A COMPARATIVE ANALYSIS OF BORNHUETTER FERGUSON AND BASIC CHAIN LADDER MODEL IN MOTOR INSURANCE: A CASE STUDY OF CIC INSURANCE.

BY

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DECLARATION

Declaration by student

I hereby declare that this is my original work; it has never been partially or wholly presented to any institution for the award of any degree to the best of my knowledge.

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Approval by the supervisor

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To my mum Nancy Angira and Dad Joel Nyanumba, my brothers and sister, I will forever be indebted to you. Great thanks to my wife Wendy and daughter Shelyanza Motanya for believing in me before I believed in myself.

ABSTRACT

Claim reserving for motor insurance business is critically important.This has led to a slight mystery in motor insurance on how to go about claim reserving for which claims has not yet come in and there are still some figment of the future. One major critical problem in motor insurance has always been on how to calculate appropriate incurred but not reported claim reserve (IBNR) based on the data that is available on the claims that has occurred. Identifying the most appropriate model to use in modeling and estimating Incurred but not reported (IBNR) claim reserve in motor insurance has made claim reserving more intricate coupled with risks of delay and underwriting process. This study aimed at comparing the analysis of IBNR in motor insurance using Bornhuetter Ferguson and Basic Chain Ladder model and determining the most appropriate model to use in claim reserving estimation in motor insurance so as to avoid and prevent companies from going into financial insolvency. The objectives of this study were; to estimate and compare outstanding motor insurance claim liability in each development year,evaluating and comparing the total claims for each particular accident year as well as to estimate and compare the next year's motor insurance outstanding liability. This was achieved by applying the model in calculating outstanding reserves of motor insurance which was then determined by summing up all individual outstanding liability in each development year. The statistical tool used was MS. Excel. The estimates obtained from Bornhuetter Ferguson and Basic chain ladder model was then examined to determine the one that best fit the data at hand for any significant difference. This research recommended the use of basic chain ladder model since the claim development pattern was stable and there was a large amount of settled claim amount.However, both Basic Chain Ladder and B-F model should be applied cautiously, respecting their circumstance under usage by combining them with their subjective assessment of actuaries based on their expertise and experience.

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CHAPTER ONE

INTRODUCTION

1.1 Background

Ideally, the world is made up of various forms of insecurity ranging from various sources and uncertainties.In the current state of the world of modernization and globalization, there are a lot of risks and uncertainties that surround every individual. In less developed countries like Kenya, sense of safety and security are the major issues that are put under consideration. Generally, "People seek security", which can be defined as a state of protection against any danger or threat [4]. Nevertheless, risk is a complex issue which cannot be highlighted or put across without having to think about loss. Having economic security, makes one to be in a position to sustain himself/herself in provision of all basic necessities in the present and future. This role is greatly played by insurance companies

Insurance company is a specialized financial institution whose role is to give provision of various insurance policies so as to give protection to an individual and business against the risk of financial loss in return to a regular payment of premiums. Insurance is a mechanism in which the insurer transfers his/her risks of financial loss in exchange for regular payment of agreed amount which is fixed whereby the payment is due before the contingent claim is serviced by the insurer. Here, contribution by people is made into a pool for the purpose of mainly compensating few of those who

suffer the loss [2].Therefore, the insured is guaranteed of reimbursement due to loss incurred to people or companies for their regular prepayment to motor insurance company. This kind of insurance policy can be stated as an agreement under which the insurer makes an agreement with the insured for compensation due to the loss arising de to a particular cause as specified in the agreement policy which can be demolition or deprivation. However, the insurer do faces the problem of delay before the claim is reported and there is also a further delay before the reported claim get settled.

Claim is a demand for payment by the insurer of an accident that maybe covered in a given arrangement or contract. Here, claim reserving is the key and it plays a major role in every insurance industry and its a major determinant in the future lifetime of insurance industry. Reserve is defined as a proportion of the amount of money set aside by the insurance company for the eventual payment of claim that has occurred. This implies that the credibility and survivability of insurance industry relies on the claim reserving models.

In Motor insurance,its a challenge to give the determination of the liability of the insured which has occurred and may lead for further investigation by risk assessors and any other practitioners of the company in order to seal their agreement deal and this might lead to a delay between the time of claim occurrence as the time of claim payment. Reserves are often classified in the balance sheet of the insurance company because they represent the expected obligation by insurer that is to be met. They are quite effec-

tive because they are applied in measuring the company's financial health and this implies that inaccurate reserve estimation can present a false image of financial position of the motor insurance company hence there is need for proper and accurate estimation of reserves based on information and kind of data that is available on that claim in motor insurance. Therefore, motor insurance companies should come up with with more effective model to asses the expected loss which is to be met based on the policies which originated in the year before. This will enable motor insurance companies to set up resources now so that they will be able to meet their future obligation to the insured[7].

A reported claim is the one whose record is intact and it has already been processed by the insurer. But claims do occurs almost daily but are not reported on same day due to various reasons. This reasons may be due to normal delay in claim reporting or due to challenges in determining and quantifying the size of the claim and so on. The only certainty and assurance known is that the provisions for those claims has to be made eventually no matter how long it takes. These claims which are not yet known to the insurer due to delay in reporting but for which a liability is believed to exist at the reserving time are known as Incurred but not Reported claims. Data from historical claim experience are the ones that are applied in the construction of the estimates for the future payments which consist of a triangle of incremental claims grouped based on the development time (time elapsed since accident) and the time of occurrence of claim or time of origin(when claim was incurred). The challenge is to

identify the most appropriate model that can accurately give the estimates which will be used effectively by general insurance companies so as to make right decisions on claim reserves. This is because overestimation of claim reserves will greatly affect investment negatively because much money will be used for reserving instead of income generation in other forms of investment similarly, underestimation of reserve will negatively impact on the insurer since they may not be able to compensate the insured or settle any claims that has occurred. Therefore, on the basis of the data obtained from historical experience, the actuarial practitioner or actuary can obtain estimates on prediction of outstanding claim liability or risk by using delay triangle result[13]. The most common and popular methods used for claim reserving are inflation adjusted chain ladder model, Bornhuetter-Ferguson model and basic chain ladder[12].

Forecasting these claim liabilities and havig adequate reserve to meet these claim demands is paramount part of the business of motor insurance company. Therefore, its important for motor insurance company to know what to reserve at a regular interval so as to meet the demands of the claims arising from incident that have taken place but its liability cannot be actualized.

1.2 Incurred But Not Reported Claims (IBNR) in motor insurance

A claim is a payment demanded by the insured of the damages that may be covered under the policy insured. The decision on the use of the most effective and appropriate model in estimating outstanding claims such as Reported But Not Settled (RBNS) and Incurred But Not Reported (IBNR) claim is of great essence to preserve the solvency of insurance company in Kenya especially in Motor Insurance.

By general assumption, in general insurance companies i.e Motor insurance, claims that are associated with policy holders that occurs in a particular year are often reported to the concerned motor insurance company in the subsequent years or many years later. However payout may be delayed due to some reasons which imply that there is need for enough reserve to set aside to cover these arising obligation hence the need for better and accurate claim approximation in Motor Insurance companies.

