total violations** trend under different values of **violation utility** (Lower **violation utility** shows lower **total violations**)

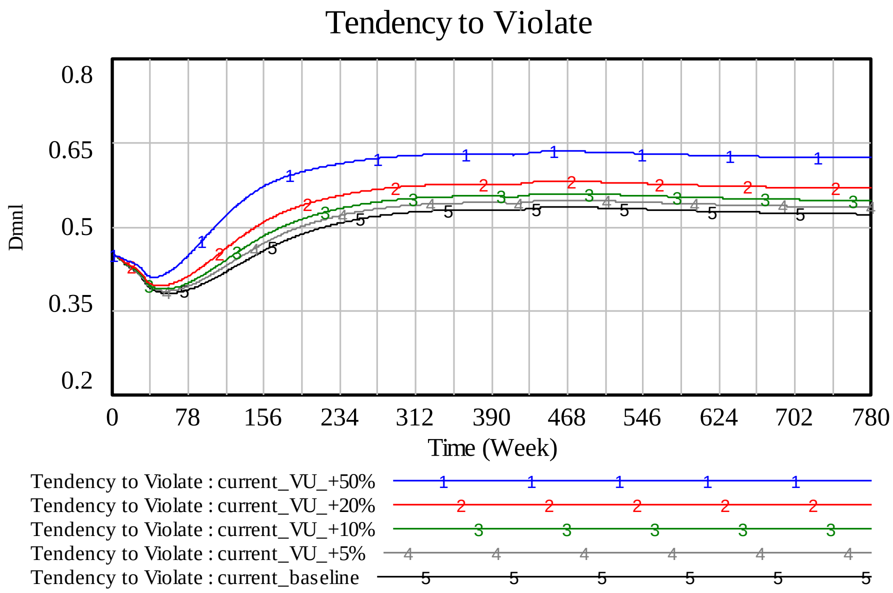


(d): **Enforcement coverage** trend under different values of **violation utility** (Reduction in **violation utility** can reduce the requirement for **enforcement coverage)**

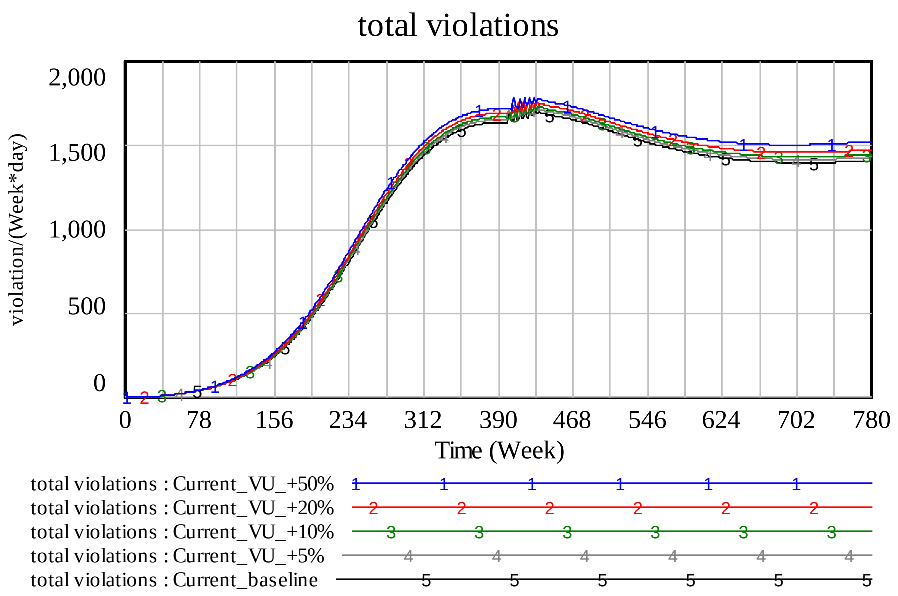
Figure 10.38: Sensitivity test for lower violation utility at 5% 10%, 20%, and 50% less than N140



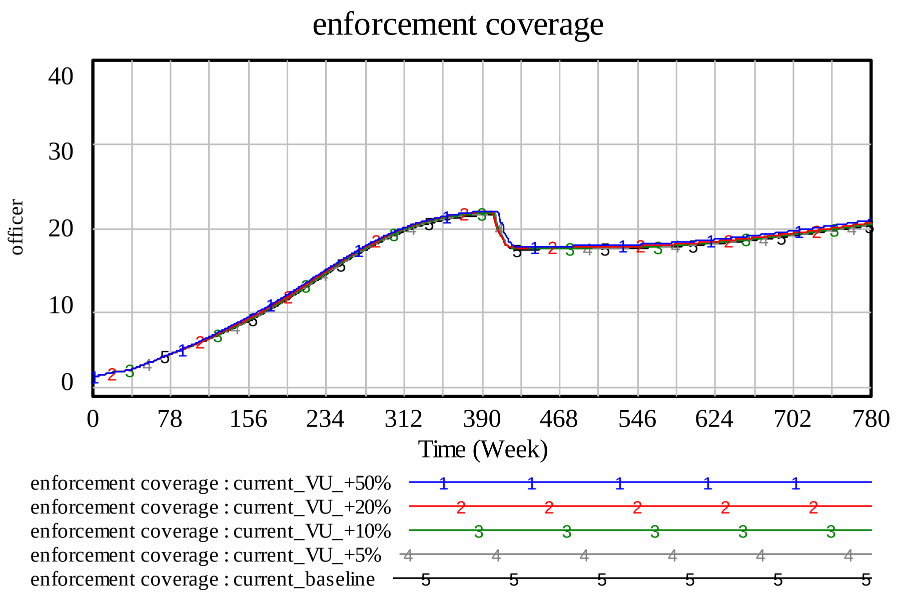
(a): **Total drivers**' population under increasing values **violation utility** (This parameter has no effect on drivers' population)



(b): Trend of **tendency to violate** under higher **violation utility** (Increasing value of **violation utility** increases drivers' **tendency to violate)**



(c): **Total violations** trend under higher values of **violation utility** (Higher **violation utility** does not significantly increase **total violations**)

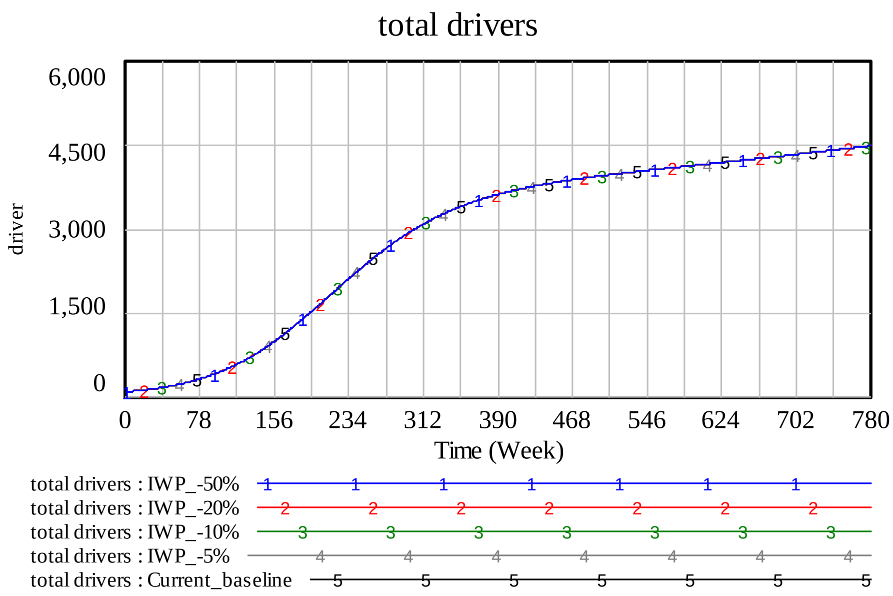


(d): **Enforcement coverage** trend under higher values of **violation utility** (Higher **violation utility** values do not seem to affect **enforcement coverage**)

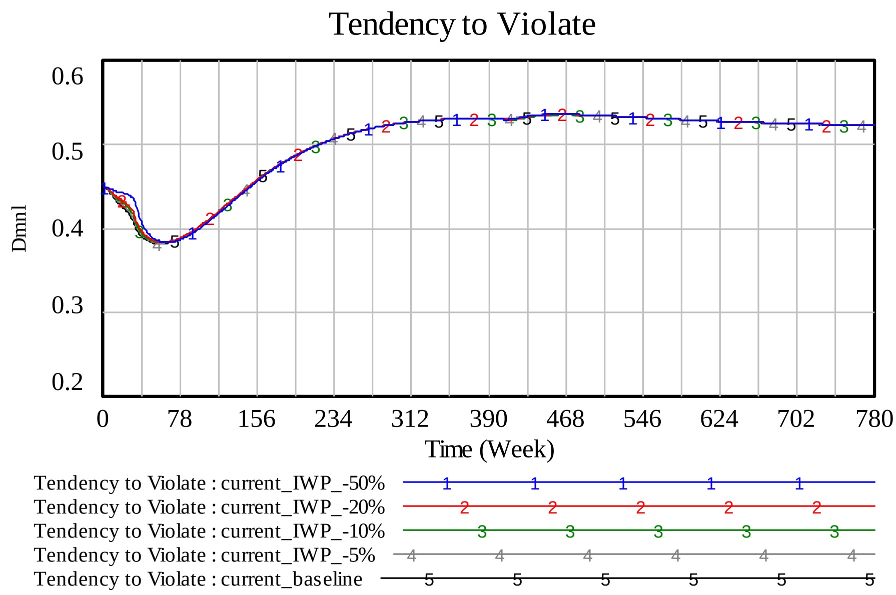
Figure 10.39: Sensitivity test for higher violation utility at 5% 10%, 20%, and 50% more than N140

10.9.6.4 Sensitivity of the parameter: initial working period

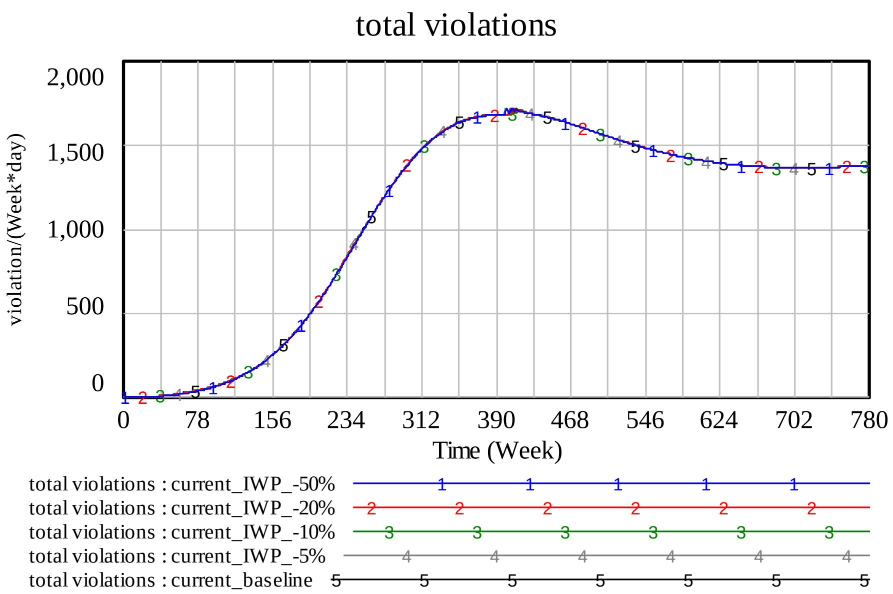
Sensitivity analysis was conducted for **initial working period** (IWP). This is shown in figure 10.40. The analysis shows that changes between three hours and six hours (six hours= IWP) do not affect the model behaviour. This shows that this parameter is not one of the major factors of influence to model behaviour.



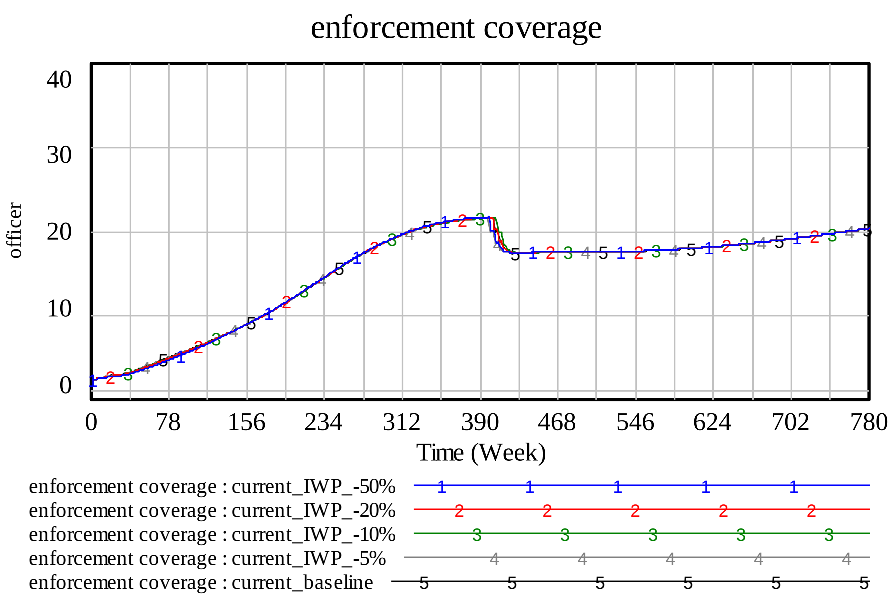
(a): **Total drivers**' population under different values of **initial working period** (This parameter has no effect on drivers' population)



(b): Trend of **tendency to violate** under different values of **initial working period**



(c): **Total violations** trend under different values of **initial working condition**

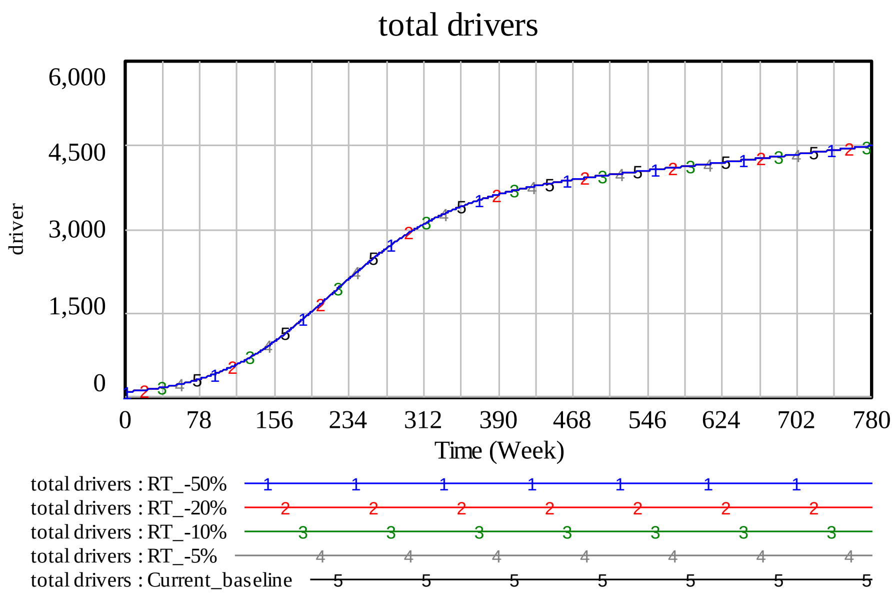


(d): **Enforcement coverage** trend under different values of **initial working period**

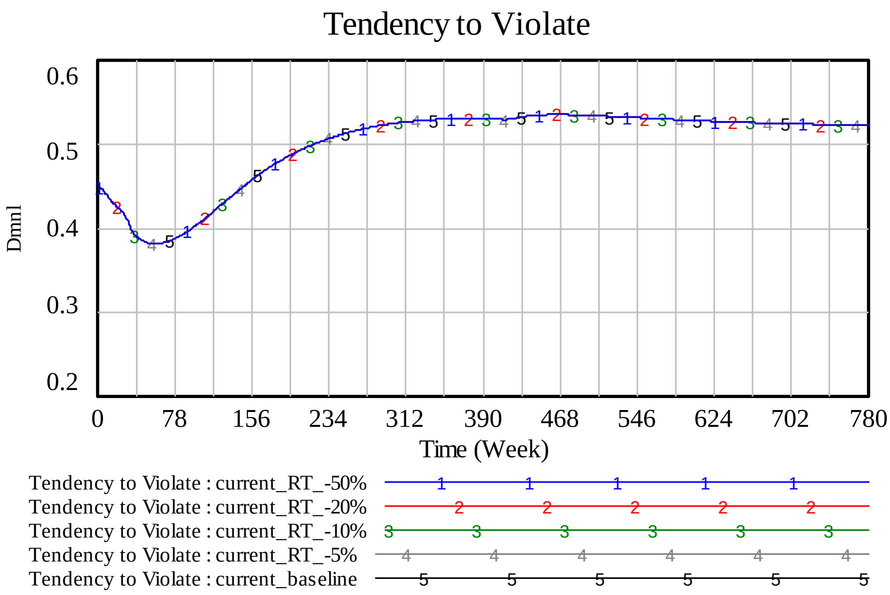
Figure 10.40: Sensitivity to lower initial working period at at 5% 10%, 20%, and 50% less than 6hours baseline

10.9.6.5 Sensitivity of the parameter: rehab time

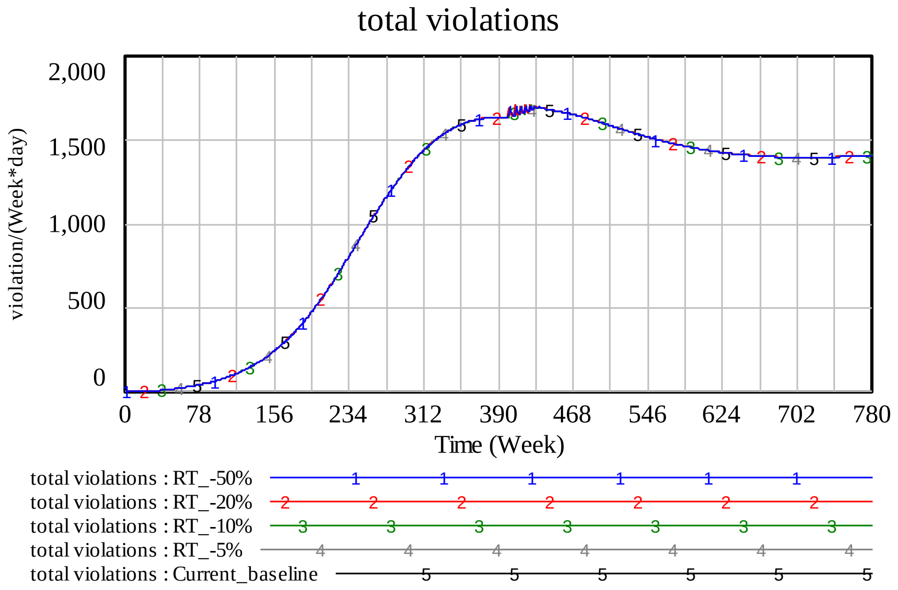
The sensitivity analysis for **rehab time span** is varied by up to 50% of its value. This is shown in figure 41. The result shows that this parameter does not affect the model behaviour noticeably based on the selected system variables. This shows that the parameter is not of a major importance to model behaviour.



