KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Modeling Motor Insurance Claim Reserves in Ghana using Bornhuetter Ferguson and Inflation Adjusted Chain Ladder.

By

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(B.Sc. Mathematics)

A THESIS SUBMITTED TO THE DEPARTMENT OF MATHEMATICS, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MSC ACTUARIAL SCIENCE

September, 2015

Declaration

I hereby declare that this submission is my own work towards the award of the MSc degree and that, to the best of my knowledge, it contains no material previously published by another person nor material which had been accepted for the award of any other degree of the university, except where due acknowledgement had been made in the text.

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Dedication

I dedicate this work to my parents Mr. and Mrs. Owusu-Sekyere for their unflinching support throughout the entire programme.

Abstract

Claims reserving for general insurance business especially motor (auto or car) insurance is critically important. The influx and proliferation of insurance companies have made claim reserving more intricate coupled with the risk underwriting processes. This research aims at modeling motor claim reserves in Ghana using inflation adjusted chain ladder and Bornhuetter Ferguson method. Motor insurance data used for our analysis ranges from January 2009 to December 2014. The analysis highlighted on estimating the next year (2015) outstanding liability and the total future outstanding liabilities. In this study, we found out that

Bornhuetter Ferguson had a better reserve estimate than that of the inflation Adjusted Chain Ladder due to its expected loss ratio and chi test value.

Acknowledgements

I am grateful and appreciative to the Almighty God for His incomprehensible protection, guidance and travelling mercies throughout the duration of this programme.

I am also indebted to my lecturers and would like to thank them, especially my supervisor Dr. A.Y. Omari-Sasu, Nana Kena Frimpong, Derick Owusu Asamoah and not forgetting Dr. Peter Amoako-Yerenkyi for their pieces of advice, constructive criticisms and the time they had to supervise this work in spite of their busy schedules.

I would also like to thank Issac Mensah Bonsu and Kwame Abankwah for assisting me with the relevant materials for this work.

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B-F - Bornhuetter Ferguson.

CL - Chain Ladder.

EDF - Exponential Distribution Family.

IACL - Inflation Adjusted Chain Ladder.

IBNR - Incurred But Not Reported.

IMF - International Monetary Fund.

NIC - National Insurance Commission.

Chapter 1

Introduction

1.1 Background of study

It is obvious that the world is surrounded by risks and uncertainties in the 21st century of modernization and globalization. Especially, in developing countries like Ghana, safety and security are one of the key issues. “People seek security”, which is a state of being devoid of any danger or threat (Gasper, 2010). However, risk is a more intricate matter which cannot be discussed without the concept of loss. A sense of security may be the next basic goal after food, clothing and shelter. An individual with economic security is equitably certain that he can satisfy his basic needs (food, shelter, medical care, and so on) in the present and the future.

Essvale (2009) explains economic risk (which we simply refer to as risk) as the “possibility of losing economic security”. Chapman (2011) states economic risk as the influence of government national macroeconomics on the performance of an individual business. Historically, economic risk was managed and shared within a well-defined community through informal agreements. If a community member or farmer’s storehouse or farm burned down and farm produce were damaged, the residents would reconstruct the farm house and provide the farmer with enough plant produce or restock his or her storehouse and cows to replenish the milking stock. This mutual arrangement or cooperative (pooling) concept became formalized in the insurance industry. Under a formal insurance arrangement, each insurance policy purchaser (policyholder) still implicitly pools his risk with all other policyholders.

The best business practice is to safeguard your assets from future losses. This assurance is in the form of insurance. Insurance is simply a devise whereby many people contribute to a pool, so that a few who suffer a loss may be compensated (Chapman, 2011). It is a promise of reimbursement in the case of loss; paid to people or companies so concerned about hazards that they have made prepayments to an insurance company. This form of insurance policy may also be broadly defined as a contract under which the insurer agrees, in return for a premium, to indemnify the insured for loss suffered as a result of the occurrence of specified events which cause the destruction, loss or injury of something in which the insured has an interest in.

Essvale (2009) explains insurance as a form of risk management primarily used to hedge against the risk of a contingent, uncertain loss or the equitable transfer of the risk of a loss, from one entity to another, in exchange for payment. Normally, only a small percentage of policyholders suffer losses. Their losses are paid out of the premiums as 'claims' collected from the pool of policyholders. The premiums paid by the policyholder are also the monetary amount the insured pays the insurer (usually an insurance company) for covering a specified risk. Accurate loss reserves are essential for insurers to maintain adequate capital to pay claims or losses and to efficiently price their insurance products (England & Verrall, 2002).

In Non-Life or General Insurance also referred to as Property and Casualty Insurance in some countries sell policies which include auto or motor insurance, fire, property. In general insurance, insurance policies usually last for a year; the policyholder pays an upfront premium and then expects any claims to be met no matter when they are made. General insurance claims complaints are three (3) times as numerous as those of life insurance claims suggesting that claims behaviour of general insurance be investigated to minimize operating losses and ensure operational excellence. A loss reserve represents an insurer's estimate of its outstanding liabilities for claims that occurred on or before a valuation date (Schmidt, 2006). As the largest liability in insurers' annual statement, loss reserves have a great impact on insurers' solvency and profitability. Hence, accurately estimating the outstanding claims liabilities is extremely important for insurers (England & Verrall, 2002).

The problem that confronts insurers is that, there is often a delay before the claims arrive or reported, and then a further delay before they are paid or settled. Claim reserving is the backbone of every insurance industry and a pivot in the future lifetime of the industry. The credibility, prestige and survival of every insurance industry is situated in their claim reserving models. Car, auto or motor insurance, however, remains the largest component of the non-life segment, accounting for 47% of non – life insurance premiums in Ghana according to KPMG report, 'The Review of the Ghana Insurance Industry', 2014. In a car accident, the liability of the policyholders involved could be hard to determine and a trial could be needed to seal the issue, requiring some delay between the occurrence of the claim and its settlement. Thus, insurance companies have to develop methods to assess the loss they will suffer in the future due to policies originated in previous years. This would enable them to set up reserves now to be able to meet their future liabilities (Kremer, 1982).

A motor claim that occurs at time T is reported to the insurer at time W, and then one or several transactions follow to make payments for the claim until the settlement at time S. The gap between occurrence and reporting, U is referred to as the 'reporting delay', and the gap between reporting and settlement, SD, is referred to as the 'settlement delay'. Insurers value the portfolio periodically. For example, an insurer would like to know how much it is liable to pay for an occurrence of a claim in future (five years time) for policies emanating from the past. Consider a policyholder who was involved in a car accident in the year, 2000. For some reasons, the claim is settled in 2005 by the insurer. The many uncertainties involved in the payment of losses makes it very difficult to estimate require liability.

Every non–life insurance company is obliged to settle claims or compensate policyholders for claim development that have occurred. This amount is usually referred to as the provision (technical) for outstanding claims or the claims reserve. It is important that the claims reserve is carefully calculated to avoid underestimation or overestimation (Mack, 2006). Overestimation of reserve will hamper investment since money which could be invested will be reserve. Underestimation of reserves will also cripple insurer since they may not be able to settle claims. On the basis of historical data the actuary can obtain estimates or predictions of the expected outstanding claims or risk by using run-off triangles results (Quarg & Mack, 2004).

In order to monitor and manage this risk it is important that the actuary's best estimate is complemented by some measure of variability which can be followed up by the insurance company. There are varieties of methods for the actuary to choose amongst for claim reserving. The claims reserve is often obtained according to case estimation of individual claims by claims handlers. Some popular actuarial method used in reserve estimation are, the chain-ladder method, the inflation adjusted chain ladder method and the Bornhuetter-Ferguson method (Ntzoufras & Dellaportas, 2002). The standard statistical approach would be to first specify a model, then find an estimate of the outstanding claims under that model and used it to find the precision of the estimate (Martinez-Miranda,
Nielson & Wuthrick).

1.1.1 Insurance Industry (world and Africa)

The world's insurance industry is dominated by wealthy developed countries, Group of Seven (G7) alone accounts for almost 65% of the world's insurance premiums (KPMG, 2014). In developed countries like United Kingdom (U.K) and United States of America (USA), insurance has received phenomenal awareness with the incorporation of insurance Internet operations. The same can not be said about our continent, Africa which is still in its elementary and developing state. Insurance is still a far-fetched commodity for the majority of Africans as most struggle to meet their basic needs like food, health and shelter. Apart from a lack of means, one major reason for low insurance penetration in Africa is "People lack of respect for insurance or financial service providers and the credibility of insurance companies to pay claims" (KPMG, 2014).

Reinsurer Swiss Re's global insurance reported total premiums in Africa amounted to US $71.9 billion in 2012, which translates into a penetration rate of 3.65%. This is well below the global average, which is 6.5%, even though it is above the average for emerging markets of 2.65%. The story is not different with that of Ghana insurance industry, even though it is one of the fastest growing insurance industries in Africa, in terms of gross written premium. The industry grew at a compound annual growth rate (CAGR) of 30.4% during the review period (2009-2013) , as compared to other African countries such as Chad with 2.3%,

Cote d'Ivoire with 3.9%, Cameroon with 9.4% and Uganda with 18.8% (Timetric Insurance Reports, 2014)

1.1.2 Insurance Industry in Ghana

The Insurance industry in Ghana represents one of the vibrant areas of the fast growing service sector. Ghana's first insurance industry was established in 1924 called the Royal Guardian Enterprise, now known as the Enterprise Insurance Company. Later was the formation of Gold Coast Insurance Company and the State Insurance Company. Ghana has two (2) main stream Insurance companies; the life and the non-life (general) insurance companies which offer range of insurance products listed under two main headings; namely life and non-life insurance.