The claim reserve in this case is made of both reserves from known and unknown claims which forms IBNR. Therefore, in General, loss reserve is made of two groups that are under consideration in Motor insurance such as reported(known) claim and unreported claims which has occurred but not yet known to the insurance [8]. Therefore, the total reserve can be classified as reserve for the known claim and IBNR.

Reserve of the known claim as depicted above is the compesation amount that will be required to settle all the reported claims not including the

payments already made on this claims [3].

In insurance, reported claims is the one whose central record exist and is intact sice it has arleady been processed.[14]

IBNR are those claims that have occurred implying that the insured has experienced a certain loss that he/she is insured against by the insurer but the insured has not yet reported the claims to the insurer. Therefore, the term IBNR is defined as the claim whose liability is believed to be in existence at the date of reserving but its not yet known to the insurer.

1.3 Reported But Not Settled (RBNS) Claims in Motor Insurance

These are claims whose reports exist but have not been paid by the elapse of the accounting time in the insurance company. Both IBNR and RBNS has not been paid by the insurer by the end of the accounting time.

1.4 Basic Concepts

In this section we start reviewing the basic definitions that are key to this study on modeling motor insurance claims using Bornhuetter Ferguson model and basic chain ladder model.

1.4.1 Insurance

Is a mechanism in which the insurer transfers his/her risks of financial loss in exchange for payment of agreed mount of money which is fixed whereby the payment amount is made before the occurrence of the contingent claim which is serviced by the insurer.

1.4.2 Claim

Is a demand for payment by the insured of damages that maybe covered by the policy of contract between the insured and the insurer

1.4.3 Basic chain ladder Model

Is a prominent actuarial loss reserving model that is used to compute incurred but not reported claims in a manner of run-off triangles. This model assumes that inflation of of claims, change in the mix of business operations, change in claim settlement rate, etc can be ignored effectively as well as all other external factors. Therefore this model assumes the form;

$$Model : C_{i,j} = S_i R_j + \varepsilon_{i,j}$$

Where;

S_i -This is the ultimate total cost of incurred claims in the period of incident i.

R_j -This is the proportionate amount of total payment made by the time of elapse of a given year of development, j.

$C_{i,j}$ -This is the cumulative amount of payment up to the end of period j.

$\varepsilon_{i,j}$ - Is the error term

1.4.4 The Bornhuetter-Ferguson Model(The B-F Model)

The B-F model is different from basic chain ladder model in relation with ultimate claim, S_i, i which can alternatively replaced by S_i^{BF}, which is an estimate based on the expert judgment and external information. Therefore, the B-F Model takes the following form:

$$Model : C_{i,j} = S_i^{BF}.R_j + \varepsilon_{i,j}$$

with parameters;

S_i^{BF} - This is an estimate which is obtained by application of a simple loss ratio on a written premium or on the basis of other measures of exposure which are suitable.

R_j -This is the total payment proportion which is made by the end of year of development j.

$\varepsilon_{i,j}$ - Is the error term

The following assumptions hold for this model;

(i). The loss ratio given is assumed to be correct.

(ii). There is stability in claim development pattern.

(iii). The historical claim development does not provide further information on the expected development of claims.

1.5 Insurance Industry in World and Africa

Global insurance industry is mainly dominated by countries which are already developed. This is a group of seven countries in the world which accounts for 65 percent of the world's insurance total premiums contributed. Developed countries such as United State of America and United Kingdom has greatly engaged in insurance which has greatly received phenomenal awareness with the incorporation of insurance internet operation.

However, Africa is still in its developing state in terms of insurance industry and it has not been incorporated by majority of the Africans. The main challenge facing people's insurance incorporation in Africa is "Lack of respect by people for financial service providers as well as insurance and the credibility of insurance companies to meet demand for payment of claims which arise". However, the insurance industry in Africa continues to to grow rapidly as reflected by increase in total premiums over period. The total premium volume reported by all countries in Africa increased by almost 5% percent in 2018 at 68.383 billion USD against 65.165 billion USD in 2012.

As reflected by 2018 data, based on Sigma publication, the shares from African Market remained more stable at 1.31 percent of global premium. The top three countries such as South Africa (70.59%) of whole continental

premium, Moroco (6.7%) and Kenya (3.12%) were unchanged. From that, it is clear that Kenya is also in its early stages of developing and incorporating insurance industry as depicted by increase in insurance industry in Kenya.

1.6 Insurance Industry In Kenya

Kenyan motor insurance sector is ripe for investment and grow for insurance industry. The motor insurance industry in Kenya is governed and controlled by insurance Act which was enacted and created in the year 1965. After independence in 1963, the Kenyan government decided to have a control in the rising insurance industry which was being controlled by branch officer of foreign companies such as Europe and India. In 1986, a new insurance Act was enacted. The office of the commission was established by the Act of insurance as the controller and regulator of insurance industry in Kenya and stipulated the roles and functions of the enacted office. Act number 11 of 2006 established the insurance regulation Authority(IRA) with chief executive officer to take up the role of regulating, supervising and developing insurance industry and the commissioner of insurance as managing director. Despite the growth of general insurance industry in Kenya, there has been hindrance to its growth. The main hindrance of the growth of insurance industry in Kenya is the claim payment delay by the insurers.There is a need for claim payment due to rise in scale of frequency of disaster and other uncertainties as time passes

without going financial insolvency. This can be done effectively and accurately by estimating claim reserves by the most appropriate model to avoid crippling the insured and at the same time to ensure insurance industry thrives. Therefore, the appropriate reserve should be calculated to meet these future claims. This will enable and guide insurance companies in Kenya against insolvency as well as elevating their credibility and boosting customer confidence. Therefore,insurance companies are always expected to leave enough amount of money from the insurance package customers have bought into. This will help to guide the company against insolvency.

In order to enhance availability of funds in motor insurance companies, the claim reserving is the way to go so as to meet the demands of the insured any time there is a demand for payment by the insured. Claim reserves are future obligations for an insurance industry. There are a various of actuarial models through which claim reserving can be done. However, despite the significance of these claim reserving models in motor insurance companies, they are still used by small number of actuarial practitioners. This could be due to lack of general understanding of the applied models, lack of flexibility and variability in some methods.

Most of motor insurance companies in Kenya have been using algorithm based loss reserving techniques despite those techniques being simple and easy to apply. Only a few of Kenyan insurance companies uses these models and they are being used randomly. There is need to compare in order to know the most appropriate model to use in estimating reserves and when

to use a particular model in claim reserving so as to maintain stability and financial solvency of motor insurance companies. The main reasons why these models are used by limited number of companies in Kenya is mainly due to lack of general understanding of the models and lack of variability and flexibility in some of these models.

1.7 Statement of the Problem

There has been a rapid increase in motor insurance industry in Kenya with influx of many insurance companies in the country on both foreign as well as well as local.Kenyans are increasingly becoming conscious of the need to do motor insurance. Notwithstanding the benefit and relevance of motor insurance to the insured, there has always been a rising complaint from part of insured on the delay of motor insurance company o make payment for claims arising since they large amount of claims which are piling from one accounting period to another. To solve this challenge, the insurance companies are expected to give a solution so as to be able to serve the insured in time as well as anytime a demand for payment is made. Its very important for motor insurance company to set aside enough and sufficient reserve at regular intervals so as to make payment of any claim whenever it arises. Accurate and proper loss reserving is quite essential for insurance to maintain enough funds for loss or claim payment and to price their insurance products efficiently.