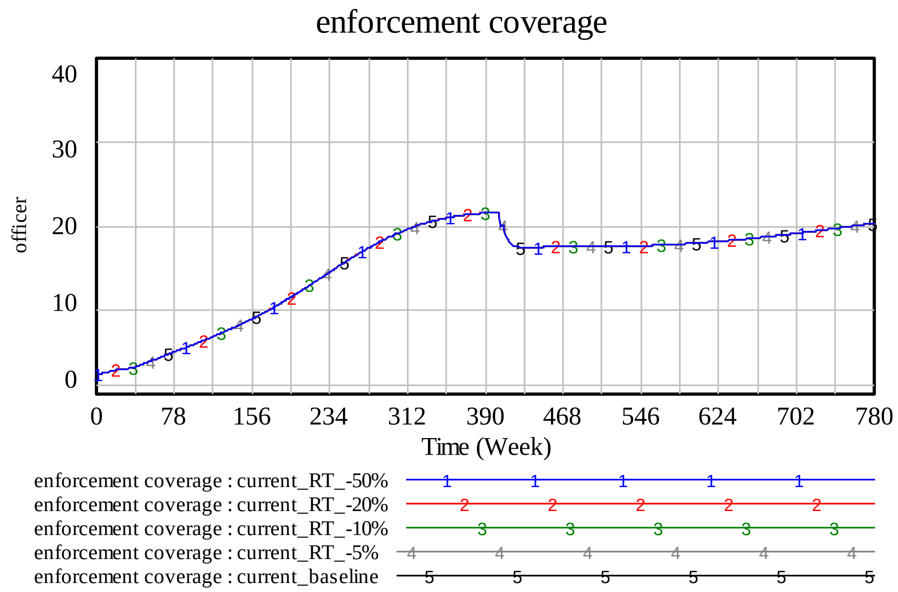
(a): **Total drivers**' population under different values of **rehab time** (This parameter has no effect on drivers' population)



(b): Trend of **tendency to violate** under different values of **rehab time**



(c): **Total violations** trend under different values of **rehab time**

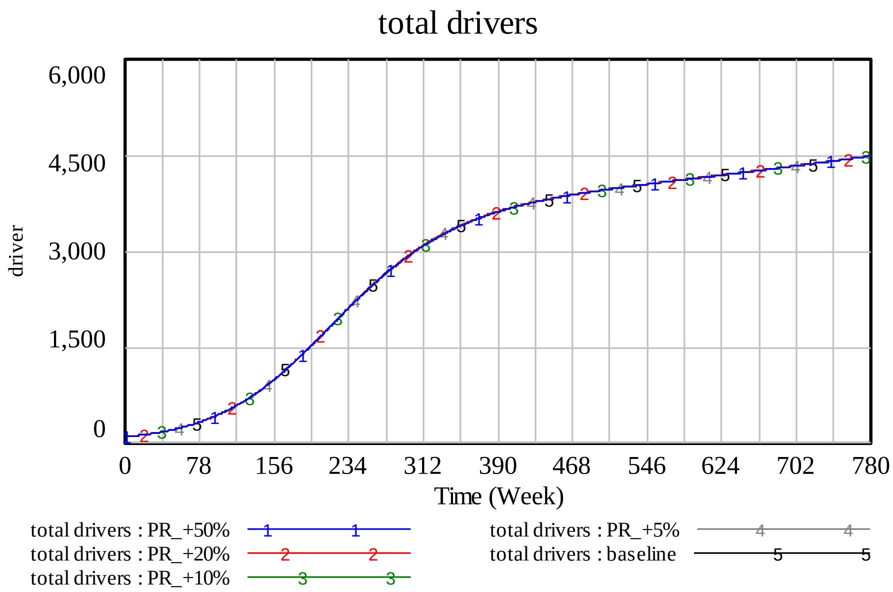


(d): **Enforcement coverage** trend under different values of **rehab time**

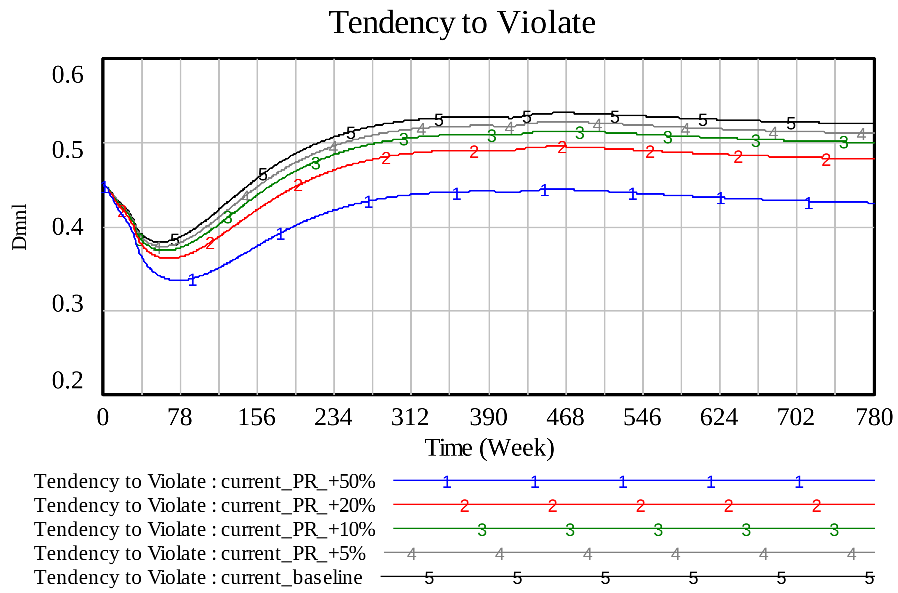
Figure 10.41: Sensitivity analysis for lower rehab time at at 5% 10%, 20%, and 50% less than 156 weeks baseline

10.9.6.6 Sensitivity of the parameter: prosecution rate

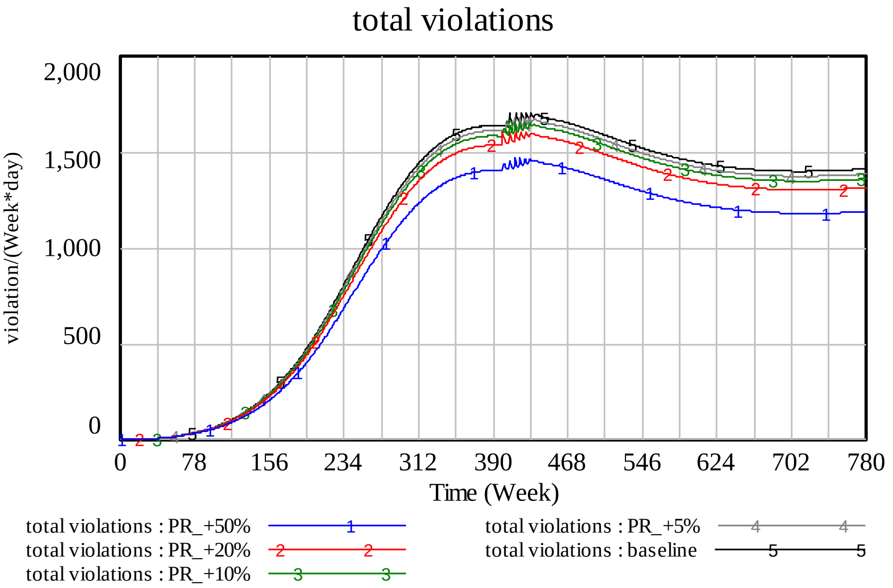
The sensitivity analyses for **prosecution rate** are shown in figures 10.42 and 10.43. It is shown that with about the same level of **enforcement coverage**, different impact can be made on the level of violations and driver behaviour by varying **prosecution rate**. This agrees with intuition and what can be expected in the real system.



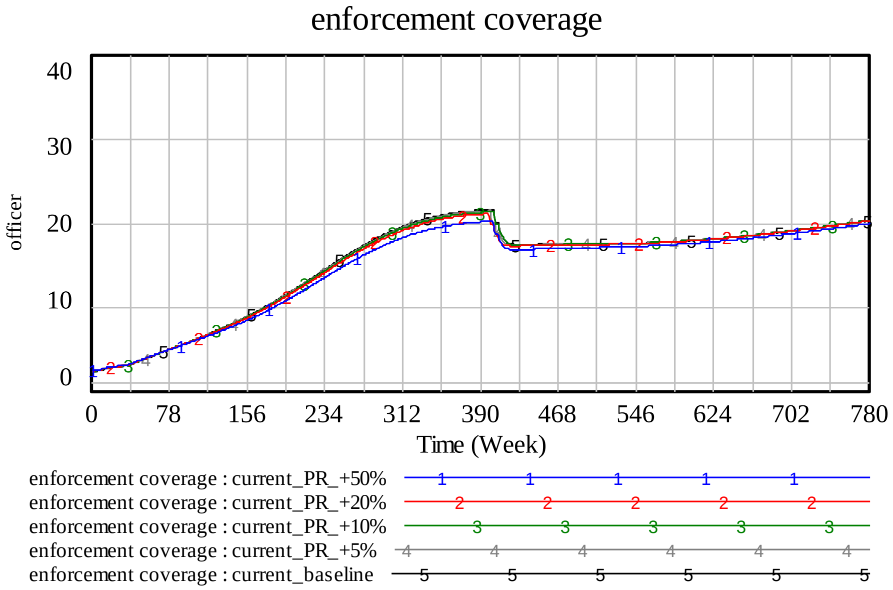
(a): **Total drivers**' population under increasing values of **prosecution rate** (This parameter has no effect on drivers' population)



(b): Trend of **tendency to violate** under different values of **fine** (Increasing prosecution rate reduces drivers' **tendency to violate)**

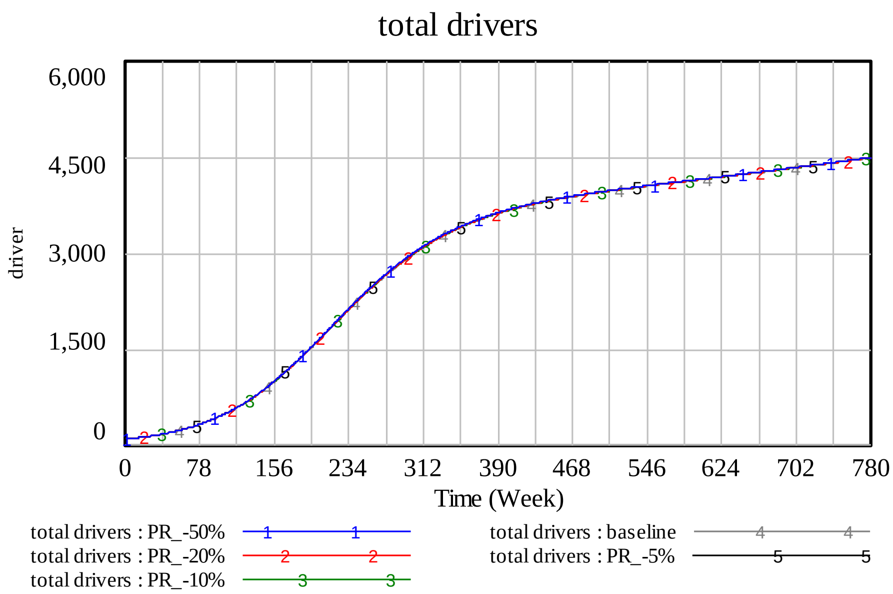


(c): **Total violations** trend under different values of **prosecution rate** (Marginal difference in **prosecution rate** does not make much difference in **total violations**)

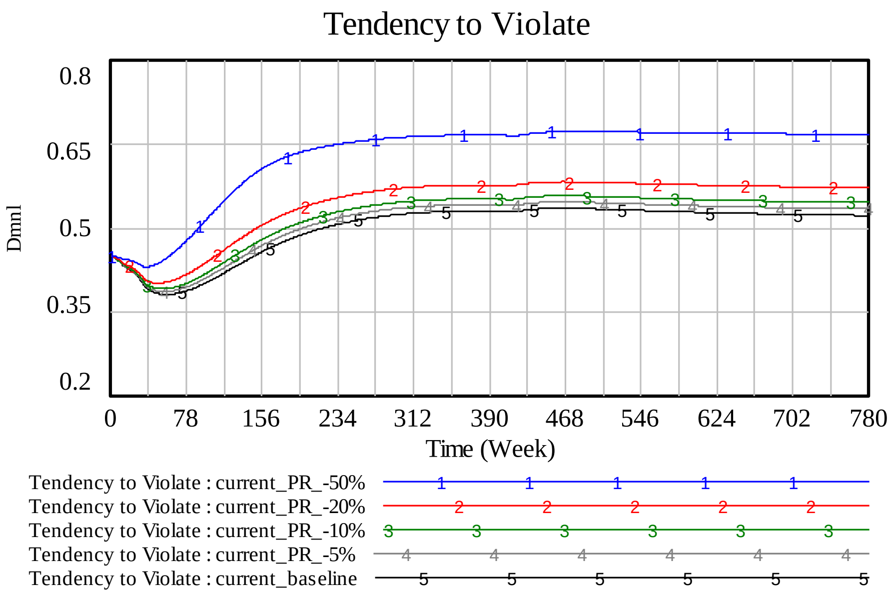


(d): **Enforcement coverage** trend under different values of **prosecution rate**

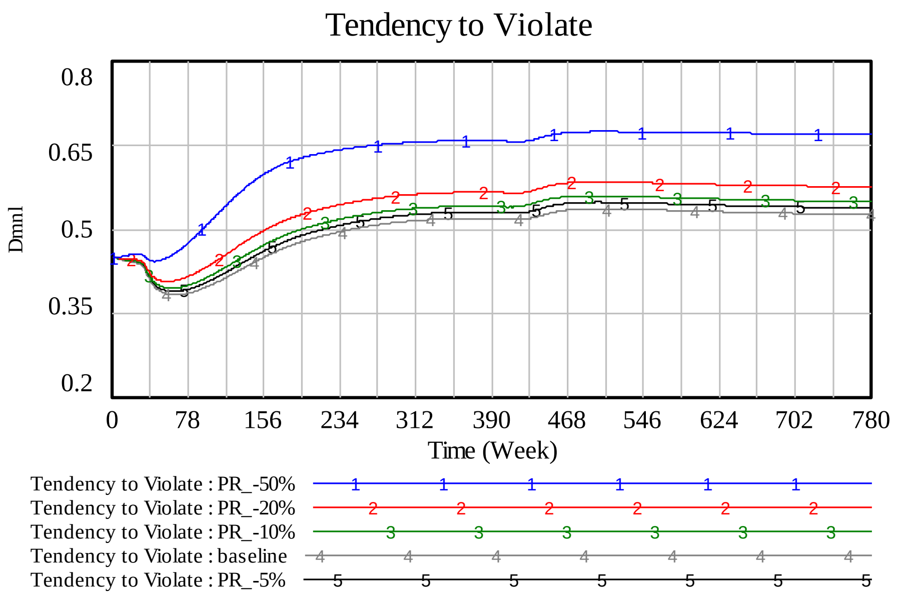
Figure 10.42: Sensitivity test for higher prosecution rate at 5% 10%, 20%, and 50% more than the 27.5% baseline



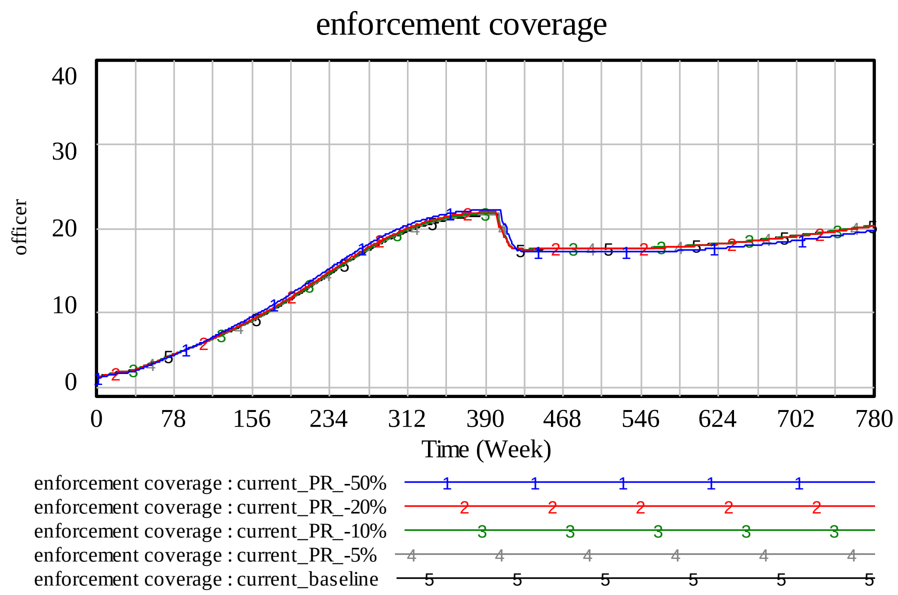
(a): **Total drivers**' population under reducing values of **prosecution rate** (This parameter has no effect on drivers' population)



(b): Trend of **tendency to violate** under different values of **prosecution rate** (Reduction in prosecution rate increases drivers' **tendency to violate**)



(c): **Total violations** trend under lower values of **prosecution rate** (Lower **prosecution rate** can increase the number of violations)



(d): **Enforcement coverage** trend under lower values of **prosecution rate**

Figure 10.43: Sensitivity test for lower prosecution rate at 5% 10%, 20%, and 50% less than 27.5% baseline

10.9.7 Behaviour replication test

A challenge with the model calibration is the availability of data. Nevertheless, both the available qualitative data obtained and secondary data helped to undertake this calibration process. The following parameters are considered for comparing model outcome with data used in the calibration process:

1. Tendency to violate
2. Total drivers
3. Drivers groups
4. Drivers' income

Tendency to violate

Figure 10.44 below compares the trend of **tendency to violate** for both the simulated and the observed trend. Though the simulated graph shows an initial dip before rising which is not in the chosen reference mode, it might not be wrong: since commercial motorcycle trade started well as indicated earlier it is possible that driver behaviour initially improved before growing population changed drivers' attitude. In addition, it should be noted that the intension is to generate a trend that might be similar to what is obtainable in the study location since the actual condition is not exactly known. This simulated outcome is therefore considered a satisfactory outcome.