As at this year 2015, there are 21 life insurance companies, 23 non-life insurance, 3 reinsurance, 69 broking companies, 1 loss adjuster, 1 reinsurance broker, 1 oil and Gas Company, 2 contact offices and 6000 insurance agents (NIC, 2014).

The insurance penetration ratio, which is the gross value of insurance premiums as a percentage of Gross Domestic Product (GDP), is often used as a measure of how deep a country's insurance market is. According to KPMG Review of the Ghanaian Insurance Industry, 2014 insurance penetration in Ghana increased by 2%. It further indicated that Non–life (general) insurance increased by 38% compared to that of life insurance. A study by FinMark Trust, commissioned by the National Insurance Commission (NIC), found that more than 23 million of Ghanaians (out of total population of 25.9 million) are living without any form of insurance. This low patronage and penetration is tantamount to poor or no confidence in the insurance industry. Unlike Ghana, South Africa enjoys a penetration rate of 14.2%, which is the highest in Africa (KPMG, 2014).

A great hindrance and challenge facing the general insurance is the delay in claim payments. Although the scale of frequency of disaster and other uncertainties rise with the passage of time, there is the need to settle claims accordingly. In 2013 Business & Times (B&T) newspaper reported that, Prime Insurance was slapped a nine–month suspension on its operations by National Insurance Commission (NIC), industry regulator for failing to meet solvency regulations. The Managing Director of Prime Insurance, Joseph Nyarkotei Dorh, told the B&T in an interview that the new owners (Alban Logistics) pumped over GHS 5 million into the company's operations to meet requirement of the regulator for its license to be restored. He said about GHS 2.5 million of the capital was used to clear all the outstanding claims while the rest was used to meet minimum capital requirement of NIC (Business & Financial Times, 2013).

Again in 2013, NIC shut down activities of Industrial and General Insurance Ghana (IGI). B&T reported that the move by the industry regulator to close down IGI's operation follows cash flow insolvency issues and operational difficulties faced by the company, which has made it difficult to settle and pay claims as they fall due.

The National Insurance Commission (NIC) which is the main regulator of all insurance companies put all the companies in proper checks. Their mandate to regulate started in 1989 when it was approved by law under Insurance Law 1989 (PNDC Law 227). The commission now operates under a new Insurance Act (Act 724) in 2006 which conforms to the International Association of Insurance Supervisors (IAIS) core principles. The objective of the Commission according to the new Act 724 is as follows;

i. To ensure effective administration, supervision, regulation and control of thebusiness of Insurance in Ghana.

ii. To perform a wide spectrum of functions including licensing of entities, settingof standards and facilitating the setting of codes for practitioners.

iii. To approve rates of insurance premiums and commissions, provide a bureaufor the resolution of complaints and arbitrate insurance claims when disputes arise.

After shutting down two insurance companies, the NIC on April 1, 2014 began to implement the "No premium, no cover" policy. This new directive required all insurance firms to collect premiums upfront before providing insurance cover. This regulation means that no insurance shall sell insurance products on credit to its customers. By patronizing various products of insurance, persons and cooperate businesses can be hopeful of future loss compensation on payments of premiums agreed according to policies signed upon. The assurance of quickly settling claims in any case of eventualities or losses like burglary, flood, theft, accident or illness will give confidence to insured to take up insurance policies.

Has NIC done enough to clamp down irregularities in Ghanaian industry? Yes, but irrespective of all the regulations, Ghanaians are still dissatisfied with the delivery and output of insurance companies. The constant delays in issuing claim payments has prevailed in the industry for years. Another complain of customers is the crude and inappropriate way in which insurance products are marketed and managed. In times past, the insurances companies did not have any actuarial model to estimating future claims and set appropriate reserves. Some companies based their reserving on assumptions and others inappropriate methods. The NIC then instructed all insurance companies to reserve 20% of their outstanding claim still 2014 (NIC, 2014).

However, since last year the regulators NIC has further instructed all insurance companies to use appropriate actuarial models to estimate their outstanding claims liability and set reserves for future claims. Most insurance companies in Ghana today, use the basic chain ladder to estimate claims since 2014 and others are oblivious of these models. This work seeks to use other actuarial methods of claim reserving to predict or find the appropriate estimate of future outstanding liabilities for general insurance companies in Ghana. This will go a long way to address claim payments issues facing insurance companies in Ghana today, how to respond to claims promptly when they are made and to set appropriate reserves to meet these claims. This will enable and guide insurance companies against insolvency, elevate their credibility and boost customers confidence.

1.2 Problem Statement

The insurance industry in Ghana is increasing with the influx of many insurance companies, both local and foreign. Ghanaians are gradually becoming conscious of the need to do insurance (both life and non-life insurance). Notwithstanding the importance of insurance to the individual, there has always been a growing complaint from the part of the insured on the longevity of the insurer to pay claims since they have huge claims piled from year to year.

This challenge is not oblivious to the insurance companies in the market. To solve this, insurance companies in the first place, should have enough capital reserves so as to be able to serve claimants anytime a claim is made. Insurance companies are always responsible to respond to any claim when it is made since that is the principal objective of the deed on the part of the insurer.

In general insurance, claims resulting from physical damage to property (including cars and buildings) and theft, suffer significant delays between the determination of the exact amount the company will pay in settlement and the time of a claim prompting event. When an accident occurs, it may experience delays in reporting. That is, the occurrence of an accident or incident to the insurer may be quickly reported. However, the extent to which the culprit or client is liable or the determination of the exact cost the insurer is obliged to pay may take some legal procedures and a lot of time. Sometimes, a legal or court procedures must be adhered to on the determination of exact claims to be paid to the insured. It is imperative for an insurance company to know what to set aside in reserves at regular intervals so as to handle claims when they arise.

In order to live by this, Insurance companies are always supposed to leave sufficient amount of money from the insurance packages (non-life insurance) customers have bought into. This is to help guide the company against insolvency. Claim reserving is therefore the way to go, in order to make funds available always, and in order to be able to pay any eventual claim. Claims reserves are future obligations of an insurance company. There are a number of actuarial models through which claims could be reserved. Unfortunately, irrespective of how beneficial these models are, they are still used by only a limited number of practitioners in Ghana. This could be as a result of general lack of understanding of the methods, lack of flexibility and variability in some methods.

1.3 Objectives of the study

The main aim of the study is to model motor claim reserves in Ghana using inflation adjusted chain ladder and Bornhuetter Ferguson method.

The specific objectives set to achieve the aim of the study are:

- To estimate the outstanding motor claim liability for each development year using the inflation adjusted chain ladder and Bornhuetter Ferguson models.
- To evaluate the total claims for each particular accident year using inflation adjusted chain ladder and Bornhuetter Ferguson models.
- To estimate the next year outstanding liability and the total outstanding liability using inflation adjusted chain ladder and Bornhuetter Ferguson model.

1.4 Methodology

This section presents the methodology which was used in the study. It explains in details the steps that were encountered in the modeling process by using inflation adjusted chain ladder method and the Bornhuetter Ferguson and also to select the best model to estimate claims reserves of motor claims in Ghana. The method or model was then used in calculating the outstanding reserves or liabilities for each development year and accident year respectively. Inflation rate was employed in the Inflation Adjusted Chain Ladder and earned premium was inculcated in the Bornhuetter Ferguson model. The overall total outstanding reserves or liabilities of motor claims were then determined by summing all the individual outstanding liabilities of each future development years. The Statistical tools used for the analysis were the Microsoft Excel and R.

1.5 Significance of Study

This work is significant since it will go a long way to help or guide insurance companies against insolvency. A model will be determined to always estimate the amount of claims; which will then be used to forecast future claims. This research will also help insurance companies reduce the burden of piled claims which exerts a lot of pressure on the financial position of the company. Policyholders will also benefit from this work since the usage of the model by the insurance company will help to always make sufficient funds available so that if there is a claim it could be treated fast enough, because the company would have enough capital reserves. Inclusion of inflation in the model would guide against the loss of value of the money a claimant is supposed to receive.

1.6 The Scope of the Study

In order to achieve these objectives, the study has been focused on general insurance in Ghana. The General Insurance companies offer a full-range of insurance products covering General & Accident Insurance. The study has been restricted to only motor claims data in Ghana. This is because motor claims is one of the highest claim each year due to the daily influx of cars and car accidents.

1.7 Limitations of the study

There are a number of factors that inhibited the success of this work. The most predominant setback was access to data or relevant information. Insurance companies were unwilling to give out or divulge information about their claims. Claims Department Officers in charge of the claims data were hesitant to furnish or disclose information which may lead to their dismissal. Amongst the many prevailing setbacks were the lack of readily available mathematical, actuarial and statistical software for data analysis.

1.8 Organization of Study

Accordingly, the study is organized in five main chapters. The first chapter of this work talks about the background of the study, problem statement, objectives of the study, methodology, significance of study, scope and limitation of the study as well as the organization of the study. The chapter two discusses the relevant literature of this study. It also reviews work done by other researchers on the same or similar field of study, the methods they used and its limitations.