There is a need for insurance companies to set aside and maintain adequate

reserve to pay claims whenever they arise. This can be achieved if insurance companies chooses the most appropriate model in estimating claims to avoid underestimation and overestimation of reserves. Various studies has been done on comparative analysis of various reserving models in insurance. A research on comparative analysis of basic chain ladder model and over-dispersed poisson was done. However the two models were not based on the same assumption since basic chain ladder was deterministic model and over-dispersed poisson was stochastic model. Further research on comparative analysis of basic chain ladder, loss ratio and Bornhuetter Ferguson model on non-life insurance was intensively done. However, the models were applied on heterogenous data which was too general of which it was therefore recommended that the model should be applied on homogenous data such as motor insurance. Therefore, none of these studies has been done on comparing reserving models on homogenous data and under the same assumptions under consideration.

This therefore prompted for a need to do a a study on comparative analysis of two main claim reserving deterministic models such as Bornhuetter Ferguson(B-F) model and Basic chain ladder model on motor insurance to identify the most appropriate model to use in motor insurance companies in Kenya.

1.8 Objectives of the Study

The main objective of this research is to compare the analysis of Bornhuetter-Ferguson and Basic chain ladder model claim reserve in motor insurance in Kenya. This study will be guided by the following specific objectives;

1. To estimate and compare the outstanding motor insurance claim liability in each development year.

2. Evaluating and comparing total claims for each year of accident based on Bornhuetter-Ferguson model and Basic chain ladder model.

3. To estimate and compare the next year motor insurance outstanding liability using Bornhuetter-Ferguson and Basic chain ladder model.

1.9 Significance of the Study

This study was of great significance and importance since it will significantly and effectively guide motor insurance companies from being financial insolvent. The most appropriate model will effectively be chosen to forecast the claim amount which in return will be applied to forecasting future claims in motor insurance companies. This work will greatly assist motor insurance companies to minimize the burdens of claims as they pile from time to time which exert a lot of pressure on financial stability of an insurance company.

The insured will greatly benefit from this research since its application in motor insurance companies will help to ensure availability of enough funds

for claim payment in time based on the most appropriate model chosen since the company will have sufficient reserve capital.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction.

This area focuses and reviews some related literature to modeling claim reserve in Motor Insurance. In this literature, most of the studies have the most commonly used claim reserving methods such as Bornhuetter Berguson model and basic chain ladder model as follows:

Basic chain ladder is the most popular model for forecasting outstanding claim reserve as stated by [9]. [9] further said that the main cause of successful application of Basic chain ladder is due to the simplicity and it doesn't rely on any distribution.[15] clarified that the main reason behind the application of Basic chain ladder model is due to its exploration of available data in the run-off triangle and it gives estimates which are simple for estimation of total claims.

Basic chain ladder model dates back to 1996, [20] suggested that this revolved from chaining of sequence of ratios into a ladder of factors from which projections of the ultimate claims value is predicted to obtain ultimate value from past historical data.

[9]) did a study on the simplified chain ladder and presented it as a distribution free model. [9] went further and developed a stochastic model for the basic chain ladder whereby it was assumed that there was no specific distribution for claim reserve estimation. He derived standard error calcu-

lation of basic chain ladder model using a distribution free formula. In his methodology, [9] did a derivation and analyzed the estimates by comparing the findings of some parametric methods using a numerical example.

A lot of research has been done on basis chain ladder model in comparison with other models of claim estimation.

[11] did a comparative study of chain ladder model and over-dispersed poisson model whereby the two models were intensively conducted and analyzed. [11] found that the two models under study reproduced almost the same estimate of the expected reserve. nevertheless, [11] were of the view that the two predictive models were significantly different in terms of their expected claim reserve, similarly there were estimation issues which were not met by the assumption under consideration.

The two models were not built under the same assumption since chain ladder is deterministic model while over-dispersed poisson is a stochastic model hence not compared under same assumption.

[5] reviewed and did a comparative analysis of three main loss reserving models,chain ladder, expected loss ratio and Bornhuetter-Ferguson model whereby they emulated the advantages and disadvantages of each model and its application on estimating loss reserve in a non-life insurance. The three models were based on the general assumption that the experienced pattern of losses in the past will continue in the future. [5] recommended that in order to ensure that adequacy of loss reserve, advantage and disadvantage combined with subjective assessment of actuaries based on their expertise and experience.

However, the models were applied on the in-homogeneous data which was too general. [5] recommended that so as to obtain valid conclusion,the model should have been applied to homogeneous data.

[23] reviewed a gap in modeling technical reserve in short term insurance contract using deterministic and stochastic modeling models. [23] analyzed and compared different stochastic and deterministic models of claim reserving estimation for a short time contract with a given claim experience.

From his findings, B-F model gave a poor fit to the observed claim reserve hence it was not considered an appropriate model in estimating claim reserve for a short term kind of business hence not reliable. However, chain ladder model was found to provide a good approximation of claim reserve together with parametric model which had an advantage of goodness of fit test statistics and the estimate error. [23] therefore, recommended B-F model to be applied in estimating claim reserve in other forms of business line as well as comparing it with other models such as Basic Chain Ladder which is the most popular model of all [20]).

[21] did a comparison of bootstrapping and stochastic reserving models.[21] discussed different claim reserving models on the basis of the chain ladder model in combination with bootstrap model using as case study way. Comparative study was carried out among other stochastic models like poisson gamma and log-normal model.

[21] therefore recommended that a practitioner or actuary should decide the combination to use based on the available models so as to make good

approximation when making decision in setting up funds for reserve. It was concluded that the effectiveness in application of a particular claim reserving model can completely tested only with extensive case study scenario with homogeneous data from various line of business. Then the claim estimated results obtained are compared with how claim develop over time so as to estimate the best estimate of claim reserve. Hence need to do comparative analysis of commonly used deterministic models such as B-F and chain model as well as doing models validation to identify the one that is most appropriate to use.

Bornhuetter-Ferguson (B-F) model differs from simplified basic chain ladder in that it is based on external particulars as well as expert judgement although both extract their principles of operation and application from the run-off triangle.

Despite the fact that the concept of B-F model is based on the loss triangle, B-F model restricts its application of the percentage of the outstanding losses and use the multiplication of the premium earned with expected ultimate loss obtained. It is clear that the B-F application relies on outstanding ultimate loss predictors whereby every predictor is calculated by multiplying an estimate of the expected ultimate loss by an estimator of the proportion of the claim amount outstanding with respect to the ultimate one. However, this model is purely based on the concept of the loss triangle like basic chain ladder.

[17] did a research on both the chain ladder model and B-F model. [17] study came up with a model that infused both chain ladder model and

B-F model. He clarifies and admitted Mack's formula was a specialized case for basic chain ladder model. However, he merged the two models for the same purpose of chain reserving.