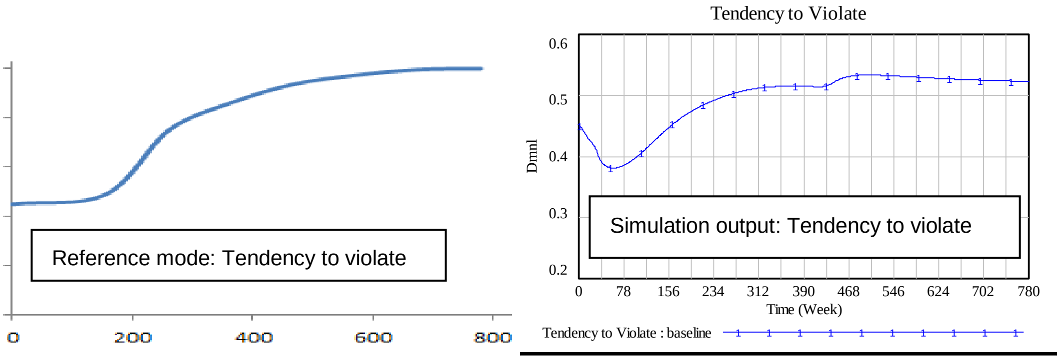


Figure 10.44: Comparison of reference and simulated trends: tendency to violate

Total driver

The data for the total population of drivers compares well with total drivers obtained from the model as shown in figure 10.45 below. The simulated output shows that the population of the drivers is increasing steadily after the initial sharp rise. This output reflects the pattern of growth obtained during the data collection phase. In addition, it shows the population of drivers to be about 100 in the model start year, about 1895 by the fourth year and 4494 in the 15th year. While this is slight below the data value, it still shows the trend of drivers' population growth.

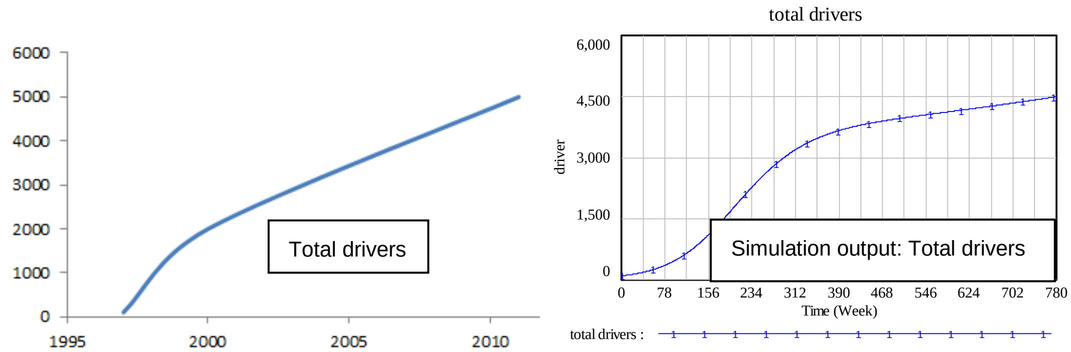


Figure 10.45: Comparison of reference and simulated trends: total drivers

Drivers' groups

In addition, the share of different drivers' groups is similar to what is found in literature. As shown in figure 10.46, the ratio of **new entrant drivers** to **ambivalent drivers** to **established drivers** is 11.34: 51.52: 37.14. **New entrant drivers** are drivers under one year old in the trade. **Ambivalent drivers** are those within the age of over one year to six years while **established drivers** are those who are more than six years old. The model outcome compares with Arosanyin et al. (2013) who found the ratio as 14.4: 66: 18 and Ogunmodede et al. (2012) who found it to be 25% for one to two years old drivers, 43% for drivers between three and five years, and 31% for drivers more than six years old in the trade. Moreover, the average driver's experience in the year 2011 in this model is 4.17 years which is similar to the range found in the literature (Arosanyin et al. 2011 found it to be 4.25 years).

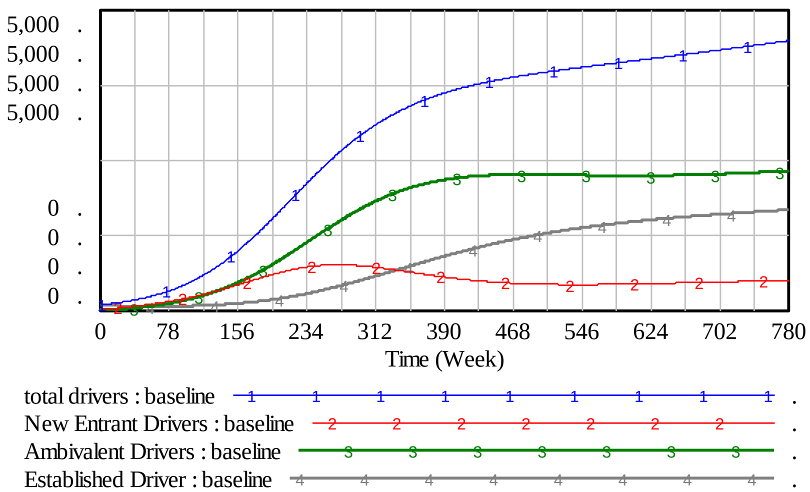


Figure 10.46: Comparison of reference and simulated ratio: Total drivers and the three drivers' groups

Drivers’ income

The income of drivers is represented by **driver’s income**. This parameter excludes the cost of fuelling the motorcycle for daily operation. **Actual income** is **drivers’ income** less the amount of money paid to enforcers due to committing a violation. Both **driver’s income** and **actual income** are shown below in figure 10.47.

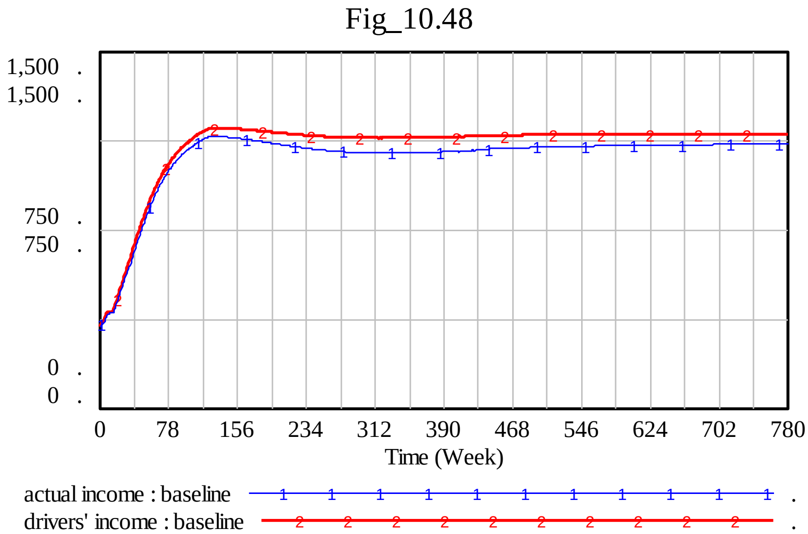


Figure 10.47: Comparison of reference and simulated values: Drivers' income and actual income

The value adopted for this model is based on the literature which shows that drivers were making about N1000 to N1200 around the year 2008 to 2010 (Mahlstein, 2009; Arosanyin et al., 2011). A comparison between **drivers’ income** and **actual income** shows that what individual drivers pay for violation committed is very negligible. This was found in an informal survey conducted with the drivers.

10.9.8 Extreme condition test

Extreme conditions test enhances model validity by analysing model behaviour beyond the initial boundary. This test shows that the equations in the model still make sense even when they take extreme values. Two of the extreme conditions tested for are:

1. No expensive motorcycle-acquisition option as well as abnormally high share of those adopting expensive option.
2. No prosecution of violators as well as full (100%) prosecution of violators

These graphs are shown below:

1. **No expensive motorcycle-acquisition option as well as abnormally high share of those adopting expensive option**

Figure 10.48 shows what the trend of driver behaviour would have been if there were no expensive ownership options at any time in the system. The figure shows that driver behaviour prior to the emergence of the trade would not initially change significantly for some time. It however later changed as the difference between the cost of violation and the benefit from violation widened (see figure A3.2 in Appendix 3). The increased cost of violation led to a positive change in drivers' behaviour with **tendency to violate** reducing to 0.2 from 0.45. It is also important to note that the model shows that the trade would remain largely a business for owners of motorcycles: the total number of drivers would only rise to 970 drivers from 100 initial population as against the current 4494 drivers after 15 years.

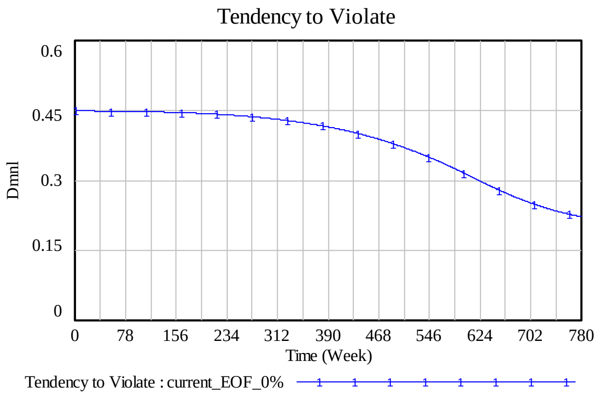


Figure 10.48: Extreme condition test: tendency to violate when there is no expensive ownership options

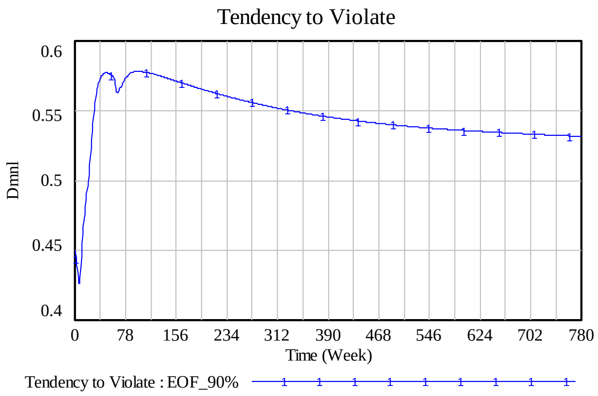


Figure 10.49: Extreme condition test: tendency to violate when drivers on expensive ownership options are 90% of newly joining drivers

In figure 10.49, the case for a situation where drivers who join commercial motorcycle trade through expensive ownership options were 90% of all new drivers is presented. It shows that the variable, **tendency to violate** would have risen earlier and quickly (figure 10.49), though would fall due to rapid and increased enforcement (see enforcement coverage response in figure A3.3 in Appendix 3). It also shows that drivers population increase would have been more rapid, reaching 3807 within the first four years (unlike 1895 drivers in the baseline model output) and 5178 drivers at the end of the 15 years (unlike 4494 drivers in the baseline model output)..

2. No prosecution and full prosecution conditions

The graph in figure 10.50 is the condition of **tendency to violate**, if prosecution rate were to be zero. The parameter did not rise to 1 (full tendency) zero immediately since this variable is a habit that requires time to build up. Similarly, making prosecution rate 100% from the start of the simulation period does not make **tendency to violate** zero. It however shows that tendency to violate would go down from the initial value of 45% to about 30%. While this value of 30% is relatively high for full prosecution condition, it might not be strange in this model. The floating goal structure for the intervention of **enforcement capacity** which supports complacency when a success is attained might be responsible for this high value of **tendency to violate**. This full prosecution condition is shown in figure 10.51.

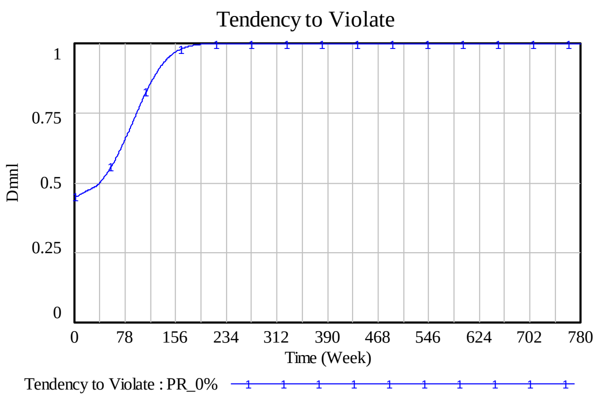


Figure 10.50:Extreme condition test: tendency to violate for prosecution rate = 0%

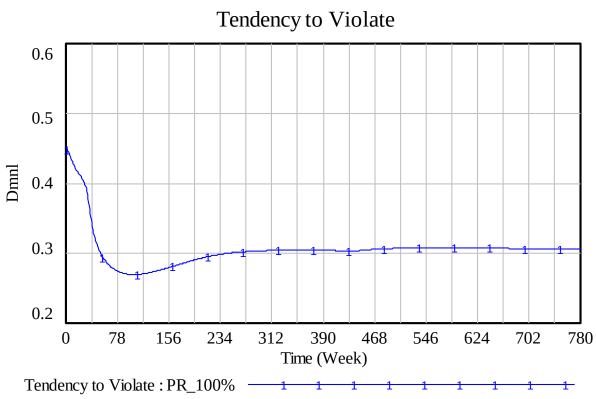


Figure 10.51: Extreme condition test: tendency to violate for prosecution rate = 100%

10.10 Model responsiveness testing

A way to further demonstrate the usefulness of the model developed is to undertake tests that check the responsiveness of its outputs to interventions. Four different parameter values are changed at the end of the simulation period (15 years) and their impact on the system, run over a period of additional 10 years (to make 25 years) is discussed. These tests include:

1. Change the assumption about expensive ownership options
2. Increase enforcement coverage by doubling recruitment rate
3. Remove the effect of competition
4. Increase prosecution rate
5. Combination of changes to ownership options and prosecution rate

First, the base line scenario is presented below in figure 10.52.

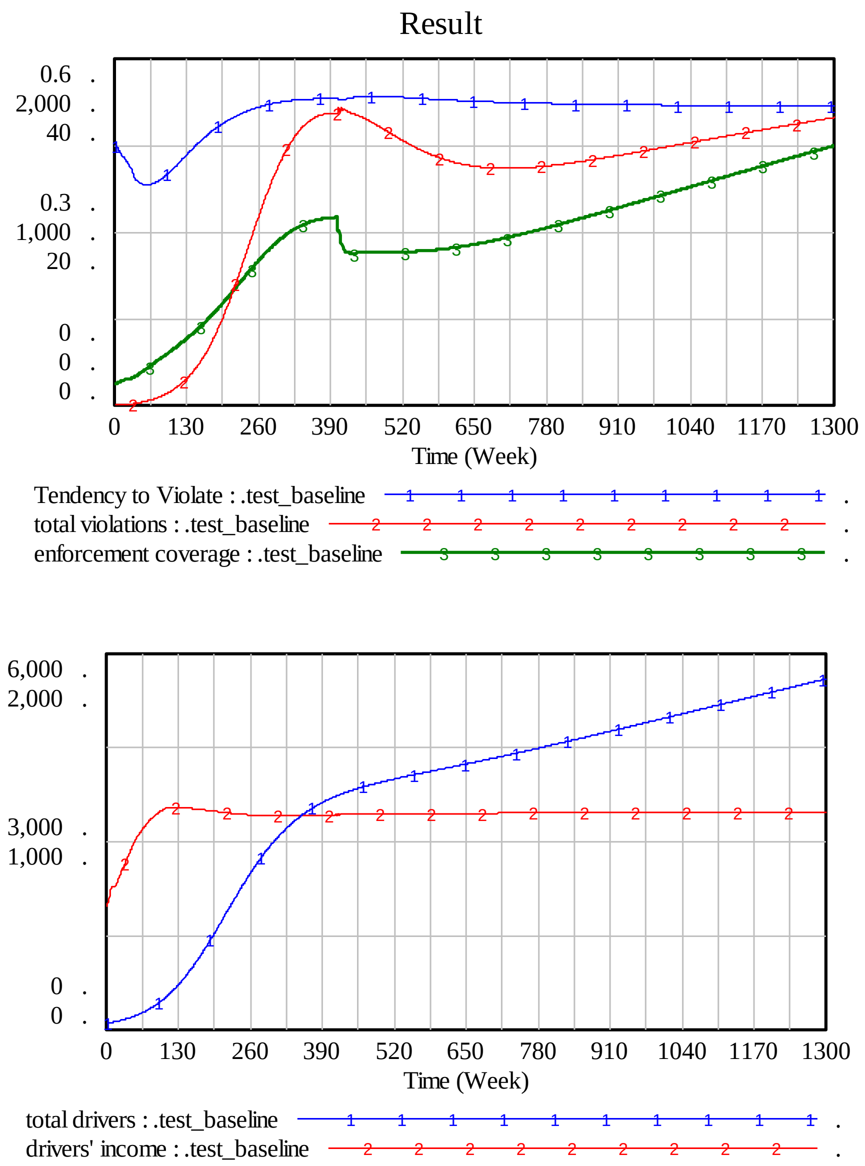


Figure 10.52: Baseline scenario for some model parameters

Figure 10.52 shows the base line scenario as obtained from the model. The blue line labelled “1” represents **tendency to violate**, the red line labelled “2” represents the **total violations** while the green line (labelled “3”) in the figure represents **enforcement coverage**. This simulation period covers 25 years: 15years into the past (between 1997 and 2011) and 10years into the future, taking the year 2011 as the reference point. The graph shows that drivers’ **tendency to violate** remains high past the first 15 ending at 0.52 unit. Similarly, the **total violations** committed in the system continue to rise after a dip that followed aggressive enforcement. **Total violations** ended at 1674 violations/week-day while **enforcement coverage** ended at 30.24 officers. The number of drivers grew to about 5598 drivers while their income ended at about NGN1507.