The third chapter deals with the detailed methodology used by the researcher in solving the problem at hand. Its further discusses the actuarial models used in the analysis. The fourth chapter has to do with the analysis of the data obtained from modeling of the data and the interpretation thereof. Finally, the fifth chapter is the summary of the piece of work done by the researcher. It also gives recommendation to areas that can be researched in the near future by other researchers and some techniques that can help others to do good work in the same or similar area of research.

Chapter 2

Literature Review

2.1 Introduction

This chapter reviews a number of studies related to modeling claim reserves with respect to general insurance companies. The chapter gives a snapshot of insurance terms and definitions and explains key terms related to the work. It also covers concepts such as modeling insurance claims, history of insurance and its management. It also highlights on loss or claim reserving and centers on the literature review of very significant methodologies employed in this research.

2.2 Historical Background of Insurance

The first experience of man with insurance was in the field of marine. Records, however, show that modern marine insurance was practiced in 1347. In this early form, vessel or cargo would be pledged against a loan and should the vessel not successfully complete the journey; the loan would not be repayable (Irukwu, 1977).

Another ancient maritime practice that has survived many generations virtually unchanged is that of “general average”. The mode of its operation is when certain cargo is jettisoned (thrown overboard) during a journey in an attempt to save the voyage. If the journey proves successful; the owners of the cargo that was not jettisoned and was saved will contribute proportionately towards a fund out of which the unfortunate ones who lost their cargo would be paid a claim (Gasper, 2010).

In West Africa, methods of spreading risk by the extended family system, age, groups, clans, religious groups among other social devices is called Susu or Esor which dates back to the pre colonial era. However, due to developments and modernization, this state of affairs is no longer ideal and adequate hence the need for more acceptable form of compensation.

As early as the 1920's, the British, representing agencies for insurance companies then operating in Great Britain, introduced conventional insurance to the West Africa sub region. These agencies later were transformed into insurance companies whiles for example in the case of Ghana, the government formed their own indigenous insurance company to take care of their growing insurance needs after independence. Based on this principle above, the various classes of insurance then developed due to occurrence of unforeseen losses hence the need for financial protection against losses (Irukwu, 1977).

Today, Ghana has quite a bit of vibrancy in the insurance industry serving the needs of both local and foreign stakeholders, thus the need to uphold the customer in high esteem and attend to their requirements with speed and efficiency. The customer in this age of globalization is hailed as 'The King' thus satisfying their requirements means an organization will continue to stay in business and vice versa.

Insurance has even been hailed as a possible solution to the catastrophic food crises affecting third world nations like Ghana. Gormley (2008) in an article titled 'Industry can help avert price disaster' published in the 'Insurance Day' stated that a study by the French Agricultural Research Centre for International Development, said, 'insurance industry could play a major part in solving the underlying problems causing rising food prices'.

The New Insurance Act 2006 in Ghana, which is enforced by the National Insurance Commission (NIC) establishes a minimum paid up capital level of US$ 1m (including reserves). Insurers are also required to maintain an adequate total assets to total liabilities ratio, which is currently set at 150%. Further guidelines are stipulated with regards to the quality of assets, with investments required to equate to a minimum 55% of total assets by December 2010, whilst investments inequities and properties are limited to 30% and 20% of total investments respectively. The non–life insurance market remains relatively small, with industry Gross Written Premium (GWP) totalling GHS 226.8m or US$ 156m in 2009. Given that 23 registered insurers compete in this market (with further entrants expected in the medium term), competition is intense, with market share predominantly contested via premium reductions.

Ghana's Insurance industry is one of the less attended to and unpublicized industry. It has a minimal impact on the economy. The insurance industry only renders services to its clients unlike other industries who offer physical products. The misconception and lack of trust within the circles of insurance in Ghana is very cumbersome. The lack of awareness and misunderstanding with respect to insurance products makes it unattractive to customers. With the collaboration of NIC and others, there will be some checks and balances within the fraternity of the industry to do the right thing especially honour their claims and pay the insured promptly.

2.3 The Mathematical Modeling and Models

Extensive research has been conducted on loss reserving over the decades. Actuaries and scholars have come out with a lot of actuarial and mathematical methods to model loss reserving in general insurance. Most of these researchers and actuaries have modelled loss reserving based on run-off triangle theory over the years. The run-off triangle concept is easy to understand and apply by most practitioners and it bases its concept on some few assumptions. These common assumptions are;

- All claims are settled with a fixed number of development years.
- The incremental claim losses from the same number of accident years are well known until the present calendar year.

With these set of assumptions, one can effectively represent claim data in a form of triangle called the Run-off triangle. Another underlying fact about the run-off triangle is that the development of losses of every accident year follows a development pattern which is common to all accident years.

A lot of actuarial and statistical models for claim reserving estimation will be extensively reviewed. The most famous and most used of these methods are the chain ladder and the Bornhuetter-Ferguson methods.

2.4 Claim Settlement Processes

Often it takes several years until a claim is finally settled. The main reasons are:

1. Reporting delay: time lag between accident date and reporting date (notification at insurance company)
2. Settlement delay: time interval between reporting date and final settlement(severity of claim, recovery process, court decisions, etc.)
3. Reopenings due to new (unexpected) claim developments (Wuthrich, 2009)

2.5 About Claim reserving methods

Claim reserve methods can be either deterministic or stochastic. These are some of the models used. The Chain Ladder method is said to be built purely on past experience. The Bornhuetter-Ferguson method builds on exposure.

The Cape Code method is analogous to the Bornhuetter-Ferguson method, but the only difference is that it uses claims experience to replace the priori loss ratio. The Benktander/Hovinen method tries to link up between the two models; Chain Ladder method and Bornhuetter-Ferguson method. It tries to make a credibility compromise between the two models by weighing them together with the assumed proportion known and unknown claims (Schmidt and Zocher, 2008).

The Chain Ladder method was presented based on an article (Mack, 1994) by Thomas Mack. The Bornhuetter Ferguson was originally presented in 1975 by two US actuaries (Bornhuetter & Ferguson, 1975). The Cape Cod method which is also referred to as Stanard-Buhlmann method in North America was invented independently by Jim Stanard and Hans Buhlmann. This presentation was based upon (Patrik, 1996) and (Gluck, 1997). The Benktander method also called Hovinen method was independently developed and named after Gunnar Benktander (Benktander, 1976) and Esa Hovinen (Hovinen, 1981). The Separation method was invented by Greg Taylor (Taylor, 1977) in his presentation.

2.6 The Chain Ladder Methods

This particular model stands out as the most popular loss reserving technique. Taylor (1986) trace its lineage back as far as Harnek (1966). He attributes the name of the technique to Prof. R. E. Beard's work in the early 1970's. Prof. Beard worked with the UK department of Trade. The name Chain Ladder is a technique in chaining a sequence of ratios into a ladder of factors which enable one to climb or project from past historical data to its predicted ultimate value. The chain ladder model is a purely computational algorithm to estimate claim reserves. It is mathematical represented as;

$$C_{ij} = x_i y_j + \varepsilon_{ij} \text{ where } i,j = \{1,2,\ldots,n\}.$$

Mack (1993) published a paper about the chain ladder and described it as a distribution free model. He developed a stochastic model for the chain ladder and assumed no specific distribution for estimating claim reserves. He came out with calculating the standard error of chain ladder reserves. He did that using the distribution-free formula to estimate the standard errors. In his methodology, he derived and analyzed the estimates by comparing results of some parametric methods using a numerical example. He received an award by Casualty Actuarial Society (CAS) for his work and in-depth contribution to estimating the variability of loss reserves. Hachemister & Stanard (1995) offered Poisson distributed incremental claims stochastic model which led to the estimates very close to the original chain-ladder estimates.

In a paper by Verrall (1996) researched and found a lot of flaws with the Chain Ladder (CL) technique. He however, wanted to improve or find other ways of enhancing the model. The first flaw he identified was that there was no close connection between the accident years. He further said the lack of connection between the accident years result in over-parametrised model and unstable forecasts. The second flaw encountered by the CL method was about the assumption being made about the run-off triangle. It is assumed that the development pattern will be the same for all accident years. The researcher also revealed other flaws about the CL method. It showed that the CL did not consider in its assumption changes in the way claims are settled or paid since other factors may influence claim payments. He suggested a solution to these flaws. He first tried to model to link up or connect the accident years. To address the no connection between the accident years, he suggested the use of Bayesian framework. He explained that the Bayesian framework assumes that row parameters have the same prior distribution. The second flaw was also tackled. The over-parametrization in the CL was as a result of no linkage between the accident years. He considered accident years separated from each other. He then came out with a methodology to inculcate all those into his model. He developed his model by incorporating other information or parameters to extent the range of the analysis. He later concluded after the analysis that Bayes assumption can be a useful tool in overcoming over-parametrisation in the CL model.

Renshaw and Verrall (1998) reviewed some actuarial and statistical method on loss reserving. They identified some lapses using the chain ladder in estimating claim reserves. They revealed that the run-off triangle in the CL was unable to process negative incremental claim data. They tried to solve these lapses in the CL method by using other statistical methods. The two methods employed were the Generalized Linear Model and the quasi -likelihood models They analyzed data from Mack (1994) which was retrieved from Historical Loss Development Study, 1991 Edition published by the Reinsurance Association of America. They analyzed negative incremental claim data using the two models. They said they chose the quasi-likelihood to rectify the flaws in the CL method because it allowed room flexibility unlike the strictness of the Poisson modeling assumption. This helped in the analysis of the data not exclusively positive integers. In their findings, it showed that the two models processed negative incremental claims data. However, they suggested that the CL method be carefully scrutinized and examined in a more modelling framework.