[18] did an extensive research on B-F model whereby they summarized it into three main categories; the simultaneous use of various forms of B-F model, the comparison of the different ultimate losses and the identification of the most appropriate one. They therefore backed their analysis using a numerical example. From [18] research, the findings indicated that B-F principle can be used to select an appropriate version of the extended B-F model for any run-off triangle.

[10] in his study titled "The predictor error of B-F" probed in to chain reserving. Mack commended by reviewing the existing literature on the chain ladder predictive error. There were no little knowledge in the predictive error in the B-F model. So [10] advised a stochastic model to formulate the prediction error of B-F reserve estimate. [10] went further and looked at the development pattern of the B-F model was different to the chain ladder model. The other parameter that he applied for the B-F model was different to the chain ladder model. The other parameter that he applied for the B-F reserve was a well-known initial estimate for the ultimate chain amount. [10] therefore concluded by using the results of the predictive error to the chain ladder model.

It is therefore evident from the literature that no much comparison that has been done for B-F model with respect to Basic chain ladder model given that the two models are popular and are being used interchange-

ably. Hence the need for comparative analysis of the two claim models so as to identify the most appropriate one in motor insurance claim reserving.

The following Chapter three of this work reflects the Methodology applied to achieve the stated objectives, followed by Chapter four which is Results and Discussion part where analysis was done with the discussion of the analyzed data. Finally, This work concludes with chapter five which is Conclusion and Recommendations part.

CHAPTER THREE

RESEARCH METHODOLOGY

This chapter outlines the various models adopted for this study. This chapter examines basic ideas and their clarification including the models of modeling reserves of the motor claim amounts. Finally, the chapter explains the approach adopted so as to selectively identify the most appropriate model that will best determines and give accurate reserve estimation in motor insurance company in Kenya.

3.1 Claim Settlement Process

Claim settlement is the prime objective of insurance, therefore, the policy holders effects insurance so that in return for insured to make a regular payment of premiums. An insurance company accepts the liability to compensate the insured on the occurrence of specific event of loss within a given period of time. However, for this event of loss to be compensated there is due process that is followed by the insured. This process is known as claim settlement process.

The claim settlement normally takes the following stages in general insurance:

$$Occurence\ of\ claim \rightarrow Claim\ Reported \rightarrow Claim\ Payment\ Made \rightarrow Claim\ File\ clos$$

However, claim settlement may take several years until it is finally settled. This is mainly due to the following reasons.

(i). Delay in Claim Reporting - The time between the occurrence of the claim and the time of reporting that involves notification at the concerned motor insurance company.

(ii). Delay in Claim settlement - Time interval between reporting date and final settlement due to reasons such as Severity of the claim, recovering process and the decision from court etc.

(iii). Reopening due to new i.e now claim development

3.2 Models and Mathematical Modeling of Claims

Much research work has been done on determination of loss reserve over time. Scholars and Actuaries have come up with a lot of Mathematical and Actuarial models to model pay out amount expected to be set aside in motor Insurance.

Majority of these scholars have modeled claim reserve based on a loss triangle theory over the decay. Loss triangle is a two dimensional matrix that are generated by accumulating claims data over a period of time. Run-off triangle is mainly used by majority of the practitioners due to the following underlying general assumptions;

(i). Claim settlement is done over a fixed number of a given development years.

(ii). Claim gradual increase in claim losses provided by the same number of years are known until the current calendar year.

With these general assumptions, claim data can be represented effectively in a form of loss triangle.

Claim data are represented by loss triangle which are $n * m$ matrix where elements $V_{,j}(i, j = 1, 2, ...)$ represent the claim amount incurred in a year i and paid with delay of $j - 1$ years or may also indicate aggregate values. In run-off triangle, development patterns are established of which these patterns are used in projection of claim cost used in reserving. Development factors are determined and applied to the appropriate case of incurred losses. The development factors may be applied to show the ratio between cumulative claim amount and claim number. Therefore claim development factor may give description on the ratio between cumulative claim amount between years or in consecutive years over a longer period of time.

In summary, highlights the purposes of the run-off triangle which has been used in a convention way of data presentation, easier to identify and see the consistency of patterns and relationships in past data experience, concise,logical and easier to explain for any data that demonstrate a reasonable development pattern.

Here, claims presentation are always attributed to the year of which the insurance policy was taken. When the loss incurred in the accident year and the time in years until the payment of the loss is refers to as development year. It may take sometime when a loss occurs to be known or paid

in full extent by the insurer.

The point is to estimate the value of the lower triangle which represent the claims that are expected to be reported in the years to come. Until the policies written are run-off and therefore the lower triangle is used to estimate the reserve.

Therefore, this study will compare the analysis of B-F and Basic chain ladder model in motor insurance In this study the B-F and Basic chain ladder model will effectively be compared since they are the commonly applied models in general insurance. Basic chain ladder is intuitively appealing and simple to calculate which often gives reasonable results making the model more popular.

The most popular statistical models used are basic chain Ladder and B-F. However, despite the B-F and basic chain ladder model being most applicable, they are rated differently due to their own deficiencies, hence the need to compare the two models.

3.3 Delay Triangle

Delay triangle which is also referred to as Run-off triangle is purely a tabulation showing the rate of claim reporting or claim settlement for groups of claims. Delay triangle is also a specific arrangements of historical claim data of the given motor insurance company which is applied for qualified claim reserve estimation. Claims Delay triangle data are generated when

there is a delay in settling incurred insurance claims. Data is arranged in a triangular format whereby the row, i denotes incident years and column,j reflects development years. The claim data analysis is based on a set of motor insurance claim data .

3.4 Presentation of Claim Data

The techniques for claims reserve estimation that are presented always require data to be presented in the form of a delay triangle. The data in this presentation is cross-classified with respect to the year of origin and development period. The year of origin varies according to various factors such as when the policy relating to policy underwriting was enacted, year for occurrence of claims and claim reporting time, while claim development year refers to the duration from the time of origin when the occurrence of claim took place, paid by the insurer or reported to the insurer.

By standard convention, the year of development relative to the year of origin is designated as development year zero. Definition of claim cohort specifically depends on the definition of claim occurrence in each year of origin and development year. This therefore mean that, one can input each entry in delay triangle as claim payment in development year j having the claim occurrence taken place in the year of origin i.

Delay triangle is always generated on the condition that there is a delay in claim settlement by motor insurance company. Therefore, the format for this kind of presentation is that the delay triangle in which the row i

denote the year occurrence of the incident and column j depicts the year of development of a claim.