10.10.1 Change the assumption about expensive ownership options

This is a test to check the soundness of model behaviour 10 years into the future. It assumes that an attempt is made to stop new drivers from acquiring motorcycles by means that require expensive repayment cost when joining the trade. To test this change, the following equations were modified/ added:

First, the equation for **new entrant repayment factor** (shown in figure 10.18) is replaced by

$$NERF_t = NERR_t + EOTR \quad (81)$$

Where $NERF$ is **new entrant repayment factor**, $NERR$ is **new entrant repayment fraction**, given as 0.5, and $EOTR$ is **expensive option test for repayment**

Similarly, **expensive option fraction** in equation 10.18, is replaced by **expensive option share** and its equation is given by

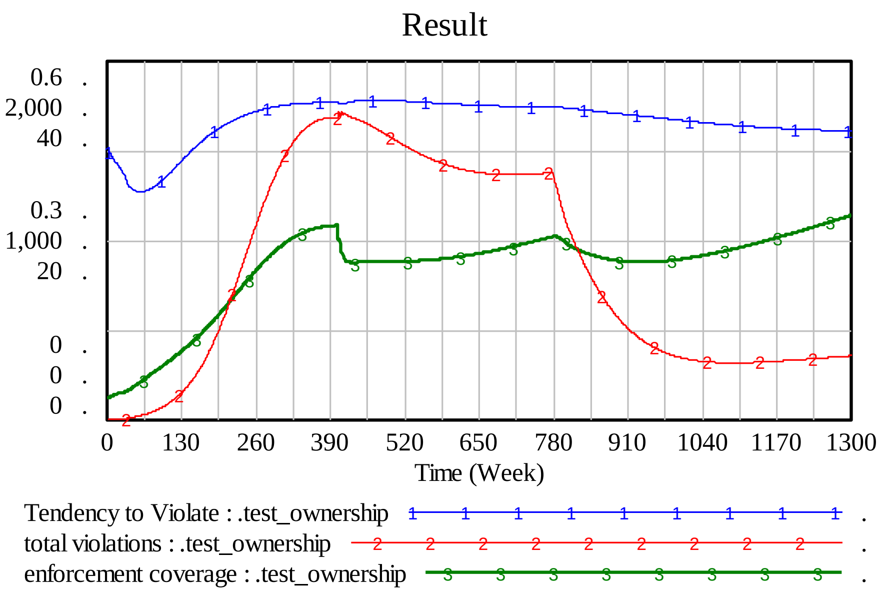
$$EOSH_t = EOF_t + PREO \quad (82)$$

where $EOSH$ is **expensive option share**, EOF **expensive option fraction**, given as 0.5, $TREO$ **test to remove expensive ownership option**. Other equations introduced are:

$$EOPR = fixed\ delay\ (-0.4, 780, 0) \quad (83)$$

$$PREO = \ ramp\ (EOPF, 780, 793) \quad (84)$$

Where $EOTF$ is **expensive option test factor** and is given the value of -0.038. What is done in this test is to smooth the implementation from week 780 to week 793 so that by week 793, no driver pays more than 10% of income on repayment for motorcycle. The effect of this test as found by the model is shown below in figure 10.53.



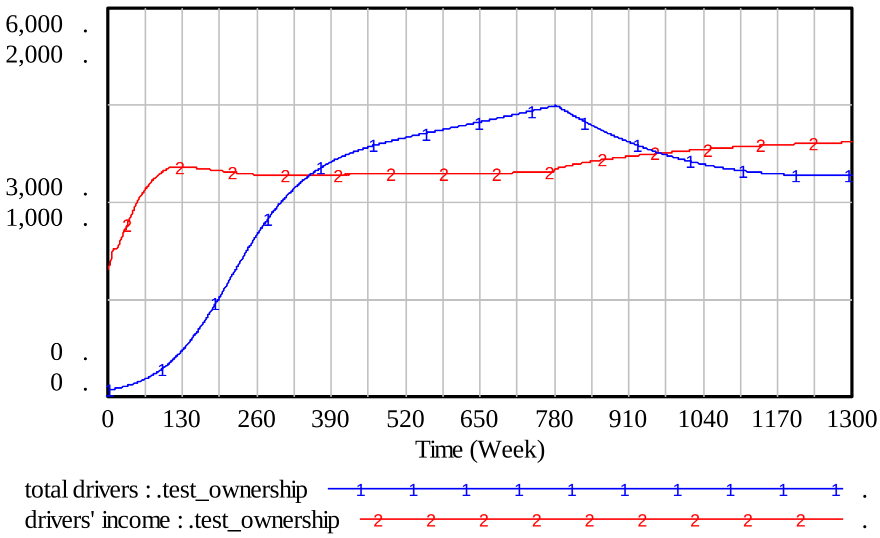


Figure 10.53: Model behaviour under a test on expensive ownership options

As shown in figure 10.53 above, **tendency to violate** fell slightly to about 0.48 in this test from 0.52 unit. The **total violations** fell significantly from its previous value of 1674 to about 352.5 violations/week-day. It however shows that **enforcement coverage** requirement later rose – with a smooth rise from about 18 to 22.69 officers. Compared with the baseline, the **enforcement coverage** is 22.69 officers (30.24 for baseline). The number of drivers under this condition fell to about 3418 drivers (5598 for baseline) while their income rose slightly from NGN1158 in the baseline condition to NGN1309. This result shows the importance of ownership characteristics in risky violations.

10.10.2 Increase enforcement coverage by doubling recruitment

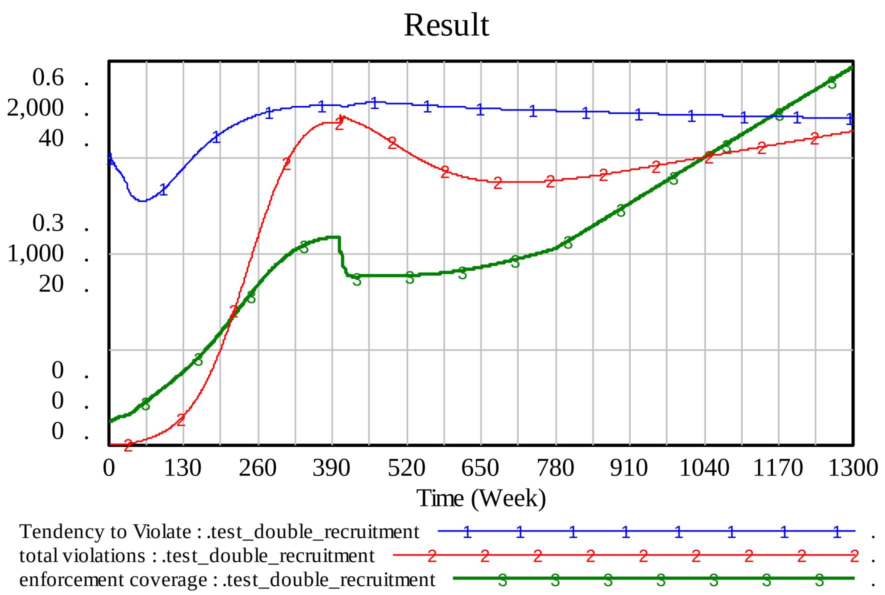
What is considered here is a test to increase the number of enforcement officers by increasing hiring rate. In this test, the hiring rate is doubled at the end of the first 15 years of the model run. To run this test, the following equations were modified/ added:

The equation for **net hire** in figure 10.6 changes to

$$NH_t = 0.0769 * (1 + PIEC_{.}) \quad (85)$$

$$TIEC_{.} = fixed\ delay\ (1, 780, 0) \quad (86)$$

Where NH is **net hire**, $TIEC$ is **test to increase enforcement coverage** The meaning of the equations above is that hiring rate of officers is double immediately at the end of week 780. The outcome of the simulation run is shown below in figure 10.54. In the figure, increasing the hiring rate of enforcement workforce raise the **enforcement coverage** from about 20 to 40 officers. However, this increase does not improve **tendency to violate** or the **total violations** significantly when compare with the baseline graph (figure 10.52).



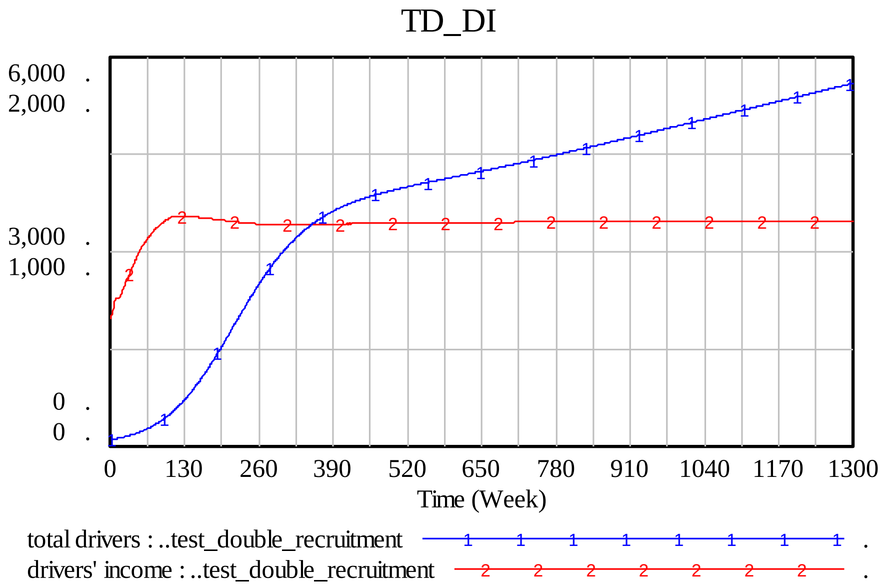


Figure 10.54: Model behaviour under a test to increase enforcement coverage

It shows that **tendency to violate** does not significantly change as it moves from 0.52 to 0.51 unit. Similarly, **total violations** only slightly falls from 1679 to 1649 violations/week-day. This result is at variance with Mehmood (2010) findings which shows significant improvement in rate of violation when enforcement coverage was increased. This difference is accounted for by the corrupt practices of the officers that make deterrence ineffective. Anbarci et al. (2006) observe that the presence of corruption in traffic enforcement has motivated the complete removal of officers rather than increasing their number. This result is nevertheless similar to the explanation by Chang et al. (2000) when they show that raising fines (in this case probability of apprehension)[57] could be counterproductive in deterring violations in a situation where corruption is widespread. The number of drivers under this condition rises to 5598 drivers (similar to baseline) and their income is similar to baseline too at NGN1158.

10.10.3 Remove the effect of competition

This is a test that implies that drivers' income is guaranteed and so removes all pressure from competition. To run this test, some equations are modified/ added. First, the variable, **new driver** is figure 10.17 is multiplied by the test factor, test to secure income, i.e.,

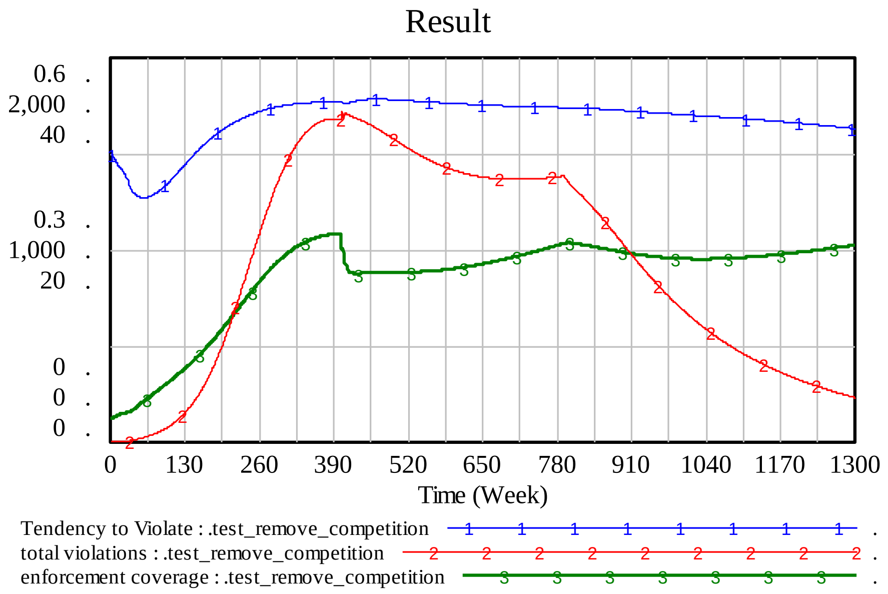
$$NDT_t = ND_t * TTSI_. \quad (87)$$

$$TTSI_. = fixed\ delay\ (0.001, 793, 1)_. \quad (88)$$

Where $NDT_.$ is **new driver** under the test, ND is **new driver** given in figure 10.17 and $TTSI$ is **test to secure income**. Similarly, the equation for **effect of competition on income** in figure 10.19 changes to

[57] Probability of apprehension relates to enforcement coverage. As shown by Polinsky and Shavell (1999), both fines and probability of apprehension are "substitutatble" in maximising "social welfare" which is the *tendency not to violate* in this model.

$$ECI_t = DPD_t * MEC * TTSI \quad (89)$$



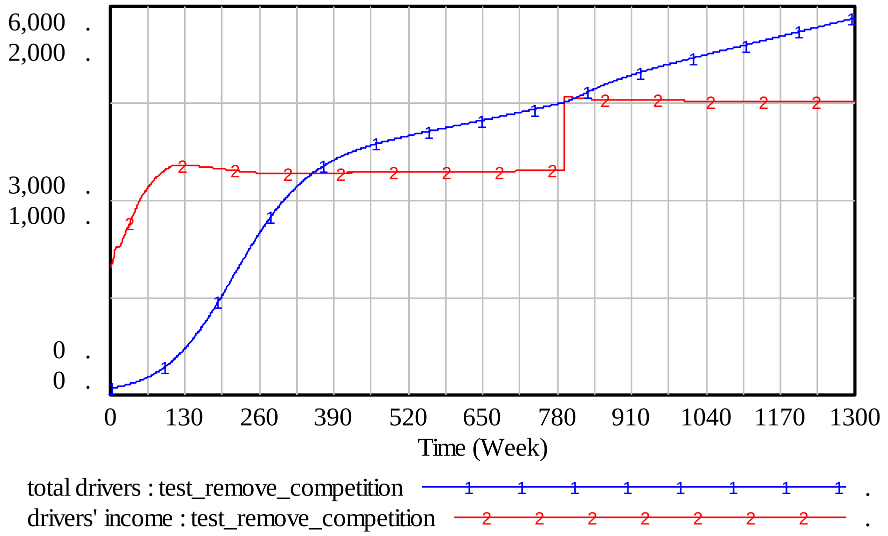


Figure 10.55: Model behaviour under a test to remove competition effect

Where ECI is **effect of competition on income**, DPD is **drivers' population density**, MEC is **max effect of competition**. The amendment to these equations is the introduction of a new factor $TTSI$ which turns the value of **effect of competition on income** to zero. The simulation output for this test is shown in figure 10.55. The figure shows that removing the effect of this parameter (ECI) would reduce the number of violations committed significantly to 236.5 from 1674 violations/week-day in the baseline case. It is also shown in this test that less **enforcement coverage** of 20.57 officers would be required compared to the baseline case of 30.2. Similarly, drivers' **tendency to violate** will come down to about 0.49 unit index from 0.52. The total number of drivers under this test is higher than the baseline case of 5598 at

5820 drivers while drivers' income is NGN1507 up from NGN1158 baseline case. This result emphasise the contribution of competition to unsafe driver behaviour.

10.10.4 Increase prosecution rate

This test assumes that corrupt practices in the enforcement process are almost removed. To run this test, the equation for **prosecution rate** in figure 10.13 changes to

$$PR = PPR + PTRP \quad (90)$$

$$PTRP = Ramp(IIR, 780, 830) \quad (91)$$

$$IIR = PRV/TOI \quad (92)$$

Where PR is **prosecution rate**, given as 0.275, PPR is **previous prosecution rate**, and $TTRP$ is **test to raise prosecution rate.** IIR is **increase in rate**, PRV is **test rate value**, ranging from 0 to $(1 - PR)$, TOI is **time of implementation**, given as 50 weeks. What is done here is to provide a period of about a year (50 weeks) to improve prosecution rate to 80%.

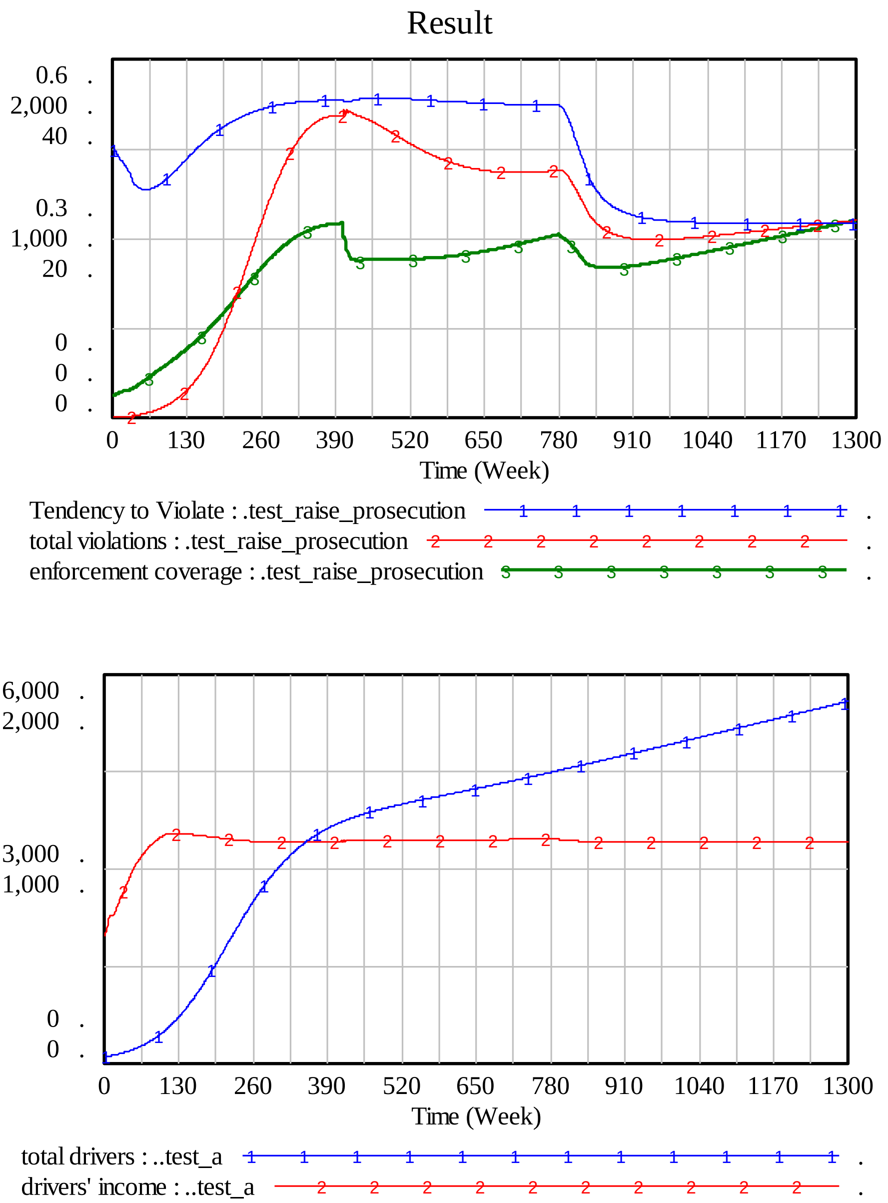
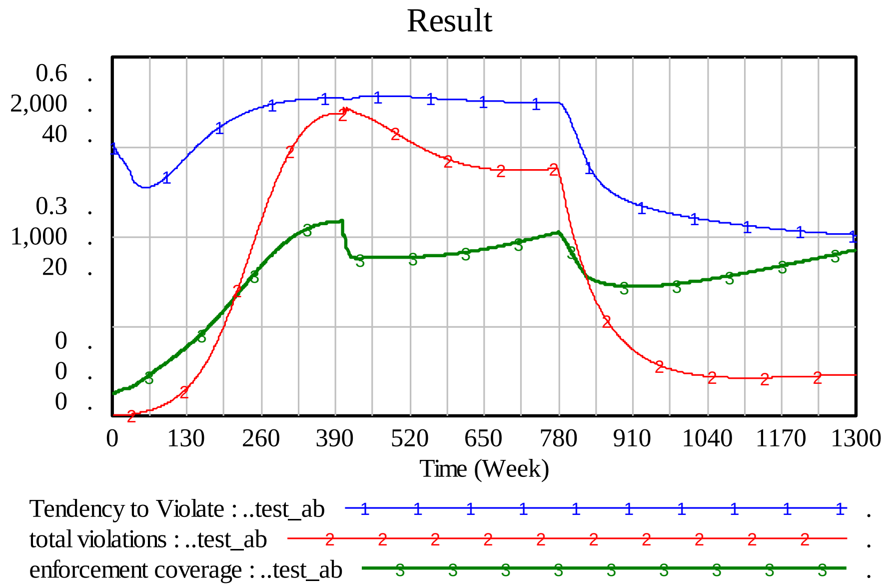