Verrall (2000) went further and explained how we can see in the chain ladder, the linear model Kremer (1982) was talking about. In Mack and Venter (2000) researched an existing works done on the CL method. They conducted and analyzed two models. The distribution free and the over-dispersed Poisson models. In their analysis, they did a comparative study of the two models. They found out that both models reproduced nearly the same reserve estimate. However, they were of the view that the two models were different in terms of the true expected claim reserves likewise estimation issues.

England and Verrall (2002) made an almost complete review of the existing reserving methods and models actually in use in the insurance field. The chain ladder method is based exclusively on the development factors; it often happens that the predicted result cannot be relied on with the confidence level we would like. This is particularly likely for more recent underwriting years where the development factor to predict from the actual to ultimate loss amount is relatively variable, due to the present lack of claims development. In that manner, actuaries thought of making use of an alternative ultimate amount, usually obtained from a supposed loss ratio.

Quarg and Mack (2008) reviewed the huge gap and analyzed the challenges with chain ladder method. They ascribed examples and generally valid equations, and proposed a solution called the Munich Chain Ladder method. They went further to show there was a correlation between paid losses and incurred losses which were not considered in previous literatures. The procedure of the method of separate chain-ladder projection for each of the paid-loss and incurred-loss triangles virtually ignored or could not identify the correlation too. The Munich Chain Ladder, rather considered these correlations in their analysis, transferring any conjunction of paid and incurred losses that occurred in the past into the projection for the future to project claim reserve estimates.

Mack (2008) indicated that the CL reserve is directly proportional to the claims amount known so far. It only considered the development until a given last development period (no tail development). As for prediction error, the results might be very volatile especially for the latest accident periods due to too little data observed.

Gould (2008) examined the stochastic models which reproduce chain-ladder estimates used in reserve estimation for non-life insurance. The Chain Ladder method provided no information regarding the variability of the outcome, thereby adding uncertainty to future claim estimations. Prediction errors could be found using a variety of stochastic chain-ladder models, but the different models were based on different assumptions. The relationship between some of these models were defined for a run-off triangle of insurance claims. Two of these models, Mack's model and the normal approximation to the negative binomial model, were applied to a data set consisting of auto liability insurance claims. This was done in order to find the prediction errors of their chain-ladder estimates, as well as verify their ability to handle negative values. The two models used in the analysis were found to produce nearly identical prediction errors, and both were able to handle negative insurance claims, which were present in the data set. A number of similarities were found between the models, to the degree that the normal approximation to the negative binomial model should be considered as underlying Mack's model. However, since it was based on a generalized linear model, the normal approximation to the negative binomial model offered greater flexibility in applied calculations than Mack's model.

Mirinda, Nielson and Wuthrick (2012) also did some research on the chain ladder and made some important revelations. Their research was on extracting another run-off triangle from the initial triangle which is the double chain ladder. Previous research works done into the double chain ladder (DCL)technique revealed how the classical chain ladder technique can be split into separate components. In their paper, they continued their investigation of the DCL and demonstrate a more simple way to include the prior knowledge of severity inflation and future zero claims into the framework of the model.

They explained that under certain model assumptions and via one particular estimation technique; it is possible to interpret the classical chain ladder method as a model of the observed number of counts with a build-in delay function from a claim is reported until it is paid. It also focused on how specific types of prior knowledge namely prior knowledge on the number of zero claims for each underwriting year and prior knowledge about the relationship between the development of the claim and its mean severity.

Taylor (2013) in a paper " Chain ladder with random effects" gave a vivid explanation to alternative solutions to challenges the chain ladder method was saddled with. In his work, he explained some revealing literature on the chain ladder models with random effect patterns. He tried to extend the literature of Mack and some cross-classified forms of CL have been previously explored. Cross-classified models involves both row and column effects. Literature on the Exponential distribution Family (EDF) was reviewed too. Mack model with random effects include only the variance structure identified in the Mack fixed effects model. He considered a more general variance structure model in his analysis. He also extended his analysis to the randomization of column effect since existing literature only considered row effect of EDF cross-classified models. In conclusion, he said the use of different prior distribution on row parameters and CL with random effect expressed in credibility form distinguished it from the other models.

Claim amounts or costs are often subject to inflation. This could be as a results of specific type,class or line of business of the policy and can also be driven by economic matters. My work contributes to this literature by analyzing the chain ladder by adjusting with inflation. I will examine the impact of inflation on past motor claims and its effect on future reserves. This will help general insurance companies in Ghana to make reserves by an inflation adjusted chain ladder model for subsequent years to avoid underestimation or overestimation.

2.7 The Bornhuetter-Ferguson Method

The next model for consideration in this research that is widely used for loss reserving is known as the Bornhuetter-Ferguson (B-F) method. Bornhuetter and Ferguson (1972) varies from the CL method although both extract their principles from the run-off triangle.

$$C_{i,j} = S_{iBF} R_i + e_{ij},$$

Although the concept is based on the run-off triangle like the CL method but the B-F restricts its use to the estimation of the percentage of the outstanding losses and uses the product of the earned premium and an expected ultimate loss. The B-F principle is based on predictors of outstanding ultimate losses and every predictor is obtained by multiplying an estimate of the expected ultimate loss by an estimator of the percentage of the outstanding loss with respect to the ultimate one. It is based on the run-off triangle like the chain-ladder. This method tries to stabilize the chain-ladder method and makes it less sensitive to outliers.

Schnieper (1991) did a study of both the CL method and the B-F method. In his study, he formulated a model which infused both models. He admitted that Mack's formula was a specialized case for the basic CL method. However, he went further in his analysis to merge both models for the same purpose of claim reserving. Subsequently more stochastic models have been developed to ascertain the variability of claim estimates or its predictive errors.

Schmidt and Zocher (2008) also came out with some shocking revelation after they delved extensively into the B-F method. They summarized into three parts; the simultaneous use of different version of B-F, the comparison of the different ultimate losses and the selection of the best ones. They backed their analysis using some numerical examples. Their findings showed that the B-F principle can be used to select an appropriate version of the extended B-F for any run-off triangle.

Mack (2008) in his paper titled "The prediction error of Bornhuetter Ferguson" probed into claim reserving. He first reviewed existing literature on the CL predictive error. There were no or little knowledge in the prediction error in the B-F. So he devised a stochastic model to formulate the prediction error of the B-F reserve estimate. He further touched on parameters used for claim estimation. He explained that the development pattern of the B-F was different for the CL pattern. The other parameter he used for the B-F reserve was a well-known initial estimate for the ultimate claims amount. He concluded by using the results of the predictive error to the CL method.

2.8 Other methods for Claim Reserving

Some claim reserving methods are deterministic, in the sense that it only gives a single estimate without situated much information about its variability. In recent years, a considerable amount of attention and research has been given to discuss and formulate possible relationships between the chain-ladder and some stochastic models.

Verrall (1990) approached the subject of predicting outstanding claims using hierarchical Bayesian linear models, considering the fact that the chain-ladder technique is based on a linear model: the two-way analysis of variance model (ANOVA). He essentially carried out a Bayesian analysis of the two-way ANOVA model to obtain Bayes and empirical Bayes estimates. The latter are given a credibility interpretation. Two alternative formulations are considered, one with no prior information and another where he uses a specific prior distribution for the parameters.

England and Verrall (2002) looked into the B-F method and its principles. They reviewed the B-F method and said it is more useful to apply in the general insurance for setting reserves. Its usefulness is due to some level of instability in the proportion of ultimate claims settled in the early development years which the CL method gave a poor estimate. The B-F method is modeled around the perfect prior (expert) knowledge of 'row' parameter ultimate claims and the development factors of the CL to estimate future claim liability. They pointed out that where there was inadequate knowledge , the Bayesian method could be adopted. However, they concluded that this analysis may not work where negative values
involved.

de Alba (2002) presented a paper on claim reserving titled "Application of Bayesian forecasting methods to outstanding insurance claims". In the analysis, they made some set of assumptions. The first assumption they made was that the time settlement for claim payment was fixed and known. They also assumed claim payment were settled annually and that development of partial payments follow a stable pay-off pattern from one year of origin to another. They considered data using IBNR to form a run-off triangle . They used the Bayesian approach in their analysis to estimate total amount (severity) and total number of claims (frequency or intensity) on the condition of provided one or more past years and partial information on development years for several occurrence years. The Bayesian had some advantages over the others. They obtained the predictive distribution of the reserve as well as the point estimate including probability intervals, mean, variance and quantiles. This helps quantify the possible range of values for the estimated reserves. They also compared their results with some researchers work and models too.

Ntzoufras and Dellaportas (2002) considered modeling claim reserves using Bayesian theory and Markov chain Monte Carlo methods. Claim counts were used in order

to add a further hierarchical stage in the model with log-normally distributed claim amounts. In a recent paper, de Alba (2002) presented a model for aggregate claims by separating number of claims and average claims, which are also assumed log–normally distributed. In their paper, they followed essentially the approach of the latter. A standard measure of variability is prediction error, defined as the standard deviation of the distribution of possible reserves. In their analysis they used the Bayesian context as a benchmark in measuring the variability of the predictive distribution of the reserves. They said that was a more prudent way of estimating reserves.