The general format of a delay triangle is given below;

Year of origin	Development Year 1 2 3 ...j n-1.. n
1	$C_{1,1}$ $C_{1,2}$ $C_{1,3}$ $C_{1,..j}$ $C_{1,n-1..}$ $C_{1,n}$
2	$C_{2,1}$ $C_{2,2}$ $C_{2,3}$ $C_{2,..j}$ $C_{2,n-1..}$
.	.
.	.
.	.
i	$C_{i,1}$ $C_{i,2}$ $C_{i,3}$ $C_{i,..j}$
.	.
.	.
.	.
n	$C_{n,1}$

From the above delay triangle,$C_{i,j}$ denotes the increment claim amount which occurred in the year of origin i, to be paid out based on development year j. We therefore define the cumulative claim amounts with incident year i which was reported up to, and including, delay period j by;

$$S_{i,j} = \sum_{k=1}^{j} C_{i,k} \tag{1}$$

Therefore, the total claim amount in the year of origin i is denoted as $S_{i,j}$ where $i = 1, 2, ..., n$ which is cumulative loses that have occured in year i and are settled until the end of period j.We take into consideration $S_{i,j}$ for which we have an observation if $i + j \leq n$ and $S_{i,n}$ is assumed to be the ultimate claim amount.

3.5 Loss Development Data

Here, a portfolio is put into consideration with an assumption that each portfolio claim is settled either in the year of origin or in the following j development years where $j = 1, 2, ..., n$. This portfolio can be modeled in the following ways;

(i). Incremental loss Approach.

(ii). Cumulative Loss Approach.

3.6 Incremental Loss Approach

For a portfolio modeling to be done by incremental losses approach, we put into consideration a family of random variables $C_{i,j}$ where $i, j = 1, 2, ..., n$ and define $C_{i,j}$ as loss incurred in the year of origin and settled with a delay of j years hence development year j and in calendar year $j + 1$

We take the assumption that $C_{i,j}$ i.e incremental loss are observable of calendar year $i + j \leq n$ and assume that they are non observable in the calendar years $i + j \geq n + 1$.

3.7 Cumulative Loss Approach

For a portfolio modeling to be done by cumulative losses approach, we put into consideration random variable $S_{i,j}$ where $i = 1, 2, ..., n$ and $j = 1, 2, ..., n$ and we interpret $S_{i,j}$ as cumulative losses of incident year i with the settlement done after a delay of utmost j years and not later than a development year j.

We define $S_{i,j}$ as the cumulative loss of the year of origin i with respect to development year j to $S_{i,n}$ which is the ultimate cumulative amount in the current calendar year n to development year j. With the assumption that $S_{i,j}$ i.e (cumulative losses) is being observed for the calendar year $i+j \leq n$ and non observable for the calendar year $i + j \geq n + 1$.

We define the cumulative amount of loss as;

$$S_{i,n} = \sum_{j=1}^{n} C_{i,j}, j = 1, 2, .., n \tag{2}$$

Therefore,the total claim amount in the year of origin i is denoted as $S_{i,j}$ which is either paid by the insurer or which was incurred up to development year j and take into consideration $S_{i,j}$ for which we have an observation if $i + j \leq n$ and $S_{i,n}$ is assumed to ultimate claim amount.

3.8 Basic Chain Ladder Model

Basic chain ladder model is a widely and most commonly used loss reserving model since its simple in its application and it does not rely on any distribution i.e it works nearly without any requirement of an assumption. The algorithm for Basic Chain Ladder model was developed as deterministic algorithm without any reliability on stochastic model for its application. The concept behind the application of of basic chain ladder model is quite simple. This model relies on the assumption that there is a significant proportional relationship between the estimates in the consecutive development years which will be consistent or maintained i future i.e the column values in the delay triangle are proportional and hence it easily enables one to obtain forecast of ultimate claim amount on the basis of observed historical data where in this case "ultimate" depicts the latest delay year so far observed and tail factor not included.

Basic chain ladder model doesn't pu into consideration external factors such as change in business mix , change in the rate of settlement of claims

as well as inflation of claims cost. Here, these facts are effectively ignored. The Basic Chain Ladder model assumes the form;

$$C_{i,j} = S_i.R_j + \varepsilon_{i,j} \quad where \quad i, j = 1, 2..., n \tag{3}$$

Where

$C_{i,j}$ - depicts the cumulative claim amount of payment up to the end of period j.

S_i - denotes the ultimate total cost of claims in the period of origin i.

R_j -is the development factor for year j representing the proportion of total payment made by the end of development year j.

$\varepsilon_{i,j}$ - is the error term.

In the absence of exterior factors, the distribution of delay between the origin years giving rise to a claim and the payments made in respect of that claim remain relatively stable over time. The model assumed that the factor R_j are constant for all origin years.

3.9 Link Ratios

Under the Basic Chain Ladder Model, link ratios also referred to as development factor or age to age factor is applied in reserve estimation in motor insurance company.

If b_j is a ratio representation of cumulative claim payment amount made by the end of development year $j+1$ to the expected value of cumulative

claim payment made by the end of development year j so as to get future liability at the development year $j+1$. Link Ratios of basic chain ladder model is denoted as b_j where $j = 1, 2, ..., n-1$ and this can be estimated using cumulative loss values from delay triangle.

The cumulative loss amount can be obtained from the incremental loss amount with a given development factor b_j.

Let $S_{i,j} = \sum_{k=1}^{j} C_{i,k}$,denote the cumulative claim amount, then the age to age factor b_j is given by;

$$b_j = \frac{\sum_{i=1}^{n-j} S_{i,j+1}}{\sum_{i=1}^{n-j} S_{i,j}} \tag{4}$$

The age to age factors are obtained through summation of each column in the delay triangle and taking the ratio of the preceding column and eliminating the last entry. If the multiplication of all link ratios i.e b_j's in estimation of last reserve outstanding in delay triangle is B_j.

The B_j is given by;

$$B_j = \prod_{j=1}^{n-1} b_j \quad where \quad j = 1, 2, ..., n-1 \tag{5}$$

3.10 Forecasting Future Cumulative claim and Outstanding Claim Reserve

To give the forecast of the future liabilities of cumulative claim amount in year $j+1$, a link ratio is applied to the latest cumulative claim amount in each row whereby the value of $S_{i,j+1}$ or $S_{i,n}$ will be obtained through

multiplication of $S_{i,j}$ or $S_{i,n-1}$ by b_j where b_j is the link ratio and $j = 1, 2, ..., n-1$.

The estimated future claim reserve in the development year $j+1$ is estimated by;

$S_{i,j+1} = S_{i,j} * b_j$ where $i = 1, 2, ..., n$.

The outstanding estimated claim reserve in each particular year of incident i and year of development j can be estimated and obtained from forecasted claim reserve. Therefore, the outstanding claim reserve is given by;

$$Outstanding \quad claim \quad reserve = S_{i,j+1} - S_{i,j}. \tag{6}$$

The estimates obtained can be applied in completion of the delay triangle of the later years of origin up to the point in which there is availability of historical experience

3.11 Bornhuetter-Ferguson Model (B-F Model)

Initially, B-F gave a proposition of Bornhuetter-Ferguson model in 1972. The Bornhuetter-Ferguson model and Basic Chain Ladder model differ in that the ultimate claim S_i is alternatively replaced by an estimate S_i^{BF} whose basis is on the expert judgment and external information. The B-F model is highly recommended for a new companies since they don't have past historical information. The B-F Model takes the form;

$$C_{i,j} = S_i^{BF} R_j + \varepsilon_{i,j}, \tag{7}$$

Where

R_i - is the proportion of total payments made by the end of development period j.

R_i - depicts total payment proportion made by the end of period of development j.