Figure 10.56: Model behaviour under a test to raise prosecution rate

The graph of the simulation outcome is presented in figure 10.56. As shown in the figure, raising the rate of prosecution reduces **tendency to violate** better than other tests, lowering it to 0.32unit. But the number of violations does not come down significantly. **Total violation** in the system is as high as 1118 violations/week-day only slightly down from 1674. Looking through the model shows that though drivers have lower desire for violating, they have more pressure to commit violations. In addition, the floating goal structure of the enforcement system results in a lower level of **enforcement coverage** being 22.19 officers under this test unlike 30.24 in the baseline case. This must be contributing to the high number of violations too. Finally, number of drivers under this condition is slightly lower than the baseline case of 5598 at 5587 drivers and their income is close to baseline case of NGN1158 at NGN1139

10.10.5 Combination of changes to ownership options and prosecution rate



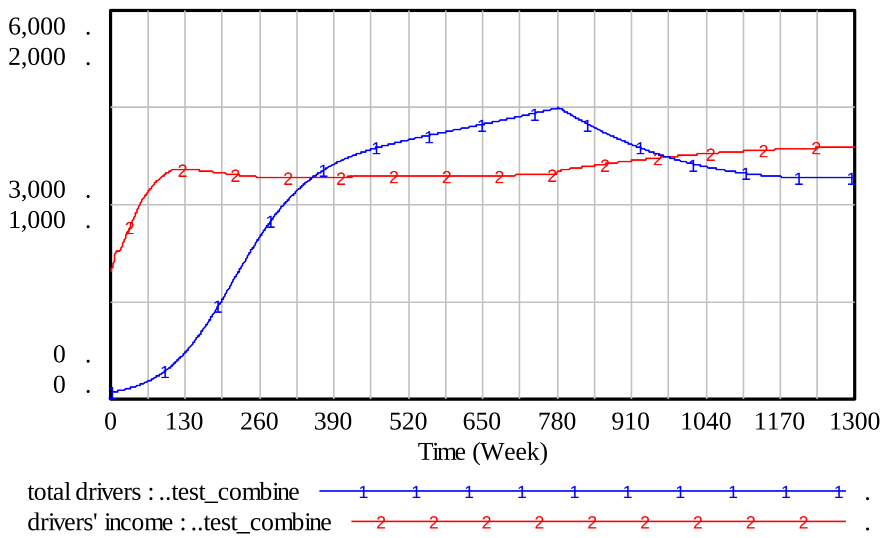


Figure 10.57: Model behaviour under test to raise prosecution rate and to remove expensive ownership options

Figure 10.57 which is a combination of tests to raise prosecution and test to remove expensive repayment option is shown to give the best outcome of the five future behaviour tests. It shows **tendency to violate** and **enforcement coverage** to be better than others at 0.30 unit and 21.10 officers respectively. It also shows total violations to reduce to 231.7 violations/week-day. However, the number of drivers under this condition falls to 3412 drivers (lower than the baseline case of 5598) and their income is slightly higher than baseline case of NGN1158 at NGN1297. This shows how leverage can be achieved by a combination of policies.

10.11 Conclusion

This chapter has developed a quantitative model (stock and flow model) that is believed to be useful in helping to improve understanding about addressing the problem of commercial motorcycle safe operation. It is also believed to be suitable for further development into a DSS This has been particularly demonstrated through the model formulation process and in the various tests conducted to assess model validity. It must be noted however that the process involved a lot of assumptions and estimations of variables. These assumptions account for about a third of the total number of factors treated in this model. While some of these factors have been conservatively chosen and some supported by the literature, they are not exact. This is more so as the sensitivity analysis shows that some of these factors are very sensitive to changes and wrongly specifying them has substantial implication on the model behaviour. In this respect, while Sterman (2000) argued that such a model can still be useful if all assumptions and boundary conditions are stated, Coyle (2000) noted that caution should be taken when there are too many unknowns. Additional research to improve on these specifications would therefore be necessary.

Nevertheless, the researcher still has confidence in the model to the extent of the validation results and model behaviour. This is more so as “all models are wrong” (Sterman, 2000, p.846): no model is “valid” or “verifiable” in the sense of establishing truth. Moreover, no model is finished; all models are subject to changes and review as new information emerges (Mashayekhi and Ghili, 2012). This model has been developed based on available information and will be improved with new information as they emerge. To rate the model therefore, the following questions[58] have been considered by the researcher:

What is the purpose of the model? The third research objective states what the model purpose is. This chapter shows that it has been able to fulfil this objective through the explicit representation of model component parts and variable behaviour representation in the validation process.

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[58] The questions are taken from Pfaffenbichler, 2003, pp.134-135 but are slightly adapted

Is the model boundary appropriate? The discussion in section 10.3 shows that important issues in this model have been endogenously treated. It also provides explanations for the exogenous factors in the model. This is intended to show that the issues important to the model are treated as endogenous.

What is the time horizon relevant to the model? The longest time (cycle) in the model is 5 years. This model covers a period of 15 years with further testing covering additional 10 years. This helps to show that the longest time delay in the system is provided for.

Is the level of aggregation consistent with the purpose? This model attempts to represent individual driver's behavioural tendencies based on factors of influence identified in the data collected from the study location and in the literature. It also represents the different pressures that an individual driver faced. This level of disaggregation makes this model consistent and suitable for its intended purpose.

Based on these assertions, it can be concluded that this model might be able to improve the understanding about commercial motorcycle drivers' safety and high-risk behaviour in addition to what is currently known.

Chapter 11 Summary of research and Conclusions

In this chapter, the conclusions reached from the conduct of the research reported in this thesis are presented. First, a summary of the research is laid out in section 11.1. Then, the contributions made by achieving the objectives of the research are shown in section 11.2. In section 11.3, the original contributions of this research are outlined. This is followed by identifying the limitations in this research in section 11.4. The chapter closes in section 11.5 with recommendations to policy makers and on areas for further research based on the findings and limitations of this study.

11.1 Research approach

As described in sections 2.4 and 2.5, this research originated from the observation that commercial motorcycle mode has become a complex system with no clear direction on what management policy might fit it most. This confusion has resulted in the debate about whether it should be banned (as it has been done in several cities) or whether the mode should continue to operate in Nigeria. This research aimed to develop a system understanding of the safety problem of commercial motorcycles. Figure 11.1 below shows the structure of the approach followed.

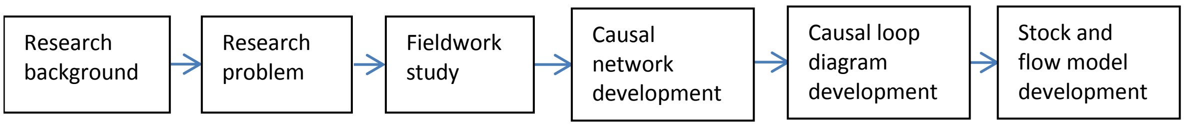

Figure 11.1: Guide through research approach

11.1.1 Research background

This research started by identifying the benefits and problems of commercial motorcycles. It acknowledges that commercial motorcycle is an essential transport mode which is facing extinction in Nigeria due to its numerous problems (such as crashes, crime, pollution) of which poor safety profile is chief. Section 2.3.5.1 shows that while commercial motorcycles operate across several continents, including South America, Africa, and Asia, they have peculiar operating characteristics in Africa which make them attract more attention than in other continents. Section 2.5 goes further to show that the challenges faced by commercial motorcycle transport in Nigeria are similar in characteristics to those in many other African countries where this transport mode operates (including places such as Cameroon, Sierra Leone and Uganda). It also shows that the attention given to commercial motorcycle mode has not improved substantially its safe operation despite several policy measures that have been provided to address the problems. In Nigeria, the literature shows that motorcycle accident now account for up to a quarter of road traffic crashes and a third of road traffic fatalities (Eze et al, 2012, Arosanyin et al., 2012).

11.1.2 Research problem

A review of the literature conducted in chapter 2 shows that many previous studies on commercial motorcycle safety adopt linear causal-and-effect approach which does not consider the combined effect of the multiple factors found to affect the operation of this transport mode, particularly the feedback effects. It also shows that the statistical methods mostly used for studying commercial motorcycle transport often have limited explanatory power due to the unavailability of reliable data and consequently models' inability to sufficiently capture the complexity of the system. These studies are therefore limited in the understanding they can provide about the complexity in the system and may be unable to support adequate understanding about the problem causes and the likely impact of proposed policies measures. The goal of this research was therefore to capture this complexity in a manner that reduces the difficulty in understanding it.

11.1.3 Fieldwork study

Following the nature of this problem and the local condition in the study area (particularly lack of reliable quantitative data), the use of qualitative and systems approaches were adopted to research the problem. The importance of qualitative information in these approaches led to the fieldwork exercise where the mental model of stakeholders in the operation of this transport mode was elicited. The fieldwork involved the use of interview method for data collection from identified stakeholders in commercial motorcycle operation in a city (Ado-Ekiti) in Nigeria. Data collected was analysed (by coding the data) using content analysis method. The result of the analysis generated three representations of the research findings. These are causal network, causal loop diagram, and stock and flow model. These are described below.

11.1.4 Causal network development

Following from the analysis of the qualitative data using descriptive and causation coding methods, a causal network was developed. Causal networks help to represent the complexity in interaction amidst multiple factors; so it was used to describe the various factors that affect the safe operation of commercial motorcycles and how they affect it. It however does not resolve the complexity as the causal network itself is complex. Nevertheless, it provides a systems view of commercial motorcycle safety problem.

11.1.5 Causal loop diagram

The research emphasises drivers' risk taking behaviour as a major contributor to safety problems based on the data obtained and the literature reviewed. From the causal network previously developed, a CLD that shows how driver behaviour can be understood was generated. The difference between the causal network and CLD is that while the causal network shows the complexity of how all factors are related within the system, the CLD describes the structure of the dynamic interactions of specific (and key) problematic structures present in the causal network. This CLD identifies nine feedback loops that shaped driver behaviour, and by that fact, the behaviour-related safety characteristics of the system. One important advantage of this CLD is its ability to clearly reveal the structure of how different factors and characteristics within this transport system interact with each other in a dynamic fashion.

11.1.6 Stock and flow model

In addition to the development of a CLD that reflects a systems understanding of the high-risk behaviour problem, the study went further to mathematically formalise the CLD to produce a quantitative model (stock and flow model). This model was subjected to a series of tests for robustness check. Being a simulation model, it was tested by comparing its output with the trend/ behaviour of a number of parameters including **drivers' population**, **drivers' experience** (number of years) on the trade, and drivers' **tendency to violate**, amidst others, to compare model output with realities. The model also underwent other validation tests which all shows that the model should be useful for its intended purpose. This model demonstrates potentials for its adaptability for policy testing and analysis.

The above presents the approaches adopted in this research. The research is novel in several respects. For example no previous research has treated commercial motorcycle safety problem from the perspective of causal relationship among the key factors as it is done in this research. The combination of methods, particularly, the analysis process through which the causal network and the CLD were obtained is another originality in this research. The complete list of original contributions is detailed in section 11.3.

11.1.7 Comparison of the outcome of the three research findings

As noted above, the aim of this research is to generate a system understanding of commercial motorcycle safety problems. The three main results obtained based on the research objectives have been summarised above in sections 11.1.4, 11.1.5, and 11.1.6. These three results are compared in table 11.1 below.

Table 11.1: Comparison of research results

	Causal network	**Causal loop diagram**	**Stock and flow model**
Benefits	The method for generating a causal network is a stand-alone method. The outcome is informative: it shows the system complexity	Shows an easier to understand structure of the system, pointing out what is important to know. Provides a structure of feedbacks that shows what drives the system problem and so offers a clearer framework for policy design.	Offers more information about the strength of the different feedback structures and of factors' influence within the system. Offers quantitative estimation and dynamic trends which can help to more clearly understand the impact of different intervention strategies. Might be more preferred by decision makers.
Limitations	Causal network can give more information than is essentially required to understand system problem. Still stands the risk of offering linear causal projections of future (as shown in section 8.7.3) trends which can result in incorrect predictions in a highly dynamic system. Of the three methods here, it might be the least easy framework for generating policies	Supplements rather than replaces analytical thinking. Depends on existing knowledge about the system under study to generate its outcome. Extracting this knowledge scientifically requires depending on some other methods. This can lead to more expensive policy framework since it is impossible to understand the strength of the different feedback structures. It might inadvertently omit an important feedback if not tested	Requires significant amount of modelling assumptions to obtain results. It is not a standalone method; it is not independent of qualitative methods If model assumptions and system boundary are ignored in using this outcome, it can lead to incorrect result

The table above shows the benefits and limitations of each of the results obtained in this research. It particularly shows that each result is good in its own right. The causal network shows a broad picture of the entire system. The causal loop diagram may offer a framework for understanding key problem structures while the stock and flow model is good for comparing behaviours of system variables.

11.2 Conclusions

The three research objectives addressed in this thesis seek to improve the understanding about the difficulty in successfully managing commercial motorcycles' safe operation in Nigeria. The analysis in chapters 8 to 10 provides answers to these questions. Specifically, sections 8.6.1 to 8.7.2 address the first research objective; the second research objective is addressed in sections 9.2 to 9.4; and sections 10.6 to 10.10 address the third research objective. These research objectives are listed below together with the summary of contributions made:

11.2.1 Objective 1

Identify factors that influence safety in commercial motorcycle operation and their relationship with one another.

Table 11.2: Summary of factors that influence commercial motorcycle safe operation

The commercial motorcycle trade and the changing pattern of drivers' population	Life as a commercial motorcycle driver	Training in commercial motorcycle operation	Violations practices in commercial motorcycle operation	Enforcement and regulation in commercial motorcycle operation
Number of drivers	Additional work capacity requirement	Availability of spare time	Accident	Corruption (corrupt practices)
Experience	Competition	Availability of training opportunity	Alcohol and drug use	Deterrence
Free and easy entry	Cost of operation	Ignorance	Inclement weather	Dodging arrest
High job return	Drivers' income	Participation in training	Loss from accident (accident losses)	Enforcement coverage
Ignorance	Earning pressure	Willingness to give time for training	Peer influence	Other road users
Rent and hire-purchase options	Spending aversion and cutting corners		Violations	Political influence
Risky and dangerous drivers	Target income			Probability of detection
	Thrift savings			Prosecution
	Work capacity			Risky road environment

Based on the analysis of the qualitative data collected and available information from other sources, especially the literature, the research found that many factors affect commercial motorcycle safe operation. These factors are grouped under five thematic headings and presented in table 11.2: These factors and their relationship with one another are represented with a causal network in figure 8.19 (page 157, section 8.7.2) in this thesis. While this research is not the first to identify driver behaviour as a major risk factor, its contribution has been to represent these various factors that promote/ inhibit a safe system in a "causal network" sense. Moreover, while previous studies have studied violations, drivers' earnings, trainings, and other drivers' characteristics, this research introduces the effect of enforcement operations' characteristics to commercial motorcycle drivers' safety study. Furthermore, this research contributes to knowledge in considering and relating the influences of this wide range of factors on commercial motorcycle driver behaviour within a single study.

11.2.2 Objective 2

Describe how these factors generate drivers' safety characteristics using a causal loop diagram.

Further analysis of the outcome of objective 1 led to the development of a CLD that explains how the factors identified affects drivers' safety characteristics. Based on the outcome of the analysis (described in section 9.2), nine key problem causalities emerged. These key causalities, which form complete loops, were developed into a CLD in sections 9.3 and 9.4. In the figure each of the feedback loops represents one of the nine key problem causalities. This CLD provides an opportunity for improved understanding about risky driver behaviour and fulfils the second objective of the research. This CLD is shown in figure 9.10 on page 188. The key problematic statements represented by the loops in the CLD are re-stated below.

i. Drivers' population growth loop: A growing drivers' population is causing further growth through the increasing awareness of the high profit margin in commercial motorcycle trade.

ii. Expensive ownership options loop: Expensive ownership options available are promoting population growth but raising working (earning) pressure within the trade.

iii. Competition reduces drivers' population loop: Increasing competition should reduce population growth but its effect is weak since, amidst other things, drivers can cut corners and commit violations to make ends meet.

iv. Trade is strenuous loop: Strenuous working condition is making drivers to turn to violations and to make career-switch plans.

v. "…not a lifetime trade" loop: Career-switch plans are promoting high savings habit and adding to earning pressure.

vi. Time for training loop: Training deficiency is reinforcing itself with drivers needing to work more but having less time for driving education.

vii. Detection loop: Enforcement officers enforce the law by detecting and arresting violators but this process is weak.

viii. Deterrence loop: The process of enforcement should deter drivers from engaging in violations and build the culture of safe driving behaviour but this process too is weak.

ix. Payment of rent to officers' loop: There is the problem of corruption in the enforcement process and this affects both drivers and officers. This is particularly with respect to rent paid to officers to avert prosecution.

11.2.3 Objective 3

Formulate a quantitative system dynamics model that can help in understanding the process of regulating commercial motorcycle operation with respect to drivers' characteristics.

Eventually, the CLD obtained under the second objective was used to develop a quantitative model that might be used to understand why the process of regulating commercial motorcycle operations has not improved. The emphasis in the model is the factor **tendency to violate**, an index of measure of drivers' attitude to violation. This model reflects the nine items listed under the second objective. The model was subjected to various tests to build confidence in it and gain more insight about the system. Some specific outcome of the tests includes the following:

i. The availability of expensive acquisition options is one of the problems causing risky driver behaviour.

ii. Improved sanction can improve driver behaviour. But improved sanction is not the same thing as increasing the number of enforcement officers working on the road.

iii. A good leverage can be attained by a combination of measures in managing commercial motorcycle safety system

The model is shown to be another useful part of the research that can be further improved for use as a learning laboratory for policy makers and stakeholders who might be interested in understanding the system behaviour better.