Li (2006) gave a vivid and exclusive work on claim reserving in his paper called "Application of Bayesian models with Markov Chain Monte Carlo (MCMC) simulation to some real claims data". They considered the three Australian private lines of business which were; motor insurance, public liability insurance, and compulsory third party (CTP) insurance. They employed the use of the software BUGS (Bayesian Inference Using Gibbs Sampling) in their analysis. They examined the effect of accident and development period in the analysis. He also calculated the parameter and process error of the reserves. They factored some over-dispersed poisson (ODP) assumption in BUGS to select a suitable noninformative prior. They made a comparative analysis of the estimate with the actual claim payments. They found that BUGS provided parameter estimates consistent with those produced by generalized linear models (GLMs). In their findings, they showed that estimated total outstanding claims liability plus the aggregate risk margin covered the actual claim payments appropriately.

Li (2006) in another paper compared several stochastic reserving methods on both qualitative and quantitative aspects in dealing with the outstanding claims liabilities. His paper did not aim to offer a panacea for measuring uncertainty of the outstanding claims liabilities, or to provide an exhaustive list of reserving methods. These methods he reviewed in his work were; Bayesian estimation with Markov Chain Monte Carlo (MCMC) simulation, the chain ladder method with bootstrapping, generalized linear models (GLMs) with bootstrapping, the Kalman filter on state-space models, the Mack model, and the stochastic chain ladder method. He compared the various models to get the one which gave an appropriate estimate of outstanding liabilities.

Jemilohun, Lawal and Adebara (2013) in their research paper, "Statistical Analysis of Insurance Claims Reserves in Nigeria" discussed issues relating to the general insurance in Nigeria. They said that there is either low correlation or at other time no correlation at all between the premiums paid by policyholders into the pool maintained by the insurer or insurance company and the payment of claims to the policyholder by the insurers for the loss cover by that policy. Hence, they explored with various method of claims reserves to find the best estimate for future liability. Their data form individual claim was interpreted as a longitudinal data. They then subjected the data to the concept of general linear mixed model as a tool to model them in both likelihood-based and bayesian models.

Quaye, Andoh and Aboagye (2014) studied loss reserve variability and loss reserve errors in their paper "An empirical analysis of the Ghanaian property and liability insurance industry". Their purpose of study was to assess the level and variability of Ghanaian insurer's reserve estimates to examine its sources and ascertain if reserve errors were random or not. They used data from insurer claim reserve provisions, claims outstanding claims incurred and claims paid for the period of 2000 – 2010. They further categorized the sources of variation as endogenous and exogenous by using the parallel correlated standard error regression model to determine sources and magnitude of industry reserve error. The study found out that size, age, lag of loss reserve error, inflation rate and real gross domestic product are significant source of variation. Their finding further revealed that industry reserve errors were random across firms; suggesting that sampled insurers act independently on reserve error decision making and are not influenced by industry trends and competition. They concluded by stating that regulatory bodies could uniquely set reserve error levels for existing firms with little influence on competition. Even though the chain–ladder (CL) method is widely used in practise, the method had some disadvantages.

In this work, we considered the inflation adjusted Bornhuetter- Ferguson principle which is also formulated around the Bayesian theory to ascertain an appropriate estimate of future motor claim reserve in Ghana. This model is also based on the credibility theorem which makes it more robust.

Chapter 3

Methodology

3.1 Introduction

The main aim of this chapter is to discuss the various methods adopted for this study. The chapter is sub-divided into three sections. The first section examines the motor insurance data in Ghana. The second section examines basic concepts and definitions, the method of modeling reserves of the motor claim amounts and the statistical tool used were Microsoft excel and R. The third section, explained the methodology adopted so as to select the best method that determines and gives correct estimates of reserves of the claim amounts in Ghana.

3.2 Research Design

Secondary data from National Insurance Commission(NIC) with regards to Metropolitan Insurance Company motor claims payments presented from (January 2009December 2014). The data was then transformed into run-off triangle for the purpose of estimating the future reserves for motor insurance claims.

3.3 Run-off Triangle

Run-off triangle which is often referred to as delay triangle is simply a tabulation showing the speed of reporting or settlement for cohorts of claims. Run-off triangle is also a specific arrangement of past claim data of the given insurance company, which is used for qualified estimation of its claim reserves (Weke, 2006). Claims run-off data are generated when there is a delay in settling incurred insurance claims. Data is arranged in a triangular format in which the row, i

denotes accident years and column, *j* delay or development years. The analysis is based on a set of general insurance data (Schmidt, 2006).

3.4 Claim Data Presentation

The methods for estimating claims reserves that are discussed require data to be presented in the form of a run-off triangle. This presentation cross classifies the data according to the period of origin and the period of development. The period of origin may be the year when the claim was incurred, or reported, or when the policy relating to the claim was underwritten, while the development period refers to the length of time since the period of origin in which the claims were incurred, reported or paid. By convention, the development year relating to the year of origin is denoted as development year zero. A claim cohort is defined depending on the definition used for claims for each origin period and development period. For example, we could have each entry in the triangle as being the value of the claim paid in development year *j* , the claim having occurred in year of origin *i*. Claims run-off data are generated when delay is incurred in the settlement of insurance claims. Typically the format for such data is that a triangle in which the row *i* denotes accident years and column *j* delay or development years (Schmidt, 2006). The general form of the run-off triangle is given by:

Yr of Origin	Development yr					
	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	$C_{2,1}$	$C_{2,2}$	$C_{2,3}$	$C_{2,j...}$	$C_{2,n-1...}$	$C_{2,n}$
...						
i	$C_{i,1}$	$C_{i,2}$	$C_{i,3}$	$...C_{1,j}$		
...						
N	$C_{n,1}$					

Where $C_{i,j}$ denotes the increment claims amount, occurred in year of origin *i*, to be paid in development year *j*. We define the cumulative claim amounts with accident year index *i* reported up to, and including, delay index *j* by:

$$S_{ij} = \sum_{k=1}^{n} C_{i,k} \tag{3.1}$$

So $S_{i,j}$ is the total claims amount of accident year i,i = {1,2,..,n} either paid or incurred up to development year j, $j = k$ = {1,2,...,n}, and we consider $S_{i,j}$ of which we have an observation if $i + j \leq n + 1$. It is assumed $S_{i,n}$ to be the ultimate claim amount (Weke, 2006).

3.5 Loss Development Data

We consider a portfolio of risks and we assume that each claim of the portfolio is settled either in the accident year or in the following j development years where $j = \{1,2,...,n\}$. The portfolio may be modelled either by incremental losses or by cumulative losses.

3.5.1 Incremental Losses

To model a portfolio by incremental losses, we consider a family of random variables $C_{i,j}$ where $i,j = \{1,2,...,n\}$ and we interpret the random variable $C_{i,j}$ as the loss of accident year i which is settled with a delay of j years and hence in development year j and in calendar year $i+j$. We refer to $C_{i,j}$ as the incremental loss of accident year i and development year j.

We assume that the incremental losses $C_{i,j}$ are observable for calendar years $i + j \leq n$ and that they are non-observable for calendar years $i + j \geq n + 1$.

3.5.2 Cumulative Losses

To model a portfolio by cumulative losses, we consider a family of random variables $S_{i,j}$,$i = \{1,2,\cdots,n\}$ and $j = \{1,2,\cdots,n\}$ and we interpret the random variable $S_{i,j}$ as the cumulative loss of accident year i which is settled with a delay of at most j years and hence not later than in development year j. We refer to $S_{i,j}$ as the cumulative loss of accident year i and development year j, to $S_{i,n-j}$ as a cumulative loss of the present calendar year n, and to $S_{i,n}$ as an ultimate cumulative loss. We assume that the cumulative losses $S_{i,j}$ are observable for calendar years $i + j \leq n$

and that they are non-observable for calendar years $i + j \geq n + 1$. The cumulative losses are given $S_{i,n} = \sum_j^n C_{i,j},\ j = \{1, 2, \cdots, n\}$

3.6 The Basic Chain-Ladder Method

The most widely used reserving method is the basic chain-ladder method, mainly because it is simple and distribution-free, i.e. it seems to work nearly without assumptions. The Chain-ladder algorithm was developed as a deterministic algorithm and did not have any stochastic model underlying it (Mack & Venter, 1999). The idea behind the chain-ladder method is comparatively simple. Method is based on the assumption that proportionate relationships between values in consecutive development years will repeat in the future, i.e. the columns in the run-off triangle are proportional and hence it is possible to obtain forecasts of ultimate claims based on the observed data, where 'ultimate' denotes the latest delay year so far observed, and does not include any tail factor. The chain ladder method assumes that all external factors, such as, inflation of claim costs, change in the mix of business, change in the rate of settlement of claims, can effectively be ignored and the model assumes the form:

$$C_{ij} = x_i y_j + \varepsilon_{ij} \text{ where } i,j = \{1,2,\ldots,n\}, \tag{3.2}$$

where $C_{i,j}$ denotes the incremental amount of claims in development year j in respect to accident year i.

x_i is the parameter varying by origin year, i, representing exposure, for example the number of claims incurred in the origin year i.

y_j is the development factor for year j, representing the proportion of total payment made by the end of the development year j. It is independent of the origin year i. ε_{ij} is the error term.

In the absence of the external factors the distribution of delays between the incident giving rise to a claim and the payments made in respect of that claim remain relatively stable over time. The method assumes that the factors y_j are constant for all years of accident.