S_i^{BF} - is a representation of an estimate obtained by application of simple loss ratio or a written premium as well as any other suitable measure of exposure. Loss ratio is mainly used for projection mechanism so as to bring more stability by eliminating more distractions.

$\varepsilon_{i,j}$ - is the error term.

Assumptions of B-F Model:

1. The simple loss ratio provided is assumed to be correct and consistent
2. There is stability in claim development pattern
3. Future development of claims does not rely on the information from past claim development.

Let b_j be a ratio obtained from he expected claim amount paid by the end of development year $j+1$. Then we can estimate b_j by;

$$b_j = \frac{\sum_{i=1}^{n-j} S_{i,j+1}}{\sum_{i=1}^{n-j} S_{i,j}} \tag{8}$$

We therefore estimate the outstanding claim liability in the development year $j+1$ by;

$S_{i,j+1} - = S_{i,j} * b_j$ where $j = 1, 2, .., n$ and $i = 1, 2, .., n$. The link ratio for each origin year based on the B-F Model is then estimated from development ratios obtained above so as to calculate emerging liabilities in each year of origin based on their earned premiums. We therefore calculate the development factor of X^{th} year of origin as;

$$m_x = \prod_{j=1}^{n-1} b_j \quad where \quad j = 1, 2, ..., n-1 \tag{9}$$

$$m_x = b_1 * b_2 * b_3 * ... * b_{n-1}$$

and For $(X-1)^{th}$ year of origin;

$$m_{x-1} = b_2 * b_3 * ... * b_{n-1}$$

. Therefore, the age to age factors $m_x, m_{x-1}, m_{x-2}....m_2$ can be forecasted in each year of origin with $x \geq 2$ and $b_1, b_2, b_3, ..., b_{n-1}$ as the link ratios for each development year j where j is given as $j = 1, 2, .., n$.

3.12 Loss Ratio

Loss ratio is a ratio of claims that has occurred to the premium earned over a given specified period of time. Different years of origin tend to have consistency in their loss ratio given that there is no distortion incurred nor any significant change in the earned premium rates.

In B-F Model, the concept of loss ratio is key and vital and it is given by;

$$Loss \quad ratio = \frac{incurred \quad claims}{earned \quad premiums} \tag{10}$$

3.13 Ultimate Liability in a Given Year of Origin

There are various tools for determining reserve with ultimate loss ratio being one of them. Ultimate Loss Ratio technique is also known as Budgeted Loss Ratio technique and it is classified in the family of techniques called loss ratio.

The Ultimate loss ratio method estimate changes over time . The estimates from initial loss ratio that emerges from pricing analysis of policies gives new estimates as time passes and this leads to a claims beginning to emerge(or not). Bornhuetter-Ferguson Model gives the estimates of Incurred But Not Reported (IBNR) in a given year of origin based on a tranche of exposure through multiplication of priori estimate such as ultimate loss from that particular exposure and an estimate of the proportion of unknown or unreported ultimate loss at that particular time. Therefore, we define ultimate liabilities as the expected liability that is supposed to be paid with a particular year of origin based on the last known reporting liability in a delay triangle.

Ultimate liability is defined as the summation of both reported liability and emerging liability. For a given year of origin, ultimate liability is

defined as;

$$Ultimate \quad liability(S_i^{BF}) = Reported \quad liabilityS_{i,j} + emerging \quad liability((1 - B_{i,j})IU$$

$$S_{i,j}^{BF} = S_{i,j} + (1 - B_{i,j})IUL_0^i, \tag{11}$$

Where

$$B_{i,j} = (\frac{1}{m_x}) \tag{12}$$

and IUL_0^i is the Initial Ultimate Liability. Emerging liability is defined as claim outstanding liability yet to be settled and it is calculated by doing a multiplication of Initial Ultimate Liability by its corresponding $(1 - B_{i,j})$. Therefore, the reported liability for a particular year of origin is the last known value in the delay triangle for a given year of origin.

$$emerging \quad liability = (1 - \frac{1}{m_x}) * initial \quad ultimate \quad liability(IUL) \tag{13}$$

$$initial\, ultimate \quad liability(IUL) = expected \quad loss \quad ratios \quad * \quad earned \quad premium \tag{14}$$

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

The main objective of this chapter is to highlight and present as well as to discuss the findings of the study. This chapter is divided into three key sections; the first section is that of run off triangles of motor claim payments from 2016 to 2021. The second section explains Bornhuetter-Ferguson and the Basic Chain Ladder Model of computing reserves. Finally, this section describe the procedure in selecting the most appropriate model in estimating motor insurance claim reserve I this research.

4.2 Incremental Losses

To demonstrate the methodology, consider the claim amount in table 4.1 below where we define the random variable $C_{i,j}$ as loss incurred in the year of origin and settled with a delay of j years hence development year j and in calendar year $j + 1$

We take the assumption that $C_{i,j}$ i.e incremental loss are observable of calendar year $i + j \leq n$ and assume that they are non observable in the calendar years $i + j \geq n + 1$. Therefore, table 4.1 below reflects the incremental loss of motor insurance company from CIC insurance company

in Kenya from 2016 to 2021.

Table 4.1: Incremental Claim losses settlement data as a run- off triangle

Year of Origin	Development Year					
	0	1	2	3	4	5
2016	1,594,246	871,638	278,703	237,137	148,211	94,115
2017	1,889,727	1,098,611	351,974	250,305	161,894	
2018	2,189,729	1,247,763	334,984	259,195		
2019	2,613,336	1,250,942	335,257			
2020	2,945,064	1,620,399				
2021	3,913,314					

Table 1: *Incremental Losses*

4.3 Cumulative Claims Losses Settled

The data in table 4.1 above can be presented as cumulative claim losses of CIC motor insurance company settled. It's clear that for each year in which claim has occurred the incremental claim settled in each particular development year is the amount settled in that particular development year. We interpret $S_{i,j}$ as the cumulative loss of accident year i which is settled with delay of utmost j years and hence not latter than development year j. Therefore, table 4.2 below is the presentation of cumulative claim losses settled.

The values along the diagonal represent the total amount settled to date for each claim occurrence year.

Table 4.2: Cumulative Claim Payment Settled

Year of Origin	Development Year					
	0	1	2	3	4	5
2016	1,594,246	2,465,884	2,744,587	2,981,724	3,129,935	**3,224,050**
2017	1,889,727	2,988,338	3,340,312	3,590,617	**3,752,511**	
2018	2,189,729	3,437,492	3,772,476	**4,031,671**		
2019	2,613,336	3,864,278	**4,199,535**			
2020	2,945,064	**4,565,463**				
2021	**3,913,314**					

Table 2: *Cumulative Claims Losses Settled*

4.4 Basic Chain Ladder Model

4.4.1 Estimation of Future Claim Liabilities Based on Basic Chain Ladder Model

In order to produce forecast of future claim liability of cumulative claims in year $j+1$, we need to apply link ratios to the latest cumulative claim amount in each row, that is $S_{i,j+1}$ or $S_{i,n}$ must be obtained through multiplication of $S_{i,j}$ or $S_{i,n-1}$ by b_j where b_j is a representation of the link ratio, $j = 1, 2, ..., n-1$.