Thus this research has used both qualitative methods and a system dynamics approach to show how complex systems that might have been showing continuous resistance to policy interventions could be better understood. This is demonstrated with the case of commercial motorcycle transport in Nigeria. In addition, it also provides a methodological option for dealing with data unavailability problem policy makers (in poor developing countries that cannot afford high quality data management systems) usually face in taking guided policy decisions.

Finally, while previous research point to the use of qualitative research methods in developing system dynamics models, some of these research do not provide detailed steps of the process. In some instances, only the outcomes are shown; the process followed to analyse qualitative data and arrive at model conceptualisation are not shown. However, rigour in qualitative research is expected to be reflected in the writing up of the findings by fully describing the principles and procedures for data organisation and analysis so that a reader can "understand what happened to the raw material to arrive at the results" (Malterud, 2001, p.485). This research provides a detail report of the analysis steps followed, what items were coded and the principles that guided the coding process. This reporting style provides a guide for future researchers who might want to adopt a similar method to undertake model conceptualisation in system dynamics model development.

11.3 Summary of original contributions

The following are some of the original contributions of this research

1. Development of a causal network: A causal network of the safety characteristics of commercial motorcycles presented in this research is novel. This causal network is unique. This is shown in figure 8.19 on page 157.
2. Systems approach for representing drivers' risk taking behaviour in commercial motorcycle operation: While feedback systems thinking has been in use for systems safety analysis for a long time, it has not been used for evaluating driver behaviour problems in commercial motorcycle operation. This is more so as there are no sufficient/ reliable data for them. This study has therefore gone beyond the typical state-of-the-art review and

has placed feedback concept in systems approach among methods for evaluating para-transit modes in developing countries which are usually characterised by inadequate data. This placement has provided insight into the rationale and relevance of feedbacks, particularly in managing commercial motorcycle driver behaviour in Nigeria and, perhaps, other countries with similar regulatory challenges. It also provides a general theory of commercial motorcycle drivers' risk taking behaviour that integrates socio-economic context of operation, drivers' characteristics, work/ operating characteristics, and risk predisposing factors. This contribution is detailed in sections 9.2 to 9.4.

3. A simulation model with potentials for policy learning in commercial motorcycle driver behaviour management in the absence of readymade data: A description of how the mental concept of stakeholders is developed into mathematical equations in which qualitative descriptions, literature and informed guess were used to generate numbers for commercial motorcycle transport characteristics is an original contribution of this research. The research also went further to test for the validity of these values and their appropriateness within the quantitative model developed. This particular aspect of the exercise is used to put forward to policy makers the possibility of developing a learning tool for exploratory policy analysis in instances of limited and/or unreliable data. Details of this process are provided in sections 10.6 to 10.10.

4. More specifically, the following themes have been treated by the system dynamics models (CLD and SFM) developed:

a) There is a growth pattern in the population of commercial motorcycle drivers which promotes unhealthy competition and poor pre-trade preparation amidst drivers.
b) This growth pattern is promoted by the availability of expensive motorcycle-acquisition options; these expensive options are an important cause of high pressure of work.
c) In addition, this pressure makes commercial motorcycle trade tedious such that drivers want to quit and start another business. Their desire to quit and start another trade propels them to engage in thrift savings which are usually high; this high savings forces driver to work harder to meet up, further raising the work pressure.

d) The pressure under which drivers work is responsible for many of their aberrant behaviours (high-risk behaviour); these aberrant behaviours also develop into a norm amidst drivers.
e) Enforcement operations have not been able to improve the system because both the enforcement officers and drivers benefit from the state of the system.

These four contributions are unique to this research.

11.4 Limitation of the research

The main limitation of this research is with the quantitative model developed. The model addresses driver behaviour rather than crash occurrence in commercial motorcycle operation in Nigeria. The main limitation of this thesis is the needed data for a more accurate specification of quantitative model parameters. This problem arises from the fact that there are no reliable data anywhere in Nigeria about the operation of commercial motorcycle. However, this model allows for improvement with additional data as they emerge and this limitation may not render the quantitative model useless.

In addition, the boundary of the quantitative model does not include other vehicles on the road. Thus they have not been included in this model and their contribution to commercial motorcycle safety has not been accounted for. Because the emphasis of this research is on driver behaviour rather than crash count, ignoring other vehicles on the road is not taken as serious enough to make the model less useful. Moreover, similar exclusion has been done in a previous research (Mehmood, 2010).

Finally this study has applied a phenomenological approach to extract data for a typical medium size city in Nigeria: Further research is required to test if the findings would apply to other African countries with similar commercial motorcycle problems as Nigeria. These limitations are beyond the scope of this research. Other challenges which the research addressed include:

1. Quantitative specifications for some model parameters were obtained from the literature. There are some variations in what the literature specifies about some variables: estimates used in the quantitative model are therefore subjected to sensitivity test to check the appropriateness of the assumptions.

2. A number of soft variables exist in the quantitative model of this work. They are represented as functions of other variables that most closely reflect their likely pattern or by functional graphs as suggested by Luna-Reyes and Andersen (2003) and Sterman (2000) respectively.

The various tests conducted on the model suggest model's robustness. None of these limitations is expected to make the observations made in the model incomprehensive or invalid.

With respect to the qualitative analysis, the researcher could not triangulate the result by using respondent for confirmation. Several efforts made did not succeed. It was however possible during the analysis to maintain contact with the drivers and verify emerging themes through calls to them. In addition, the final analysis result was shared with students from Nigeria studying in the UK for review and criticism. This process helped to make up for respondents' triangulation.

The effect of these limitations is therefore not expected to be significant in the research.

11.5 Recommendations

Following from the conduct and findings of this research, a number of recommendations are made. The first set of recommendations relates to policy makers while the second set of recommendations deal with research limitations. These recommendations are presented below:

11.5.1 Recommendations for policy makers

The following recommendations are made to policy makers based on the outcome of this research:

i. The causal network obtained in this research indicates that commercial motorcycle safety problem is a complex one. It is recommended that policy makers should acknowledge this complexity and avoid arbitrary regulatory pronouncements that usually do not succeed.

ii. For an effective regulatory framework for commercial motorcycle transport, the use of the causal loop diagram is recommended for identifying important themes a good regulatory framework might have to address.

iii. Regulation in Nigeria is often associated with making payments. This study finds that regulatory process that charges drivers additional fees only succeeds in increasing their working pressure and may not improve the system as anticipated. Regulations should take cognisance of the system characteristics and identify leverage points rather than strengthen further a problematic feedback loop.

iv. The current practice of increasing the number of enforcement officers to improve traffic safety should be reviewed. This is because there are indications that the corrupt practices in prosecution may be causing this measure to be less effective than it should be. But previous studies show that engaging the drivers' union is an option for improving sanction. These unions are strong (Arosanyin et al., 2012) and can enforce compliance amidst members better than enforcement officers would do.

v. The recommendations presented in this research are based primarily on the outcome of the qualitative data analysis and the CLD developed. While the SFM developed lend some credence to these recommendations, it is not advised that the SFM should be treated as a complete model ready for application/ implementation. It is recommended that a more critical stakeholders' review be conducted on the SFM first before any implementation is contemplated. Nevertheless, in its current state, the SFM is able to elicit some useful insight which may require further research to confirm them. This is further stressed in section 11.5.2

11.5.2 Recommendations for model improvement

In the light of the limitations identified in section 11.4, two research areas are recommended for the future: i) further testing and refinement of model and ii) extension of model to cover all road users and all vehicle types.

Further testing and refinement

The quantitative model developed in this study indicates the feasibility of system dynamics approach to dealing with problems having limited data. Noting that "SD is not meant for precise point forecast" (Shepherd, 2014, p.102), the model behaviour have been found to resemble the real system. However, this tool does not lay claim on a flawless formulations. Further refinements is required by introducing the model to policy makers for further scrutiny and broader testing to identify areas where more accurate information might be able to improve parameter specification. It will be useful to more accurately specify the effect of some factors such as training, competition. Also the parameters the model is highly sensitive to their changes should be further studied. In addition, there might be need for structural modification and inclusion of other local conditions in the model if it is to be tested for conditions different from the study location characteristics.

Extending model boundary

One of the outcomes of this research is the development of a model that can help understand the structure of the drivers' risk taking behaviour in commercial motorcycle safety problem. A broader model will be required that provides the structure of the interaction between different modes on the road, not just commercial motorcycles. Such model will be useful in planning for the entire transport network rather than for commercial motorcycle mode alone.

References

Abane, A.M. 1994. Driver behaviour and city traffic: empirical observations from Accra, Ghana. *Research Review (N).* 10(1 & 2).

Abdullah, L. and Zamri, N. 2012. Road Accident Models with Two Threshold Levels of Fuzzy Linear Regression. *Journal of Emerging Trends in Computing and Information Sciences.* 3(2), pp.225-230.

Adeniji, K. 1987. Para-transit modes in Nigeria: Problems and prospects. *Cities.* pp.339-347.

Adisa, R.S. 2010. A Study of the Use of Intoxicants among Rural Commercial Motorcyclists in Kwara State, Nigeria. *J Soc Sci, 2010.* 22(2), pp.85-91.

Akinbami, J.F.K. and Fadare, S.O. 1997. Strategies for sustainable urban and transport development in Nigeria. *Transport Policy.* 4(4), pp.237-245.

Albin, S. 1997. Building a System Dynamics Model Part 1: Conceptualization Unpublished.

Alti-Muazu, M. and Aliyu, A.A. 2008. Prevalence of psychoactive substance use among commercial motorcyclists and its health and social consequences in Zaria, Nigeria. *Ann Afr Med [serial online]* 7(2), pp.67-71.

Anbarci, N. et al. 2006. Traffic Fatalities and Public Sector Corruption. *KYKLOS.* 59(3).

Andersen, D. et al. 2011. Developing a Scripted Approach to Planning Client-Based Strategic Modelling Sessions. In: *The 11th Biennial and 20th Anniversary Public Management Research Conference*.

Andersen, D.F. and Richardson, G.P. 1997. Scripts for group model building. *System Dynamics Review.* 13(2), pp.107-129.

Andersen, D.F. and Richardson, G.P. 2007. Improvising around roles and scripts in Group Model Building. Group Decision and Negotiation. In: – *INFORMS. Mt. Tremblant,*, *Quebec*.

Andersen, D.F. and Richardson, G.P. 2010. Improvised Facilitation: A Third Leg on the Group Model Building Stool. In: *2010 International System Dynamics Research Conference*, *Seoul, Korea*. p.[no pagination].

Annells, M. 1996. Grounded Theory Method: Philosophical Perspectives, Paradigm of Inquiry, and Postmodernism. *Qual Health Res* 6(3), pp.379-393

Arosanyin, G.T. et al. 2011. Employment Generation and Earnings in the Informal Transport Sector in Nigeria *International Business and Management.* 2(2), pp.139-148.

Arosanyin, G.T. et al. 2012. Compliance with Road Safety Regulations Among Commercial Motorcyclists in Nigeria. *Canadian Social Science.* 8(1), pp. 92-100.

Arosanyin, G.T. et al. 2013. An evaluation of savings culture among commercial motorcyclists in Nigeria: A case study. *CENTREPOINT.* 15(2), pp.229-249.

Ayodele, S.-D. 2010. The menace of motorcycle as a paratransit mode in Lagos Metropolis. *Journal Of ESTATE SURVEYING.* 3, pp.64-79.

Barbour, R.S. 2001. Checklists for improving rigour in qualitative research: a case of the tail wagging the dog? *BMJ [PMC free article] [PubMed].* 322, pp.1115-117.

Barlas, Y. 1989. Multiple tests for validations of system dynamics type of simulation models. *European Journalof Operational Research.* 42(1), pp.59-87.

Barlas, Y. 1996. Formal aspects of model validity and validation in system dynamics. *System Dynamics Review.* 12(3), pp.183-210.

Barriball, K.L. and While, A. 1994. Collecting data using a semi-structured interview: a discussion paper. *Journal of Advanced Nursing.* 19, pp.328-335.

Baxter, P. and Jack, S. 2008. Qualitative Case Study Methodology: Study Design and Implementation for Novice Researchers. *The Qualitative Report.* 13(4), pp.544-559.

Beekers, D. 2009. Children of a "Fallen House": Lives and Livelihoods of Youth in Nigeria. Unpublished.

Borowsky, A. et al. 2010. Age, skill, and hazard perception in driving. *Accident Analysis & Prevention.* 42(4), pp.1240-1249.

Bos, W. and Tarnai, C. 1999. Content analysis in empirical social research. *International Journal of Educational Research.* 31(8), pp.659-671.

Bowles, R. and Garoupa, N. 1997. Causal Police Corruption and the economics of crime. *Int Rev Law Eco.* 17, pp.75-87.

Bredeweg, B. et al. 2008. Towards a structured approach to building qualitative reasoning models and simulations. *Ecological Informatics.* 3(1), pp.1-12.

Breitenbach, T.C. et al. 2012. High rates of injured motorcycle drivers in emergency rooms and the association with substance use in Porto Alegre, Brazil. *Emerg Med J.* 29(3), pp.205-7.

Broom, A. 2005. Using qualitative interviews in CAM research: a guide to study design, data collection and data analysis. *Complement Ther Med.* 13(1), pp.65-73.

Bryman, A. 2001. *Social Research Methods.* [no place]: Oxford University Press.

Bürge, M. 2011. Riding the Narrow Tracks of Moral Life: Commercial Motorbike Riders in Makeni, Sierra Leone. *Africa Today.* 58(2), pp.58-95.

Burnard, P. 1991. A method of analysing interview transcripts in qualitative research. *Nurse Education Today.* 11(6), pp.461-466.

Carhart, N. and Yearworth, M. 2010. The Use of System Dynamics Group Model Building for Analysing Event Causality within the Nuclear Industry. In: *The 28th International Conference of the System Dynamics Society*, *Seoul, Korea*. Proceedings of the 28th International Conference of the System Dynamics Society, p.[no pagination].

Cervero, R. 2000. *Informal Transport in the Developing World.* Nairobi: United Nations Centre for Human Settlements (Habitat).

Cervero, R. and Golub, A. 2007. Informal transport: A global perspective. *Transport Policy.* 14(6), pp.445-457.

Chang, J.-j. et al. 2000. Casual police corruption and the economics of crime:: Further results. *International Review of Law and Economics.* 20(1), pp.35-51.

Cheng, A.S.K. et al. 2011. A comparison of the hazard perception ability of accident-involved and accident-free motorcycle riders. *Accident Analysis & Prevention.* 43(4), pp.1464-1471.

Chorlton, K. et al. 2012. Identifying the psychological determinants of risky riding: An application of an extended Theory of Planned Behaviour. *Accident Analysis & Prevention.* 49(0), pp.142-153.

Conroy, D.M. and Allen, W. 2010. Who do you think you are? An examination of how systems thinking can help social marketing support new identities and more sustainable living patterns. *Australasian Marketing Journal (AMJ).* 18(3), pp.195-197.

Cordazzo, S.T.D. et al. 2014. The Driver Behaviour Questionnaire: A North American analysis. *Journal of Safety Research.* 50(0), pp.99-107.

Coyle, G. 1998. The practice of system dynamics: milestones, lessons and ideas from 30 years experience. *System Dynamics Review.* 14(4), pp.343-365.

Coyle, R.G. 1996. System Dynamics Modelling; A Practical Approach. London: Chapman & Hall.

Coyle, R.G. 2000. Qualitative and Quantitative Modelling in System Dynamics: Some Research Questions. *System Dynamics Review.* 16(3), pp.225-244.

Coyne, I.T. 1997. Sampling in qualitative research. Purposeful and theoretical sampling; merging or clear boundaries? *Journal of Advanced Nursing.* 26(3), pp.623-630.

Curry, L.A. et al. 2009. Qualitative and mixed methods provide unique contributions to outcomes research. *Circulation.* 119(10), pp.1442-52.

Dandona, R. et al. 2006. Risky Behaviour of Drivers of Motorized Two-Wheeled Vehicles in India. *Journal of Safety Research.* 37, pp.149-158.

Davey, J. et al. 2007. An application of the driver behaviour questionnaire in an Australian organisational fleet setting. *Transportation Research Part F, 10.* pp.11-21.

de Waard, D. and Rooijers, T. 1994. An experimental study to evaluate the effectiveness of different methods and intensities of law enforcement on driving speed on motorways. *Accident Analysis & Prevention.* 26(6), pp.751-765.

Dicicco-Bloom, B. and Crabtree, B.F. 2006. The qualitative research interview. *Med Educ.* 40(4), pp.314-21.

Diker, V. et al. 2005. Interviewing as a Strategy for the Assessment of System Dynamics Models. In: *23rd International Conference of the System Dynamics Society, Boston, MA*.

Doucet, J.J. et al. 2011. The unrecognized danger of a new transportation mechanism of injury – Pedicabs, . *Journal of Safety Research.* 42(2), pp.131-135.

Dowling, A.M. et al. 1995. Simulation of Systems Archetypes. In: *Proceedings of the 1995 International System Dynamics Conference, Tokyo*. pp.454-463.

Dowling, M. 2007. From Husserl to van Manen. A review of different phenomenological approaches. *International Journal of Nursing Studies.* 44, pp.131–142.

Dutta, M. and Bhattacharya, J. 2009. Influencing Modal Choice for Pollution Control: Feasibility, Costs, and Benefits: The Case of an Indian Megacity, Kolkata In: *CODATU XIII*.

Ehikhamenor, E. and Agwubike, E.O. 2004. The need for blood alcohol concentration (BAC) legislation in Nigeria. *Tropical Journal of Pharmaceutical Research.* 3(1), pp.319-327.

Etukumana, I.A. et al. 2010. Possible causes of motorcycle (okada) accidents in karu, nigeria. *Inj Prev.* 16(A88).

Eze, U.O. et al. 2012. Fatal road traffic injuries in Ibadan, using the mortuary as a data source. *Injury Prevention.* 0, pp.1-6.

Fasakin, J.O. 2000. Willingness to pay for the services of commercial motorcycles in Akure, Nigeria. *Cities.* 17(6), pp.447-452.

Fasakin, J.O. 2001. Some factors affecting daily profits of commercial motorcycles in Akure, Nigeria. *Transport Policy.* 8(1), pp.63-69.

Fasakin, J.O. 2002. Daily cost considerations in the operations of commercial motorcycles in Nigeria: a locational analysis for Akure township. *Transportation Research Part A: Policy and Practice.* 36(3), pp.189-202.