3.6.1 Development Factor

Under the basic chain ladder method development factor is used to estimate reserves. If b_j represents the ratio of the cumulative payments made by the end of year $j + 1$ to the expected value of the cumulative payments made by the end of year j, then b_j is the development factor that will be used to multiply the current payment or liability at development year j to obtain the future liability at development year $j+1$. The development factors of the chain-ladder technique, known also as age-to-age factors or link ratios, are denoted by $b_j, j = \{1,2,\cdots,n - 1\}$ and it is estimated by using the cumulative loss from the run off triangle. If $S_{i,j} = \sum_{k=1}^{n} C_{i,k},\ j = k = \{1,2,\cdots,n\}$ is the cumulative loss obtain from the incremental loss values, the development factor b_j is given as;

$$b_j = \frac{\sum_{i=1}^{n-j} S_{i,j+1}}{\sum_{i=1}^{n-j} S_{i,j}} \quad . \tag{3.3}$$

The b_j factors are thus calculated by summing each column in the run-off triangle and taking the ratio to the previous column total excluding the last entry. If the product of all the b_j's for estimating the last reserve liability of the triangle is B_j, Then it is given by:

$$B_j = \prod_{j=1}^{n-1} b_j \ where \ j = \{1, 2, \cdots, n-1\} \quad (3.4)$$

3.6.2 Forecasting Future Cumulative Claim and Outstanding Claim Reserves

In order to produce forecasts of future values or liability of cumulative claims in year j+1 we need to apply development factors to the latest cumulative claims in each row, that is $S_{i,j+1}$ or $S_{i,n}$ must be obtain by multiplying $S_{i,j}$ or $S_{i,n-1}$ by b_j, where b_j is the development factor, j = {1,2,....n−1}, The outstanding forecast liability cumulative claims in development year j +1 is given by $S_{i,j+1} = S_{i,j} \times b_j$ where i = {1,2,⋯ ,n} and j = {1,2,⋯ ,n}. The outstanding claim reserves for each accident year i and development year j can be estimated from forecast cumulative claims by:

$$\textit{Outstanding Claim reserve} = S_{i,j+1} - S_{i,j}. \quad (3.5)$$

These estimates can then be used to complete the run-off of the later years of origin up to the point for which past experience is available.

3.6.3 Inflation Adjusted Chain Ladder Method (IACL)

The inflation adjusted chain ladder (IACL) method which is based on adapting the generalized model by introducing an assumed index of claims cost can also be considered. This method adopts the general model in the form:

$$C_{ij} = S_i R_j B_{i+j} + e_{ij}, \quad (3.6)$$

where :

C_{ij} are the payments made in development year j of year of origin i (i.e., non cumulative).

S_i is the ultimate total cost in real terms of claims incurred in the period of origin i.

R_j is the proportion of total payments in real terms made in development year j.

B_{i+j} is an assumed index of claims cost.

e_{ij} is the error term.

Under the IACL method, the run-off triangle has to be presented as incremental claims for each year of origin and development. Using a claims inflation index, the past values are brought to current monetary values. Incremental claims along the same diagonal (moving from bottom left to top right) arise from the same year and hence the same inflation index value is applied on them. The adjusted incremental claims are then accumulated and the normal procedures of the basic chain ladder method are applied. These estimated claims reserves are also in current monetary terms.

3.7 The Bornhuetter–Ferguson Technique (The B–F method)

Originally, Bornhuetter and Ferguson proposed this method (B-F method) in 1972. The B-F method differs from the basic chain ladder method in that the ultimate claim,S_i, is replaced by an alternative estimate, S_i^{BF}, which is based on external information and expert judgement. The model is thus of the form:

$$C_{i,j} = S_i^{BF} R_i + e_{ij}, \tag{3.7}$$

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

S_i^{BF} could be an estimate found by using a simple loss ratio on written premiums (or some other suitable measure of exposure).

Assumptions:

1. the given loss ratio is correct
2. the claims development pattern is stable
3. the past claims development does not provide any additional informationon the future development of claims

If b_j is the ratio of the expected amount of claims paid by the end of period j+1, then b_j can be estimated by:

$$b_j = \frac{\sum_{i-1}^{n-j} S_{i,j+1}}{\sum_{i=1}^{n-j} S_{i,j}} \tag{3.8}$$

The outstanding forecast liability cumulative claims in development year j +1 is given by; $S_{i,j+1} = S_{i,j} \times b_j$ where $i = \{1,2,\cdots,n\}$ and $j = \{1,2,\cdots,n\}$. The development factor for each accident year under Bornhuetter-Ferguson is then estimated from the development ratios obtained above to be able to calculate the emerging liabilities for each accident year from their earned premiums. The development factor of k^{th} accident year is calculated as follows: For k^{th} accident year

$$f_k = b_1 \times b_2 \times b_3 \times \cdots \times b_{n-1}$$

For $(k-1)^{th}$ accident year,

$$f_{k-1} = b_2 \times b_3 \times \cdots \times b_{n-1}$$

Hence the development factor, $f_k, f_{k-1}, f_{k-2}, \cdots, f_2$ are estimated for each accident year, where $k \geq 2$ and $b_1, b_2, \cdots, b_{n-1}$ are development factors for each development year j, where $j = \{1, 2, \cdots, n\}$

3.7.1 Loss Ratio

Loss ratio is the ratio of incurred claims to earned premiums over a defined period. Loss ratio for each of several different origin years would normally show some consistency, provided that there have not been any distortions, and in particular no significant change in premium rates. The concept of a loss ratio plays a pivotal role in the B-F model and is given as;

$$loss\ ratio = \frac{incurred\ claims}{earned\ premiums} \tag{3.9}$$

3.7.2 Ultimate Liability at Accident Year

The ultimate loss ratio method is also referred to as the Budgeted Loss Ratio Method. It belongs to a family of methods also called loss ratio method. It is another way or tool for determining reserves. It estimates changes over time. the initial loss ratio estimate that emerges from the pricing analysis for a tranche of policies soon gives way to a new estimate as time passes and claims begin to emerge(or not).

The B-F method estimates IBNR for an accident or origin year (tranche of exposure) as the product of and a-priori estimate of ultimate loss for that exposure and an estimate of the percent of that ultimate loss unknown or unreported at the time. The ultimate liability is the expected liability needed to be paid in a particular accident year with respect to the last known reporting liability in the run-off triangle. The ultimate liability is the sum of the emerging liability and reported liability. Ultimate liability for a given accident year k is determined as:

$$Ultimate\ liability\ (S_{ij}^{BF}) = reported\ liability(S_{ij}) + emerging\ liability((1-B_{ij})IUL_0^i)$$

$$S_{ij}^{BF} = S_{ij} + (1 - B_{ij})IUL_0^{(i)}, \tag{3.10}$$

where

$$B_{ij} = (\frac{1}{f_k}). \tag{3.11}$$

Emerging Liability is the outstanding claims yet to be settled and its calculated by multiplying the initial UL by the corresponding value of (1 – B_{ij}). The reported liability for a particular accident year is the last known figure in the run-off triangle for that accident year.

$$emerging\ liability = (1 - \frac{1}{f_k}) \times initial\ ultimate\ liability\ (IUL). \tag{3.12}$$

initial ultimate liability = expected loss ratio × earned premium at year.

(3.13)

3.8 Model Fit Tests

The chi-square goodness-of-fit test is used to test how well the Metropolitan Insurance Company data, used for runoff triangle from January 2009 to December 2014 fit inflationary adjusted chain ladder and Bornhuetter Ferguson models. The study calculates the expected claims E_i of each development year using the development ratios against the actual claims O_i for each model chi-square value. The study then measures the fit of the hypothesized null distribution obtained from the chi-square test statistic below;

$$X^2 = \frac{(O_i - E_i)^2}{E_i} \qquad (3.14)$$

The model with large chi-square test value was rejected under the null hypothesis signifying a lack of fit between the observed and expected value.

Chapter 4

Analysis and Findings

4.1 Introduction

The purpose of this chapter is to present and discuss the findings of the study. The chapter is divided into four sections; we start with the run-off triangle of incremental losses of motor claims from 2009 to 2014. The inflation adjusted run-off triangles to bring the loss data into current real losses. The second section explains the inflation adjusted Chain Ladder and Bornhuetter Ferguson method of computing reserves. The third section described the procedure to select the best method out of the two considered in this research.

4.2 Incremental Losses

Table 4.1 shows the incremental losses of motor claims from NIC record file from 2009 to 2014. The table is run-off to 2014 because the total claims presented in 2009 were all paid off in 2014. The random variable $Z_{i,j}$ is the loss amount of accident year i which is settled with a delay of j years the development year j in calendar year $i + j$. The incremental losses $Z_{i,j}$ are observable for calendar years $i + j \leq n$ and that they are non-observable for calendar years $i + j \geq n+1$. The incremental losses $Z_{i,j}$ observable for calendar years $i+j \leq n$ is then adjusted by past inflation data to obtain the current real claims in table 4.1.

Table 4.1: Incremental Loss

Accident	Dev't yr (j)					
Year(i)	0	1	2	3	4	5
2009	40415.47	10438.1	40798.86	49877.23	33418	4500
2010	206424.2	35232.77	32767.09	8200	44800	

2011	110783.5	207736.4	51235	78325		
2012	111261.6	155835.8	55511.8			
2013	186789.3	125734.9				
2014	114909.8					

Source: NIC (2014).