The outstanding forecast liability cumulative claims in development year $j+1$ is given by $S_{i,j+1} = S_{i,j} * b_j$ where $i = 1, 2, ..., n$ and $j = 1, 2, ..., n-1$. The cumulative Basic chain ladder claims and determination of future cumulative liabilities are shown in table 4.3

Table 4.3: Observed and Estimated Cumulative Claim Loss Settlement

Year of Origin	Development Year					
	0	1	2	3	4	5
2016	1,594,246	2,465,884	2,744,587	2,981,724	3,129,935	**3,224,050**
2017	1,889,727	2,988,338	3,340,312	3,590,617	**3,752,511**	3,865,346
2018	2,189,729	3,437,492	3,772,476	**4,031,671**	4,221,899	4,348,848
2019	2,613,336	3,864,278	**4,199,535**	4,517,625	4,730,781	4,873,033
2020	2,945,064	**4,565,463**	5,031,071	5,412,145	5,667,508	5,837,926
2021	**3,913,314**	6,034,872	6,650,337	7,154,060	7,491,613	7,716,880
Totals	15,145,416	17,321,455	14,056,910	10,604,012	6,882,446	3,224,050
Dev. Factor (DF)		1.5421383	1.1019849	1.075744	1.0471833	1.0300693

Table 3: *Estimation of Future Claim Liabilities Based on Basic Chain Ladder Model*

4.4.2 Determining Future Outstanding Liabilities by Basic Chain Ladder Model

The outstanding claim reserves for each accident year i and development year j can be estimated from the forecast cumulative claims by;

$$Outstanding \quad claim \quad reserve = S_{i,j+1} - S_{i,j}. \tag{15}$$

Therefore, the Reserves are the totaled to arrive at each calendar year

Table 4.4: Observed and Estimated Incremental Claim Loss Settlement

Year of Origin	Development Year					
	0	1	2	3	4	5
2016	1,594,246	871,638	278,703	237,137	148,211	94,115
2017	1,889,727	1,098,611	351,974	250,305	161,894	112,835
2018	2,189,729	1,247,763	334,984	259,195	190,228	126,950
2019	2,613,336	1,250,942	335,257	318,090	213,157	142,251
2020	2,945,064	1,620,399	465,608	381,073	255,363	170,418
2021	3,913,314	2,121,558	615,465	503,723	337,552	225,268

Table 4: *Determining Future Outstanding Liabilities by Basic Chain Ladder Model*

liability. The calendar year 2022 reserves were obtained by summing the first diagonal of claim Reserves marked by asterisk (*) from table 4.4 above.

The other calendar year were obtained the same way. Therefore, table 4.5 below shows the estimated reserves for each calendar year to be reserved for the next 5 years. Note that no projection that can be done for the year of origin 2021 because it is not possible to project beyond the highest development year.

Table 4.5: Estimated Reserves for Each year of origin

Year of Origin	Estimated Claim Loss Settlement Amounts (Ksh.)
2016	0
2017	112,835
2018	317,178
2019	673,498
2020	1,272,462
2021	3,803,566
Total Reserve	**6,179,540**

Table 5: *Estimated reserves for each calendar year to be reserved for the next 5 years*

From table 4.5 above, a total reserve of Ksh. 6,179,540 should be reserved for the next 5 years for the company to run its activities effectively without going into financial insolvency.

4.5 Bornhuetter - Ferguson Model

The Bornhuetter - Ferguson model which is based on application of the expected ultimate loss ratio to the premium earned to give the initial estimates of the total ultimate loss for each accident year was used by the researcher. The estimation of ultimate liability by the end of 2021 was calculated from cumulative claim settled in table 4.2 above. The link

ratios were obtained through multiplication of the ratios. The results are shown in table 4.6 below;

Table 4.6: Cumulative Reserves and Development Factors

Year of Origin	Claim Payment in Development Year						
	0	1	2	3	4	5	Ultimate
2016	1,594,246	2,465,884	2,744,587	2,981,724	3,129,935	3,224,050	3,224,050
2017	1,889,727	2,988,338	3,340,312	3,590,617	3,752,511		
2018	2,189,729	3,437,492	3,772,476	4,031,671			
2019	2,613,336	3,864,278	4,199,535				
2020	2,945,064	4,565,463					
2021	3,913,314						
Total	15,145,416	17,321,455	14,056,910	10,604,012	6,882,446	3,224,050	
Total - Last no.	11,232,102	12,755,992	9,857,375	6,572,341	3,129,935		
Dev. Ratio(r).		1.542138328	1.10198486	1.075744	1.0471833	1.0300693	
Dev. Factor(f)		1.971955287	1.27871492	1.16037431	1.0786714	1.0300693	

Table 6: *Cumulative reserves and development factors*

4.5.1 Initial Expected Ultimate Liability and the Expected Loss Ratio

The Initial expected ultimate liability and expected loss ratio is determined by applying the ultimate loss and the premiums earned of each year of origin. The researcher used the assumption that Ultimate Loss Ratio is stable and consistent and that it's the same for the different origin years. The model will establish the amount to be paid in future for each year of origin after each cumulative payment. The Initial Ultimate Liability was arrived at by multiplying the Ultimate Loss ratio by Earned Premium as shown in table 4.7 below;

Table 4.7: Ultimate Loss Ratio and Initial Ultimate Liability

Year of Origin	Ultimate Loss	Earned Premium	Ultimate Loss Ratio	Initial Ultimate Liability
2016	3,224,050	1,402,883	1.20	1,689,071
2017	3,752,511	1,678,762		2,014,514
2018	4,031,671	2,438,740		2,916,733
2019	4,199,535	2,944,990		3,533,988
2020	4,565,463	3,790,434		4,548,521
2021	3,913,314	3,860,858		4,633,030

Table 7: *Initial Expected Ultimate Liability and the Expected Loss Ratio*

4.5.2 Future/Emerging Claim Liability and Ultimate Claim Liabilities for each Year of Origin

The emerging and ultimate liabilities for each year of origin was determined by applying the development factors and initial expected ultimate liabilities as shown in table 4.8 below; From the findings in table 4.8 above,

Table 4.8: Emerging/Future and Ultimate liability for each Origin Year

Year of Origin	Dev. factor(f).	(1 - 1/f)	Initial Ultimate Liability	Emerging Liability	Reported Liability	Ultimate Liability
2016	1.00	0.00000	1,689,071.1	-	3,224,050	3,224,050.0
2017	1.03	0.02913	2,014,514.4	58,675.18	3,752,511	3,811,186.2
2018	1.08	0.07407	2,916,733.0	216,054.30	4,031,671	4,247,725.3
2019	1.16	0.13793	3,533,988.0	487,446.62	4,199,535	4,686,981.6
2020	1.28	0.21875	4,548,520.8	994,988.93	4,565,463	5,560,451.9
2021	1.97	0.49239	4,633,029.6	2,281,237.92	3,913,314	6,194,551.9

Table 8: *Future/Emerging Claim Liability and Ultimate Claim Liabilities for each Year of Origin*

the total expected outgo in the year of origin 2016 is Ksh. 3,224,050 since the year 2016 is fully run-off. In the year of origin 2017, the expected outgo was initially Ksh. 2,014,514.4 and the future emerging liability out of this was 58,675.18 which should be paid in future. The reported or incurred or

paid liability for 2017 was Ksh. 3,752,511, therefore, the final ultimate liability will be (58,675.18 + 3,752,511) = Ksh. 3,811,186.2. The subsequent origin years of ultimate liability are computed same as for the origin year 2017. The total emerging liability to be reserved is Ksh. 4,038,402.95.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Generally, the actuarial models of insurance should be of a particular importance since its actually based on the insurance premiums paid by the policy holder and the reserves which are to be constituted by the motor insurance company based on the analysis and assessment of the findings on the financial strength of motor insurance company through the analysis of the outstanding claim reserve. In this research, two main actuarial models of estimating outstanding claim reserve were presented under the assumption that the losses in the past will continue in the future.