Forrester, J.W. 1991. System Dynamics and the Lessons of 35 Years. In: Greene, K.B.D. ed. *The Systemic Basis of Policy Making in the 1990s.* Massachusetts: Massachusetts Institute of Technology, pp.1-35.

French, M.T. et al. 2009. Public policies and motorcycle safety. *Journal of Health Economics.* 28(4), pp.831-838.

Fuller, R. 2005. Towards a general theory of driver behaviour. *Accident Analysis & Prevention.* 37(3), pp.461-472.

Content Analysis: A Methodology for Structuring and Analyzing Written Material. 1989. [Database]. United States General Accounting Office.

Garoupa, N. 1997. The theory of optimal law enforcement. *Journal of Economic Surveys.* 11, pp.267-295.

Garoupa, N. 2003. Behavioral Economic Analysis of Crime: A Critical Review∗. *European Journal of Law and Economics.* 15, pp.5-15.

Gasper, D. 2000. Evaluating the 'logical framework approach' towards learning-oriented development evaluation. *Public Administration and Development.* 20, pp.17-28.

Gbadamosi, K.T. 2006. The Emergence of Motorcycle in Urban Transportation in Nigeria and its Implication on Traffic Safety. In: *Association for European Transport and Contributors*

GIZ. 2010. Urban Mobility for Indonesia. Indonesia.

Goh, Y.M. et al. 2010. Applying systems thinking concepts in the analysis of major incidents and safety culture. *Safety Science.* 48(3), pp.302-309.

Goh, Y.M. et al. 2012. Organizational Accidents: A Systemic Model of Production versus Protection. *Journal of Management Studies.* 49(1), pp.52-76.

Golafshani, N. 2003. Understanding Reliability and Validity in Qualitative Research. *The Qualitative Report.* 8(4), pp.597-607.

Graham, A.K. 2002. On positioning system dynamics as an applied science of strategy or:

SD is scientific. We haven't said so explicitly, and we should. In: 20th International Conference of the System Dynamics Society, Palermo, Italy.

Graneheim, U.H. and Lundman, B. 2004. Qualitative content analysis in nursing research: concepts, procedures and measures to achieve trustworthiness. *Nurse Education Today.* 24(2), pp.105-112.

Guba, E. and Lincoln, Y. eds. 1994. *Competing paradigms in qualitative research.* CA: Thousand Oaks, CA: Sage. .

Guillen, M.D. and Ishida, H. 2004. Motorcycle-propelled public transport and local policy development. *IATSS Research* 28(1), pp.56-66.

Guillen, M.D. et al. 2013. Is the use of informal public transport modes in developing countries habitual? An empirical study in Davao City, Philippines. *Transport Policy.* 26, pp.31-42.

Guion, L.A. et al. 2011. *Triangulation: Establishing the Validity of Qualitative Studies.* University of Florida: University of Florida.

Halai, N. 2007. Making Use of Bilingual Interview Data: Some Experiences from the Field *The Qualitative Report.* 12(3), pp.344-355.

Handy, S. 2002. Accessibility vs. Mobility – Enhancing Strategies for Addressing Automobile Dependence in the U.S. . In: *European Conference of Ministers of Transport, May 2002*.

Harris, B. and Williams, B. 2005. *System dynamics methodology*. Unpublished.

Hathaway, J.T. 1993. 'Go-slow': the Political Economy of Urban Transport in Nigeria with an Emphasis on Ado-Ekiti. *Geoforum.* 24(2), pp.165-182.

Hayward, K. 2007. Situational Crime Prevention and its Discontents: Rational Choice Theory versus the 'Culture of Now'. *Social Policy & Administration.* 41(3), pp.232-250.

Hirschheim, R. et al. 1995. Information systems development and data modeling: conceptual and philosophical foundations. Cambridge Cambridge University Press, .

Hoffman, R.R. 1987. The problem of extracting the knowledge of experts from the perspective of experimental psychology. *The AI Magazine.* 8(Summer), pp.53-66.

Homer, J. and Oliva, R. 2001. Maps and models in system dynamics: a response to Coyle. *System Dynamics Review.* 17(4), pp.347-355.

Hsieh, H.-F. and Shannon, S.E. 2005. Three approaches to qualitative analysis. *Qualitative Health Research.* 15(9), pp.1277-1288.

Huth, V. et al. 2014. Motorcycle riders' perceptions, attitudes and strategies: Findings from a focus group study. *Transportation Research Part F: Traffic Psychology and Behaviour.* 25, Part A(0), pp.74-85.

Hwang, L. and Hu, G. 1999. Steps in conceptualising a system for system dynamics model-building: A case study of an oil refinery of a petroleum corporation. In: *International System Dynamics Conference*, *NJew Zealand*.

Hyder, A.A. et al. 2007. Exploring the Economics of Motorcycle Helmet Laws Implications for Low and Middle-Income Countries. *Asia-Pacific Journal of Public Health.* 19(2), pp.16-22.

Irene, N. et al. 2012. S-D logic research directions and opportunities: The perspective of systems, complexity and engineering. *Marketing Theory.* 12(2), pp.213-217.

Iribhogbe, P.E. and Odai, E.D. 2009. Driver-Related Risk Factors in Commercial Motorcycle (Okada) Crashes in Benin City, Nigeria *Prehospital and Disaster Medicine* 24(4), pp.356-359.

Iyer, N.V. and Badami, M.G. 2007. Two-wheeled Motor Vehicle Technology in India: Evolution, Prospects and Issues *Energy Policy.* 35, pp.4319-4331.

Jacobs, G.D. and Greaves, N. 2003. Transport in Developing and Emerging Nations *Transport Reviews.* 23(2), pp.133-138.

Johnson, O.E. 2012. Prevalence and pattern of road traffic accidents among commercial motorcyclists in a city in Southern Nigeria. *Educational Research.* 3(6), pp.537-542.

Jones, S. et al. 2014. Incorporating stakeholder input into transport project selection – A step towards urban prosperity in developing countries?, . *Habitat International.* in press.

Júnior, J. and Filho, M. 2002. The Brazilian Motorcycle Taxi Phenomenon. In: *International Conference on Traffic and Transportation Studies, Guilin, China*. American Society of Civil Engineers, pp.1566-1572.

Kasantikul, V.M.D. 2001. Motorcycle accident causation and identification of countermeasures in thailand. Thailand: Chulalongkorn University.

Kirkebøen, G. ed. 2009. *Decision Behavior – Improving Expert Judgment.* New York: Palgrave-Macmillan.

Kirkwood, C.W. 1998. *System Dynamics Methods: A Quick Introduction.* Arizona State University.

Konings, P. 2006a. Solving Transportation Problems in African Cities: Innovative Responses by the Youth in Douala, Cameroon. *Africa Today.* 53(1), pp.35-50.

Konings, P.J.J. ed. 2006b. ‘Bendskin’ drivers in Douala’s New Bell neighbourhood: Masters of the road and the city neighbourhood. Brill, Leiden.

Kubota, T.B. and Joewono, H. 2005. The characteristics of paratransit and non-motorized transport in bandung, indonesia. *Journal of the Eastern Asia Society for Transportation Studies.* 6, pp.262-277.

Kumar, A. 2011. Understanding the emerging role of motorcycles in African cities: A political economy perspective Urban Transport Series ed. Sub-Saharan Africa Transport Policy Program.

Kummerow, M. 1999. A System Dynamics Model of Cyclical Office Oversupply. *The Journal of Real Estate Research.* 18(1), pp.233-255.

Lajunen, T. and Summala, H. 2003. Can we trust self reports of driving? Effect of impression management on driver behaviour questionnaire responses, . *Transportation Research Part F, 6.* pp.97-107.

Lakoff, G. and Johnson, M. 1980. *Metaphors we live by.* Chicago: University of Chicago Press.

Lane, D.C. 1998. Can We Have Confidence in Generic Structures? *The Journal of the Operational Research Society.* 49(9), pp.936-947.

Lane, D.C. and Oliva, R. 1998. The greater whole: Towards a synthesis of system dynamics and soft systems methodology. *European journal of operations research.* 107(1), pp.214-235.

Lee, J. 2010. An Emperical Test of Offseting Behavior Motorcycle Safety Regulation. *[no publisher].*

Leveson, N. 2004. A new accident model for engineering safer systems. *Safety Science.* 42(4), pp.237-270.

Leveson, N.G. 2011. Applying systems thinking to analyze and learn from events. *Safety Science.* 49(1), pp.55-64.

Lord, D. and Mannering, F. 2010. The statistical analysis of crash-frequency data: A review and assessment of methodological alternatives. *Transportation Research Part A: Policy and Practice.* 44(5), pp.291-305.

Luna-Reyes, L.F. and Andersen, D.L. 2003. Collecting and Analysing Qualitative Data for System Dynamics: Methods and Models. *System Dynamics Review* 19(4), pp.271-296.

Luna-Reyes, L.F. et al. 2005. Interviewing as a Strategy for the Assessment of System Dynamics Models Unpublished.

Luna-Reyes, L.F. et al. 2006. Anatomy of a group model-building intervention: building dynamic theory from case study research. *System Dynamics Review.* 22(4), pp.291-320.

Mack, N. et al. 2005. Qualitative research methods: A data collector's field guide. *Research Triangle Park NC: Family Health International.*

Mahlstein, M. 2009. Shaping and Being Shaped: The Regulation of Commercial Motorcycle Operation and Social Change in Calabar, Nigeria. Unpublished.

Malterud, K. 2001. Qualitative research: standards, challenges, and guidelines. *The Lancet.* 358(9280), pp.483-488.

Mannering, F.L. and Bhat, C.R. 2014. Analytic methods in accident research: Methodological frontier and future directions. *Analytic Methods in Accident Research.* 1, pp.1-22.

Marsden, G. et al. 2011. How do cities approach policy innovation and policy learning? A study of 30 policies in Northern Europe and North America. *Transport Policy.* 18(3), pp.501-512.

Mashayekhi, A.N. and Ghili, S. 2012. System dynamics problem definition as an evolutionary process using the concept of ambiguity. *System Dynamics Review.* 28(2), pp.182-198.

Mason, J. 2002. *Qualitative researching.* 2nd ed. London: Sage.

Ethnomethodology. 2007. s.v. pp.1483-1486.

Mays, N. and Pope, C. 2000. Qualitative research in health care: assessing quality in qualitative reseach. *BMJ [PMC free article] [PubMed].* 320, pp. 114-116.

McNally, B. and Bradley, G.L. 2014. Re-conceptualising the reckless driving behaviour of young drivers. *Accident Analysis & Prevention.* 70(0), pp.245-257.

McNamara, M.S. 2005. Knowing and doing phenomenology: The implications of the critique of ‘nursing phenomenology’ for a phenomenological inquiry: A discussion paper. *International Journal of Nursing Studies.* 42, pp.695-704.

Mehmood, A. 2010. An integrated approach to evaluate policies for controlling traffic law violations. *Accident Analysis & Prevention.* 42(2), pp.427-436.

Menzel, A. 2011. Between Ex-Combatization and Opportunities for Peace: The Double-Edged Qualities of Motorcycle-Taxi Driving in Urban Postwar Sierra Leone. *Africa Today, Indiana University Press.* 58(2), pp.96-127.

Miles, M.B. et al. 2014. *Qualitative data Analysis: A Methods Sourcebook.* California: SAGE Publications, Inc.

Milton, J.C. et al. 2008. Highway accident severities and the mixed logit model: an exploratory empirical analysis. *Accid Anal Prev.* 40(1), pp.260-6.

Mirzaei, R. et al. 2014. Dominant role of drivers' attitude in prevention of road traffic crashes: A study on knowledge, attitude, and practice of drivers in Iran. *Accident Analysis & Prevention.* 66(0), pp.36-42.

Morenikeji, W. and Umaru, E. 2012. Flying without navigational aids – The case of commercial motorcyclists in Minna, Nigeria. *Transportation Research Part F: Traffic Psychology and Behaviour.* 15(3), pp.311-318.

Mullai, A. and Paulsson, U. 2011. A grounded theory model for analysis of marine accidents. *Accid Anal Prev.* 43(4), pp.1590-603.

Musselwhite, C.B.A. et al. 2012. Public attitudes towards motorcyclists' safety: A qualitative study from the United Kingdom. *Accident Analysis & Prevention.* 49(0), pp.105-113.

Myers, M.D. and Newman, M. 2007. The qualitative interview in IS research: Examining the craft. *Information and Organization.* 17(1), pp.2-26.

Nantulya, V.M. and Reich, M.R. 2002. The Neglected Epidemic: Road Traffic Injuries in Developing Countries *Education and Debate BNJ* 324.

Nduka, J.K. and Orisakwe, O.E. 2010. Assessment of Environmental Distribution of Lead in Some Municipalities of South-Eastern Nigeria. *International Journal of Environmental Research and Public Health 2010.* 7, pp.2501-2513.

Newnam, S. et al. 2014. Exploring differences in driving behaviour across age and years of education of taxi drivers in Addis Ababa, Ethiopia. *Safety Science.* 68(0), pp.1-5.

Nwadiaro, H.C. et al. 2011. Motorcycle injuries in north-central Nigeria. *Nigerian Journal of Clinical Practice.* 14(2), pp.186-189.

Odumosu, A. and Yaro, D. [undated]. *Perception of Motorcycle Infrastructure, Provision And Use In Abuja Metropolis.* Nigeria Institute of Transport Technology [NITT], Nigeria.

Ogunbodede, E.F. 2008. Urban Road Transportation in Nigeria from 1960 to 2006: Problems, Prospects and Challenges. *Ethiopian Journal of Environmental Studies and Management.* 1(1).

Ogunlana, S.O. et al. 1998. Desman: A dynamic model for managing civil engineering design projects. *Computers & Structures, Pergamon Press Ltd.* 67, pp.401-419.

Ogunmodede, T.A. et al. 2012. Factors Influencing High Rate of Commercial Motorcycle Accidents in Nigeria. *American International Journal of Contemporary Research.* 2(11), pp.130-140.

Ogunmodede, T.A. and Akangbe, C.A. 2013. Effect of road safety information availability and utilization on commercial motorcycle accidents in Nigeria. *Academic Journals.* 5(3), pp.68-76.

Ogunrinola, I.O. 2011. Informal Self-Employment and Poverty Alleviation: Empirical Evidence from Motorcycle Taxi Riders in Nigeria. *International Journal of Economics and Finance.* 3(2).

Okoli, C. and Pawlowski, S.D. 2004. The Delphi method as a research tool: an example, design considerations and applications. *Information & Management.* 42(1), pp.15-29.

Olawole, M.O. et al. 2010. Risk perceptions among users of commercial motorcycles in cities of southwestern nigeria. *Ife Psychologia.* 18(2), pp.253-269.

Olowokudejo, F. and Aduloju, K. 2010. Perception of parties to third party motorcycle insurance policy in lagos metropolis, nigeria. *International Journal of Economic Development Research and Investment.* 1(2 & 3), pp.107-114.

Olubomehin, O.O. 2012. The Development and Impact of Motorcycles as Means of Commercial Transportation in Nigeria. *Research on Humanities and Social Sciences.* 2(6), pp.231-239.

Oluwadiya, K.S. et al. 2009. Motorcycle crash characteristics in Nigeria: implication for control. *Accid Anal Prev.* 41(2), pp.294-8.

Olvera, L.D. et al. 2012. Motorbike taxis in the "transport crisis" of West and Central African cities. *EchoGéo [En ligne].* 20.

Oni, S.A. et al. 2011. The Motorcycle Crash Characteristics in Lagos State, Nigeria. *Journal of Environmental Management and Safety.* 2(1).

Oriye, O. 2013. Urban expansion and urban land use in Ado Ekiti, Nigeria. *American Journal of Research Communication.* 1(2).

Oshima, R. et al. 2007. Study on regulation of motorcycle taxi service in bangkok. In: *Proceedings of the Eastern Asia Society for Transportation Studies*.

Oster, C.V. and Strong, J.S. 2013. Analysing Road Safety in the United States. *Research in transport economics.* (43), pp.98-111.

Oyesiku, O.K. and Odufuwa, B.O. 2002. Gender Perspective in Travel Behaviour of Motorcycle Passengers in Nigerian Intermediate Cities. In: Godard and Fatonzoun, eds. *Urban Mobility for All, CODATU X*, *The Netherlands*. Swets and Zeitlinger B.V., Lisse, .

Öz, B. et al. 2013. An investigation of professional drivers: Organizational safety climate, driver behaviours and performance. *Transportation Research Part F: Traffic Psychology and Behaviour.* 16(0), pp.81-91.

Öz, B. et al. 2014. Trip-focused organizational safety climate: Investigating the relationships with errors, violations and positive driver behaviours in professional driving. *Transportation Research Part F: Traffic Psychology and Behaviour.* 26, Part B(0), pp.361-369.

Özkan, T. et al. 2012. Motorcycle accidents, rider behaviour, and psychological models. *Accident Analysis & Prevention.* 49(0), pp.124-132.

Özkan, T. et al. 2006. Driver Behaviour Questionnaire: A follow-up study. *Accident Analysis & Prevention.* 38(2), pp.386-395.

Perdicoúlis, A. and Glasson, J. 2006. Causal networks in EIA. *Environmental Impact Assessment Review.* 26(6), pp.553-569.

Pfaffenbichler, P. 2003. The strategic, dynamic and integrated urban land use and transport model MARS (Metropolitan Activity Relocation Simulator)

Development, testing and application PhD thesis, Vienna University of Technology.

Pfaffenbichler, P. 2011. Modelling with system dynamics as a method to bridge the gap between poliutics, planning and science? Lessons learnt from the development of Land use and Transport Model, MARS *Transport Reviews.* 31(2), pp.267-289.

Polinsky, A.M. and Shavell, S. 2001. Corruption and optimal law enforcement. *Journal of Public Economics.* 81, pp.1-24.

Pope, C. et al. 2000. Qualitative research in health care: Analysing qualitative data. *BMJ [PMC free article] [PubMed].* 320, pp.114-116.

Pucher, J. et al. 2005. Urban Transport Crisis in India *Transport Policy.* 12, pp.185-198.

Pucher, J. et al. 2007. Urban Transport Trends and Policies in China and India: Impact of Rapid Economic Growth *Transport Reviews.* 27(4), pp.379-410.

Qudrat-Ullah, H. and Seong, B.S. 2010. How to do structural validity of a system dynamics type simulation model: The case of an energy policy model. *Energy Policy.* 38(5), pp.2216-2224.

Radzicki, M.J. and Taylor , R.A. 1997. *Introduction to System Dynamics A Systems Approach to Understanding Complex Policy Issues* Office of Science & Technology Policy and Cooperation

Rasmussen, J. 1997. Risk management in a dynamic society: A modelling problem. *Safety Science.* 27(2/3), pp.183-213.