The past annual inflation rates from 2010 to 2014 over 12 months period shown in Table 4.2 was then used to transform the incremental losses to current real losses for determining the future reserves. The basic Chain ladder reserves estimates can be referred in table 5.1 and 5.2 on the appendix.

Table 4.2: Annual Past Inflation

Year	Inflation %
2009	13.139
2010	6.698
2011	7.676
2012	7.072
2013	11.666
2014	15.486

Source: International Monetary Fund (IMF).

4.3 Inflation Adjusted Incremental Losses

The inflation adjusted chain ladder method which is based on adapting the generalized model by introducing an assumed index. The past values are brought to current monetary values by adjusting them with past inflation index. Incremental claims along the same diagonal (moving from bottom left to top right) arise from the same year and hence the same inflation index value is applied on them. Table 4.3 shows the inflation adjusted claim values and the graph shows a plot of each inflated incremental claims to development year.

Table 4.3: Past Inflation adjusted Incremental Loss.

Accident	Dev't yr (j)					
Year(j)	0	1	2	3	4	5
2009	64113.43	15519.1	64320.98	64320.98	38593.11	4500
2010	306906.3	48648.9	42255.98	9469.85	44800	
2011	152968.3	267893.9	59169.25	78325		
2012	143481.4	174015.5	55511.8			
2013	215715.4	125734.9				
2014	114909.8					

Source: NIC (2014).

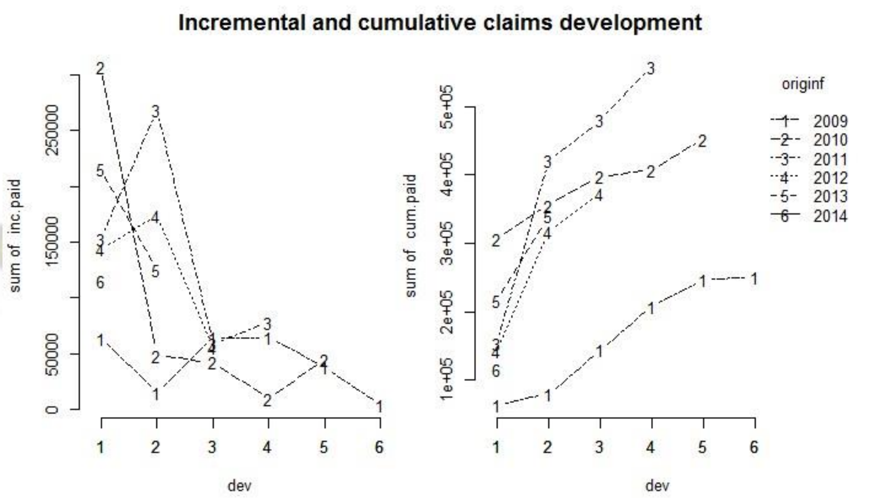

Figure 4.1: Graph of inflated incremental development.

4.4 Estimating Future Cumulative Liabilities

In order to produce forecasts of future values or liability of cumulative claims in year j +1 we need to apply development factors or ratio to the latest cumulative claims in each row, that is $S_{i,j+1}$ or $S_{i,n}$ must be obtain by multiplying $S_{i,j}$ or $S_{i,n-1}$ by b_j, where $b_j$is the development factor or ratio, $j = \{1,2,...,n-1\}$, The outstanding forecast liability cumulative claims in development year j+1 is given by $S_{i,j+1} = S_{i,j} \times b_j$ where $i = \{1,2,...,n\}$ and $j = \{1,2,...,n\}$. The cumulative inflation adjusted claims and determination of the future cumulative liabilities are shown in Table 4.4 below as well as a graph of cumulative claim development.

Table 4.4: Cumulative Reserves and Development Ratios.

Accident	Dev't yr (j)					
Year(i)	0	1	2	3	4	5
2009	64113.43	79632.53	135967	200288	238881.1	243381.1
2010	306906.3	355555.2	397811.2	407281	452081	**460580.1**
2011	152968.3	420862.2	480031.5	558356.5	**635018.8**	**646957.2**
2012	143481.4	317496.9	373008.7	**428960**	**487856.2**	**497027.9**
2013	215715.4	341450.3	**403491.8**	**464015.6**	**527724.9**	**537646.2**
2014	114909.8	**197116.3**	**232932.3**	**267872.1**	**304651**	**310378.4**
Total	998094.6	1514997	1386818	1165926	690962.1	243381.1
Total-last no.	883184.8	1173547	1013810	607569	238881.1	
Dev. Ratio	1.7154	1.1817	1.15	1.1373	1.0188	1

Source: NIC (2014).

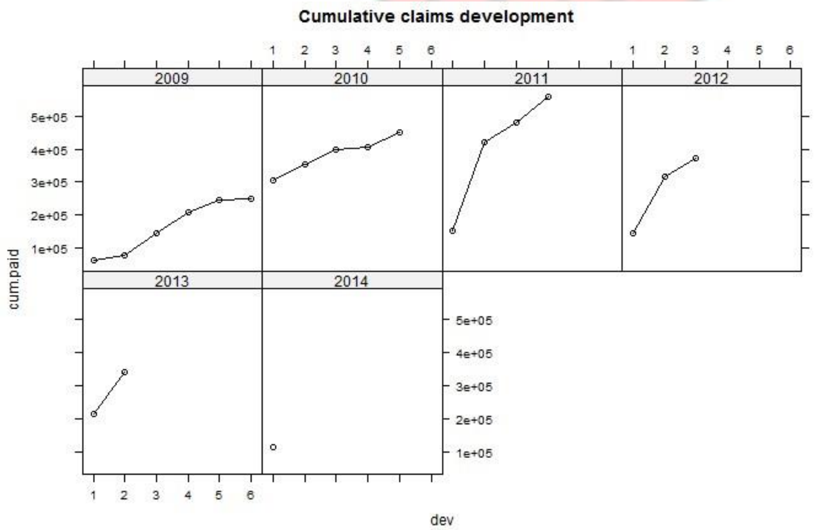

Figure 4.2: Graph of cumulative claim development.

4.5 Determining Future Outstanding Liabilities

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

Outstanding Claim reserve = $S_{i,j+1} - S_{i,j}$.

Table 4.5: Outstanding Future Liabilities or Reserves (unadjusted future inflationary reserves)

Accident	Dev't yr (j)					
Year(i)	0	1	2	3	4	5
2009	64113.43	79632.53	135967	200288	238881.1	243381.1
2010	306906.3	355555.2	397811.2	407281	452081	**8499.1**∗
2011	152968.3	420862.2	480031.5	558356.5	**76662.3**∗	**11938.4**
2012	143481.4	317496.9	373008.7	**55951.3**∗	**58896.2**	**9171.7**
2013	215715.4	341450.3	**62041.5**∗	**60523.8**	**63709.3**	**9921.3**
2014	114909.8	**82206.5** ∗	**35816**	**34939.8**	**36778.9**	**5727.4**

The outstanding unadjusted future inflationary liabilities are then totalled to arrive at each calendar year liability. The calendar year 2015 outstanding liabilities were obtained by summing the first diagonal of claim liabilities or reserves marked asterisk (∗) from table 4.5. The other calendar years were obtained the same way.

4.6 Unadjusted Inflationary Reserves

Table 4.6 shows that an amount (unadjusted by future inflation rate) of GHS 570721.4 must be reserved to avoid insolvency.

Table 4.6: Unadjusted Inflationary Reserves

Calender Year	Unadjusted Reserves (GHS)
2010	8499.1
2011	76662.3
2012	55951.3
2013	62041.5
2014	82206.5
total	570721.4

4.7 Inflation Adjusted Reserves for 2015 Calender Year

The unadjusted inflation reserves for calendar year 2015 in Table 4.6 above were then adjusted by 2014 annual inflation rate to arrive at the inflationary adjusted reserves for 2015 (15.486%) calendar year shown in Table 4.7. We assume that inflation rate for 2014 will remain constant for the next year and subsequent years.

Table 4.7: Inflation Adjusted Reserves for 2015 Calendar year

AY	Unadjusted reserves	Inflation	Adjusted 2015 Reserves
2010	8499.1	8499.1(1.15486)	9815.271
2011	76662.3	76662.3(1.15486)	88534.22
2012	55951.3	55951.3(1.15486)	64615.92
2013	62041.5	62041.5(1.15486)	71649.25
2014	82206.5	82206.5(1.15486)	94937
total			329551.661

Source: NIC (2014).

Table 4.7 shows that we have to put down GHS 329551.661 Ghana cedis reserves adjusted by future inflation to avoid insolvency in 2015. Also total liability to be reserved for next four years is GHS 813415.95

4.8 The Bornhuetter – Ferguson Technique.

The Bornhuetter – Ferguson method which is based on applying the expected ultimate loss ratio to the earned premium to give the initial estimate of the total ultimate loss for each accident year was used by the researcher. The estimation of 2015 ultimate liability was calculated from the inflation adjusted cumulative figures in Table 4.4. The Development factors were obtained by multiplying the ratios. The results are shown in Table 4.8 below.