From the findings in table 4.5, the total estimated outstanding reserve by basic chain ladder model was Ksh. 6,179,540 by the end of year 2021. Actually, the motor insurance company and practitioners are very keen on the values shown in table 4.5 since they reflect the estimates of outstanding claim provision at the present time with respect to each year of origin and the total overall outstanding claim reserve for the whole year. These estimates are quite significant in forecasting IBNR claim reserve in motor insurance company in Kenya.

The findings from table 4.9 shows that the Bornhuetter Ferguson model has an estimated claim reserve of Ksh. 4,038,402.95 which is slightly lower that that of Basic Chain Ladder model. Chain ladder is one of the most

common applied actuarial models in reserve estimation in a case of stable pattern of claim development and large claim amount. Generally, B - F model should grant higher accuracy it entails both projections and loss ratio mechanism. This is because undervaluation can lead to diminished profit and financial insolvency in motor insurance company due to occurrence of unexpected losses and with uneven pattern.

Therefore, since each of the model applied results in different amount of reserve provision, actuaries must decide which model provide the best estimate since an attempt to reconcile more different estimated values is extremely difficult. Therefore, this research recommends the use of basic chain ladder model since the claim development pattern is relatively stable and there is a large number of settled claim amount. It would be of great significance to seek explanation for unusual and historical trends in the development losses which might affect the pattern of claim development in future so that in case of any irregularity in the pattern of any origin year, then there is need to do further analysis on the activities of motor insurance company to identify the cause of this anomaly. In order to ensure adequacy of claim reserve estimation, the two models should be applied cautiously, respecting their circumstances under usage by combining them with their subjective assessment of actuaries based on their expertise and experience.

The, contribution of this research is to show that estimates of claim reserve cannot be established easily and that each model is only reliable based on a particular circumstance and to identify the most appropriate model to

use in modeling motor insurance claim reserve based on many factors so as to ensure optimal utility of the available funds.

5.2 Recommendations

In addition to above conclusions, I would like to recommend for a passion stream of future research of stochastic models for estimating reserves in motor insurance that will eliminate the shortcomings of the deterministic models.

From this research, I would recommend a further study to be done to analyze how the two models behave when we introduce inflation trend of claim inflation in motor insurance.

REFERENCES

[1] **Bjorkwall, S.,** Stochastic claim reserving in Non-life Insurance; Bootstrap and Smoothing models, *Department of Mathematics, Stockholm University,* **15** (2011),.

[2] **Chapman, J. R.,** Simple Tools and Techniques for Enterprise Risk Management, , **15** (2011), ISBN-1119995531.

[3] **David, S. ,** A survey of loss recovery methods, , **15** (2000),.

[4] **Gasper, D.,** The idea of human security., **15** (2010).

[5] **J. Kocovic et.al.,** Advantages and Disadvantages of Loss Reserving Methods in Non-life insurance, , **15** (2019), .

[6] **Gitonga A. ,** Analysis of Variability in IBNR Estimates with Run-off Triangle, *College of Biological and Physical Sciences, School of Mathematics,* **15** (2015),.

[7] **Kremer, E. ,**IBNR-claims and the two way model of ANOVA, *Scand.Act, J.,* **15** (1982), 1:47-55.

[8] **Liu, H.,** Stochastic claim recoveryfor methods which combine information from Multiple Data sets, **15** (2008),

[9] **Mack, T. ,** Distribution-Free Calculation of the Standard error of Chain-Ladder reserve estimates, *ASTIN Bulletin,* **15** (1993), 23:201-235.

[10] **Mack, T.,** The prediction error of Bornhuetter Ferguson, *ASTIN Bulletin,* **15** (2008), 38(1):87-103.

[11] **Mack, T and Venter, G.,** A comparison of Stochastic models that reproduce chain-ladder reserve estimates, *Insurance: Mathematics and Economics,* **15** (2000), 26:101-107.

[12] **Ntzoufras, I. & Dellaportas, P.,**Bayesian Modelling of Outstanding Liabilities Incorporating Claim Count Uncertainty, *North American Actuarial Journals,* **15** (2002), 6(1): 113-128

[13] **Quarg, G. & Mack, T. (2004),** Munich Chain Ladder: A Reserving Method thatreduces the Gap between IBNR projections Based on Paid Losses and IBNR Projections Based on Incurred Losses, , **15** (2004), 26(4): 597-630.

[14] **Ratemo, C. & Weke, P. ,**Estimating IBNR Claims Reserves for General Insurance using ArchimedianCopulas, *School of Mathematics, University of Nairobi, Kenya,* **15** (2013),.

[15] **Schmidt, K. D., & Wunsche, A. ,**Chain ladder, marginal sum and maximum likelihood estimation, *Blatter der DGVFM,* **15** (1998), 23(3), 267-277,. **Schmidt, K.D & Zocher, M. ,** Bornhuetter-

Ferguson as a General Principle of Loss Reserving, *ariance Journal,* **15** (2008),.

[16] **Schmidt, K.D. ,** Methods and Models of Loss Reserving Based on Run-Off Triangles: A unifying survey, *Casualty Actuarial Society Forum,* **15** (2006),270-300 .

[17] **Schnieper, R.,** Separating True IBNR and IBNER Claims, *ASTIN Bulletin,* **15** (1991), 21(1):111-127.

[18]

[19] **Taylor, G.,** Loss reserving: An Actuarial Perspective, *Springer Science and business media 21,* **15** (2012),.

[20] **Taylor, G. C.,** Claim Reserving in Non-life insurance, *North Holland,* **15** (1986),.

[21] **Tee, Levikia, Kaarik, Meelis, Viin, Rauns,** On Comparison of Stochastic Reserving Methods with Bootstarpping risks, **15** (2017), ISSN 2227-9091, MDPI, Basel Vol(5(1): 1-21

[22] **Theresa, B.,** Property and Casualty Reserving Techniques, Valuation and Reserving Technique, , **15** (2007),.

[23] **Weke, P. G. O.,** Deterministic claim Reseving in short term insurance contract, *E. A. J. of Statistics,* **15** (2006), Vol 1(2):198-213.

[24] **Wuthrich, M. V. ,** Modeling the Claims Development Results for Solvency Purposes, , **15** (2009),.