Ree, D. et al. 2011. Developing Model Based Theories: Improving the Quality of Conversation. In: *International Conference of the System Dynamics Society*.

Rehak, L.A. et al. 2006. Systems archetypes for military dynamic decision making. Toronto: Department of national defence

Richards, L. and Morse, J. 2007. *Readme first for a user's guide to qualitative methods.* 2nd ed ed. Thousand Oaks, Sage.

Richardson, G.P. 1996. Problems for the future of system dynamics. *System Dynamics Review.* **12**(2), pp.141-157.

Richardson, G.P. and Andersen, D.F. 1995. Teamwork in group model building. *System Dynamics Review.* 11(2), pp.113-137.

RIPCORD-ISEREST. 2008. Accident Prediction Models and Road Safety Impact Assessment: recommendations for using these tools. . (Deliverable-D2.doc 506184).

Rubin, H.J. and Rubin, I.S. 2005. *Qualitative interviewing: the art of hearing data.* 2nd edition ed. Thousand Oaks: Sage.

Salako, A. et al. 2013. Risk behaviors for road traffic accidents and severe crash injuries among commercial motorcyclists in Sagamu, South West, Nigeria. *Online Journal of Medicine and Medical Science Research.* 2(2), pp.19-23.

Saldana, J. 2013. The coding manual for qualitative researchers. London: Sage.

Saleh, W. et al. 2009. Real World Driving Cycle for Motorcycles in Edinburgh *Transport Research Part D 14.* pp.326-333.

Schoderbek, C.G. et al. 1980. *Management Systems: Conceptual Considerations.* Dallas, Texas, : Business Publications Inc.

Senge, P.M. 1990. The fifth discipline: The art & practice of the learning organization. New York: Doubleday.

Shams, M. et al. 2011. Taxi drivers' views on risky driving behavior in Tehran: A qualitative study using a social marketing approach. *Accident Analysis & Prevention.* 43(3), pp.646-651.

Shepherd, S. et al. 2009. Overcoming Barriers to Model Use. *EJTIR.* 9(3), pp.277-295.

Shepherd, S.P. 2014. A review of system dynamics models applied in transportation. *Transportmetrica B: Transport Dynamics.* 2(2), pp.83-105.

Shin, D. and Konrad, A.M. 2014. Causality Between High-Performance Work Systems and Organizational Performance. *Journal of Management.* 0.

Sietchiping, R. et al. 2012. Transport and mobility in sub-Saharan African cities: An overview of practices, lessons and options for improvements. *Cities.* 29(3), pp.183-189.

Smith, N. 2000. First Steps in Formalising Qualitative Systems Dynamic s. In: *14th International Workshop on Qualitative Reasoning*, pp.138-143.

Solagberu, B.A. et al. 2006. Motorcycle injuries in a developing country and the vulnerability of riders, passengers, and pedestrians. *Injury Prevention* 12, pp.266-268.

Spectora, J.M. et al. 2001. Models and simulations for learning in complex domains: using causal loop diagrams for assessment and evaluation. *Computers in Human Behavior.* 17(5-6), pp.517-545.

Sperley, M. and Pietz, J.A. 2010. *Motorcycle Lane-Sharing* Oregon: Oregon Department of Transport Research Section.

Stake, R.E. 1995. *The art of case study research.* Thousand Oaks, Sage.

Stanojević, P. et al. 2013. Influence of traffic enforcement on the attitudes and behavior of drivers. *Accident Analysis & Prevention.* 52(0), pp.29-38.

Sterman, J.D. 2000. Business Dynamics: Systems Thinking and Modelling for a Complex World. Boston: Irwin/McGraw-Hill.

Struben, J. and Sterman, J. 2008. Transition Challenges for Alternative Fuel Vehicle and Transportation Systems. *Environment and Planning B.* 35(6), pp.1070-1097.

Summala, H. 1996 Accident risk and driver behaviour. *Safety Science.* 22(1-3), pp.103-117.

Talvitie, A. 2012. Observed difference in corruption between Asia and Africa: The Industrial organisation of corruption and its cure. In: *IPMR*.

Tetali, S. et al. 2013. Qualitative study to explore stakeholder perceptions related to road safety in Hyderabad, India. *Injury.* 44, Supplement 4(0), pp.S17-S23.

Thorne, S. 2000. Data analysis in qualitative research. *Evid Based Nurs.* 3, pp.68-70.

Tien-Pen, H. et al. 2003. *A comparison study on motorcycle traffic development in some Asian countries – case of Taiwan, Malaysia, and Vietnam.* The Eastern Asia Society for Transportation Studies (EASTS) International Cooperative Research Activity.

TranSafety. 1998. Strategies for solving Urban Transportation Problems in Developing Countries.

Twinn, S. 1997. An exploratory study examining the influence of translation on the validity and reliability of qualitative data in nursing research. *Journal of Advanced Nursing.* 26, pp.418-423.

Ülengin, F. et al. 2007. An integrated transportation decision support system for transportation policy decisions: The case of Turkey. *Transportation Research Part A: Policy and Practice.* 41(1), pp.80-97.

Underwood, P. and Waterson, P. 2013. Systems thinking, the Swiss Cheese Model and accident analysis: A comparative systemic analysis of the Grayrigg train derailment using the ATSB, AcciMap and STAMP models. *Accid Anal Prev.* [no volume number], p[no pagination].

University of Surrey. [no date]. *Introduction to research.* [Online]. [Accessed 29 December]. Available from: http://libweb.surrey.ac.uk/library/skills/Introduction%20to%20Research%20and%20Managing%20Information%20Leicester/page_61.htm).

Uschold, M. et al. 1995. *The enterprise ontology.* Edinburgh, UK: The University of Edinburgh, UK.

Vensim Ventana Simulation Environment, Vensim Documentation. 2007. 149 Waverley Street, Belmont, MA 02178: Ventana Systems Inc.

Verma, A. et al. 2011. Recommendations for driver licensing and traffic law enforcement in India aiming to improve road safety *Current Science (Bangalore).* 100(9), pp.1373-1385.

Videira, N. et al. 2014. Improving understanding on degrowth pathways: An exploratory study using collaborative causal models. *Futures.* 55(0), pp.58-77.

Vlachos, D. et al. 2007. A system dynamics model for dynamic capacity planning of remanufacturing in closed-loop supply chains. *Computers & Operations Research.* 34(2), pp.367-394.

Wand, Y. and Weber, R. 1993. On the ontological expressiveness of information systems analysis and design grammars. *J. Inf. Syst.* 3(4), pp.217-237.

Warner, H.W. and Åberg, L. 2014. Drivers' tendency to commit different aberrant driving behaviours in comparison with their perception of how often other drivers commit the same behaviours. *Transportation Research Part F: Traffic Psychology and Behaviour.* 27, Part A(0), pp.37-43.

West, R. et al. 1993. Direct observation of driving, self report of driver behaviour, and accident involvement *Ergonomics.* 36(5), pp.557-567.

Winter, J.C.F. and Dodou, D. 2010. The Driver Behaviour Questionnaire as a predictor of accidents: A meta-analysis. *Journal of Safety Research.* 41(6), pp.463-470.

Wolstenholme, E.F. 1992. The definition and application of a stepwise approach to model conceptualisation and analysis. *European Journal of Operational Research.* 59(1), pp.123-136.

Wolstenholme, E.F. 1999. Qualitative vs quantitative modelling: the evolving balance. *Journal of the Operational Research Society.* 50, pp.422-428.

Wolstenholme, E. 2004. Using generic system archetypes to support thinking and modelling. *System Dynamics Review.* **20**(4(Winter 2004)), pp.341–356.

Wolstenholme, E.F. and Corben, D.A. 1993. Towards a core set of archetypal structures in system dynamics. In: *The role of strategic modelling in international competitiveness, Cancum, Mexico*. System Dynamics Society.

Woudenberg, F. 1991. An evaluation of Delphi. *Technological Forecasting and Social Change.* 40, pp.131-150.

Xu, J. 2009. The Robbery of Motorcycle Taxi Drivers (Dake Zai) in China: A Lifestyle/Routine Activity Perspective and Beyond. *British Journal of Criminology.* 49(4), pp.491-512.

Xu, J. 2012. Drive-away policing and situational crime prevention in China: an analysis of motorcycle ban (jinmo) policy in Guangzhou. *Int J Offender Ther Comp Criminol.* 56(2), pp.239-64.

Yakubu, A.T. 2012. Determinants of Earnings among Commercial Motorcycle Operators in Kwara State, Nigeria. *International Journal of Economics and Management Sciences.* 2(2), pp.11-17.

Yearworth, M. and White, L. 2013. The uses of qualitative data in multimethodology: Developing causal loop diagrams during the coding process. *European Journal of Operational Research.* 231(1), pp.151-161.

Zucker, D.M. 2009. *How to Do Case Study Research.* School of Nursing Faculty Publication Series. Paper 2: University of Massachusetts - Amherst.

Appendix 1: Fieldwork script extract

What Participants will do:

Participants will be involved either in a personal interview or in a group discussion. Contacts with participants in expert groups will be three times each while contact with non-expert groups will be once. This single contact should normally be before the second contact with participants in the expert group. Duration is also shown to be about one hour or less for all except the group discussion exercise which may last up to 2 hours maximum. Though, it is a semi-structured interview, these three questions will be general to all participants both in interviews and in discussion groups. These are:

> In your opinion, how does the operation of commercial motorcycles result in safety problems? What are the particular factors identifiable?
>
> Describe what each of these factors mean to you.
>
> What values/quantities would you give these factors? How have they been changing over time? How do you expect them to change in future? Can you sketch these variation/changes? Do you have any record or data to explain this?

These questions will be further explained in the course of the exercise. Many other questions will also be asked. In addition, all participants will be asked for secondary data they may have which can be relevant to the study. For participants in the expert groups, these other questions will be raised in the second contact:

> Do the diagram/map of factors and links being shown represent your view as discussed in the first meeting?
>
> Do you want to amend it, remove some part, or add anything to the map?
>
> Other people have these views shown on other maps. What do you think about their views?

A third contact with participants in the expert groups will raise this question:

> This is a combination of maps from over ten individuals/groups. Do you agree with it this way? Do you want to make additional comments?

Other questions will follow from answers given to these questions and will therefore vary from participant to participant.

Appendix 2: Additional equations

Section 10.6.1

1 critical attention level = (public perception about risk in operation + 1) * modes share in traffic / critical attention level) , 0)

2 previous risk perception= DELAY FIXED (public perception about risk in operation ,time to form perception , 0)

Section 10.6.2

3 Violation utility effect = violation utility*(1-violation utility factor)

Section 10.6.3

4 bribe factor rate= -((equivalence of number of officers motivated for overtime service/total legal enforcement)-previous ratio in overtime service)*prosecution rate/unit time

5 bribe factor= INTEG (bribe factor rate, prosecution rate)

These formulations is chosen based on the Bowles and Garoupa (1997) model (B-G model) described in Chang et al. (2000, 36). This B-G model indicates that high corruption level supports low rent and low corruption promotes high rent.

6 previous ratio in overtime service= DELAY FIXED (equivalence of number of officers motivated for overtime service/total legal enforcement, time to review earning, equivalence of number of officers motivated for overtime service/ total legal enforcement)

Section 10.7.1

7 change in total drivers = total drivers / previous total drivers

8 experience = ((New Entrant Drivers * repayment period) + (Ambivalent Drivers* maturity) + (Established Driver * adroit drivers' experience)) / (New Entrant Drivers + Ambivalent Drivers + Established Driver)

9 Effect of maturity = MIN((ZIDZ(initial established drivers, initial established drivers+initial new drivers)), ZIDZ(Established Driver, Ambivalent Drivers+New Entrant Drivers))

10 Previous total drivers = Fixed delay (total drivers, 1, total drivers)

11 effect of alternative ownership options = MAX (0.25, ZIDZ (expensive option share, self-owned fraction))

12 self-owned fraction = 1 - expensive option share

Section 10.7.2

13 average income per effective hour = driver's capacity less repayments/ (Working Period * work effectiveness factor)

14 time to mature = maturity + repayment period

15 actual income = drivers' income - average payment per day

16 effect of income shortfall = SMOOTH (income shortfall ratio, time to form expectation)

Section 10.8.2

17 alcohol and drug effect = MAX (Alcohol and Drug Users * influence of use/ total drivers , 0)

18 cumulative effect of change in policing on violating opportunity = WITH LOOKUP(violating opportunity , ([(0,0.2)-(2,2)], (0.00611621,0.223684), (0.232416,0.239474), (0.40367,0.263158), (0.605505,0.342105), (0.721713,0.444737), (0.850153,0.642105), (0.954128,0.8),(1,1), (1.07034,1.25), (1.14985,1.49474), (1.24771,1.67632), (1.38838,1.81053), (1.55963,1.88158), (1.70031,1.91316), (2,2)))

19 effect of lack of training = 1 - drivers' training

20 tendency change effect on utility= violation frequency-previous violation frequency

21 violation utility factor= ZIDZ(tendency change effect on utility, violation frequency)

22 violation frequency= detectable violations frequency + undetectable violations frequency

23 previous violation frequency= DELAY FIXED(violation frequency, 1, violation frequency)

Appendix 3: Additional graphs

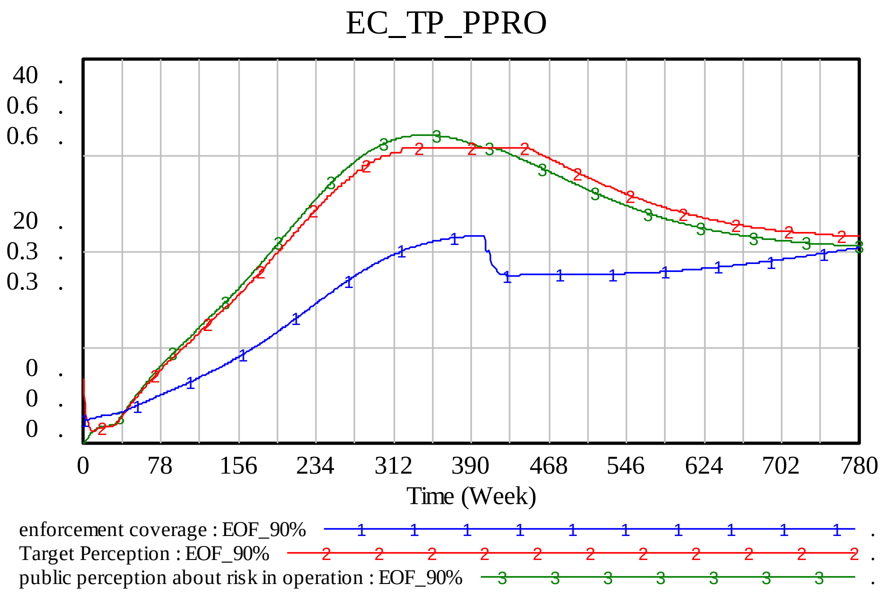

Figure A3.1: Additional support for figure 10.29

(Graph showing that **enforcement coverage** fell after **target perception** of enforcement system met with **public perception about risk in operation**)

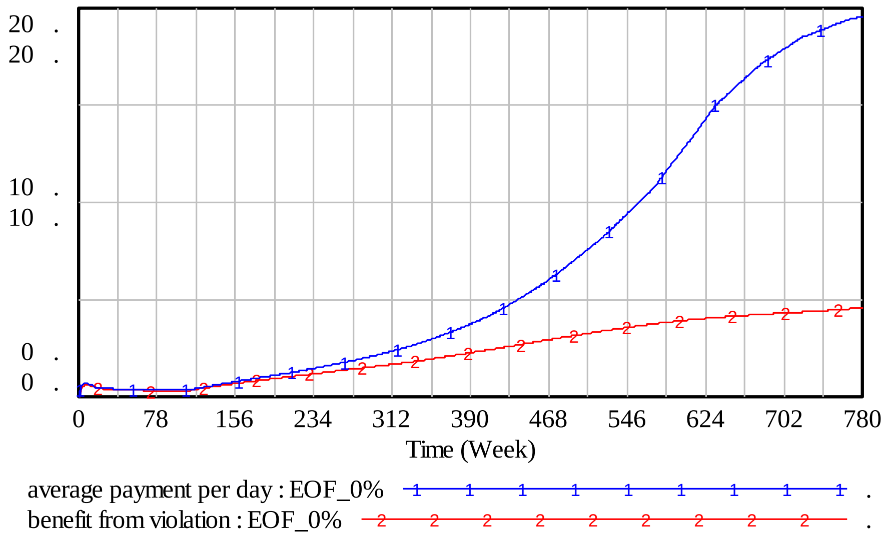

Figure A3.2: Supporting graph for figure 10.48

(The widening gap between **average payment per day** and **benefit from violation** in this graph is responsible for the improved **tendency to violate** in figure 10.48)

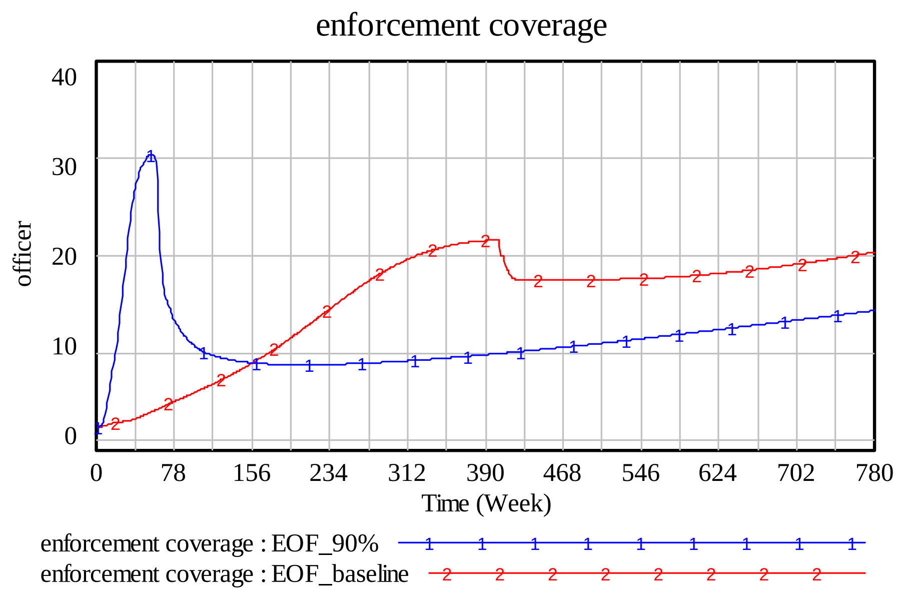

Figure A3.3: Supporting graph for figure 10.49

(Comparison of **enforcement coverage** between baseline condition and 90% **expensive option fraction** condition)