Table 4.8: Inflation Adjusted Cumulative Reserves and Development Factors

Accident	Dev't yr (j)						
Year(j)	0	1	2	3	4	5	ult.
2009	64113.43	79632.53	135967	200288	238881.1	243381.1	243381.1
2010	306906.3	355555.2	397811.2	407281	452081		
2011	152968.3	420862.2	480031.5	558356.5			

2012	143481.4	317496.9	373008.7				
2013	215715	341450.3					
2014	114909.8						
Total	998094.6	1514997	1386818	1165926	690962.1	243381.1	243381.1
Total-last no.	883184.8	1173547	1013810	607569	238881.1		
Dev.Ratio(r)	1.7154	1.1817	1.15	1.1373	1.0188	1	
Dev.factor(f)	2.7011	1.5746	1.1373	1.1587	1.0188	1	

4.9 Expected Loss Ratio and Initial Expected Ultimate Liability

The expected loss ratio and Initial expected ultimate liability is determined by using the ultimate loss and earned premium of each accident year. The researcher used different expected loss ratios in determining the ultimate liabilities with an assumption that claims experience are likely to be different for each accident year. The method will establish the amount to be paid in future for each accident year after each cumulative payment. The Initial Expected Ultimate Liability was arrived at by multiplying Expected Loss ratio by Earned Premium. The results are shown in Table 4.9 .

Table 4.9: Expected Loss Ratio and Initial Expected Ultimate Liability

Acc. yr	Ult. Loss	Earned Prem.	Exp. Loss Ratio	Initial Exp. Ult. liab.
2009	243381.1	130500.7	1.865	243381.1
2010	452081	156163.9	2.895	452094.49
2011	558356.5	226859.5	2.461	558301.23
2012	373008.7	273952.6	1.362	373123.44
2013	341450.3	352368.8	0.969	341445.37
2014	114909.84	359149.6	0.32	114927.87

Source: NIC (2014)

Table 4.9 above shows initial expected liabilities for each accident year with respect to each different expected loss ratio due to claims experience are likely to be different for each accident year.

4.10 Emerging/Future and Ultimate Liabilities for each Accident Year

The emerging/future and ultimate liability for each accident year was determined by using the development factors and the initial expected ultimate liabilities. Table 4.10 shows the results.

Table 4.10: Emerging / Future and Ultimate Liabilities for each Accident Year

AY	Devt fac.	$1-\frac{1}{f_i}$	Initial Exp Liab.	Emerg Liab	Report. Liab	Ult Liab
2009	1	0	244036.81	0	243381.1	243381.1
2010	1.0188	0.0185	452094.49	8342.537	452081	460423.5
2011	1.1587	0.1370	558301.23	76467.08	558356.5	634823.6
2012	1.3324	0.2495	373123.44	93084.83	373008.8	466093.6
2013	1.5746	0.3649	341445.37	124599.6	341450.3	466049.9
2014	2.7011	0.6298	114927.87	72379.33	114909.8	187289.1
Total				374873.36		2458061

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From Table 4.10, the total expected outgo for accident year 2009 is GHS 243381.1, because accident year 2009 is fully run – off. For accident year 2010,the expected outgo was initially GHS 452081 and the future emerging liability out of this is GHS 8342.537 which should be paid in future. The reported or incurred or paid liability for 2010 was GHS 452081 , therefore the final ultimate liability will be (8342.537+452081) = 460423.5 for accident year 2010. The subsequent accident years of ultimate liability are computed the same as accident year 2010. The 2015 liability using Bornhuetter Ferguson method is GHS 224842.8. However total emerging or future liability to be reserved is GHS 374873.36

4.11 Checking the Model Fit

4.11.1 Inflationary Adjusted Chain ladder Model Test

Table 4.11 below shows the actual, expected claims, errors and the chi-square values computed from Table 4.4 using inflationary adjusted chain ladder data from metropolitan insurance company.

Table 4.11: Inflationary Adjusted Chain ladder Model Test

Acc. yr	Devt yr	Actual Claims	Exp. Claims	Errors	*Error²/Expected*
2009	0	64113.43	-	-	-
	1	15519.1	45866.75	-30347.65	20079.47
	2	64320.98	14469.23	629851.75	27417715.1
	3	64320.98	20395.93	43925.93	94601.58
	4	38593.11	27499.54	11093.57	4475.24
	5	4500	4490.96	9.04	0.0182
2010	0	306906.3	-	-	-
	1	48648.9	219560.76	-170911.86	13304107400
	2	42255.98	64604.37	-22348.39	7730.900
	3	9469.85	59671.68	-50201.83	42234.83
	4	44800	55919.68	-11119.68	2211.16
2011	0	152968.3	-	-	-
	1	26789.3	109433.52	154860.38	229451.56
	2	59169.25	63129.33	-3960.08	248.41
	3	78325	72004.75	6320.21	554.75
2012	0	143481.4	-	-	-
	1	174015.5	102646.59	71368.91	49621.92
	2	15511.8	57689.18	-42177.38	30836.48
2013	0	215715.4	-	-	-
	1	125734.9	154322.79	110412.11	78995.68
2014	0	114909.8	-	-	-
Total					13332086160

Table 4.11 shows the actual, expected, errors and calculated chi-square values for the inflationary adjusted chain ladder model. The expected claims of each development year were computed from cumulative reserves claims by multiplying each cumulative figure by its corresponding development ratio. The expected claims for accident year 2009 for development year 1 was calculated as $(64113.43 \times 1.7154) - 64113.43 = 45866.75$ and the expected claims for development year 2 was calculated as $(79632.53 \times 1.1817) - 79632.53 = 14469.23$. The rest of the expected claims in Table 4.11 were calculated in the same way. The chi-square value computed from Table 4.11 is 13332086160 which signify lack of fit. The chi-square value is very large and this shows that inflationary adjusted chain ladder is not good fit for Metropolitan insurance company motor claim

data.

4.11.2 Bornhuetter Ferguson Models Test

Table 4.12 below shows the actual, expected claims, errors and the chi-square values computed from Table 4.12 using inflationary adjusted chain ladder data from Metropolitan insurance company.

Table 4.12: Showing Reported, Expected liability, Errors and Chi- squares values

Accident year	Reported Liability	Expected Liability	Error	*Error²/Expected*
2009	243381.1	244036.81	-655.71	1.762
2010	452081	452094.49	-13.49	0.000403
2011	558356.5	558301.23	.27	0.0055
2012	373008.78	373123.44	-114.66	0.0352
2013	341450.3	341445.37	4.93	0.0000712
2014	114909.8	114927.87	-18.07	0.00284
Total				1.8059

Table 4.12 shows the actual, expected liabilities, errors calculated chi-square values from. The chi-square value computed from Table 4.12 is 1.8059 which

signify good fit. The chi-square value from Bornhuetter Ferguson model is very small as compare to the chi-square value from inflationary adjusted chain ladder model and this shows that Bornhuetter Ferguson model is a good fit for Metropolitan insurance company data.

Chapter 5

Conclusion and Recommendations

5.1 Introduction

This chapter presents the major findings, conclusion and recommendations of this work.

5.2 Major Finding of the Study

Table 4.1 shows the incremental losses of motor insurance claims generated record file from 2009 to 2014. The incremental claims of the run-off triangle for any development year as revealed in the Table 4.1 shows randomness, which is each claim amount do not follow any pattern from the previous ones. Table 4.1 also revealed that the highest incremental claim amount occurs in 2013 accident year and it is GHS 186789.3 and minimum claim occurs in accident year 2009 development year 5 which is GHS 4500. Table 4.4 also shows inflation adjusted cumulative claims, it revealed that the claims cumulative shows increasing pattern. The development ratios from the chain ladder was used to find the future outstanding liabilities. Table 4.7 also shows that the estimated inflation adjusted chain ladder outstanding future liabilities for calendar year 2015 was GHS 329551.661 and total outstanding liabilities was GHS 813415.95.

Table 4.9 shows the expected loss ratio and expected ultimate liability using the B-F method. Table 4.10 shows the emerging or outstanding liability for calendar year 2015 is GHS 224842.8 and the total emerging and total ultimate liability are GHS 374873.36 and GHS 2458061 respectively. The Chi test value for Bornhuetter Ferguson method was 1.8059 as compared to Inflation Adjusted Chain Ladder.

5.3 Conclusion

In the remit of claim reserving in general insurance, this work has highlighted three models, which if carefully followed can be used to obtain outstanding liabilities as well as set appropriate reserves. The concept of development pattern, which can be expressed in different but similar ways provides a powerful tool for the comparison of different methods and different models of loss reserving. The focus was estimating the claim amount for each accident and calendar years. In the analysis, it showed results obtained from B-F model are different and lower than that of the inflation adjusted chain ladder.

The inflation- adjusted chain ladder recorded a moderately good fit on the observed claims experience for motor claims in Ghana (Jan. 2009 - Dec. 2014). We also observed an increasing trend which could result in overestimation in later years of origin observed. This observed consistent overestimation of claim reserves makes it an inappropriate model to estimate claim reserves. B-F method obtained an estimate of expected ultimate losses by finding the expected loss ratio (incurred claims or ultimate claims divided by earned premium). the model fit test also showed the best estimate for motor claim reserves. The chi-square value from Bornhuetter Ferguson model was very small as compare to the chi-square value from inflationary adjusted chain ladder model and emphasizes that Bornhuetter Ferguson model is a good fit for Metropolitan insurance company motor claim reserves.

5.4 Recommendations

The models pivoted around the Run-Off triangle theory has its merit and demerits. Its usage is more practical and friendly in the field of general insurance. But it is bound to some limitations of general run-off triangle theory such as inadequate data caused by distortion of data. We would like to recommend that reserve estimate work be done with B-F model which is built on an exposure measure unlike the CL based only historical claim development to avoid underestimation or overestimation.

It is recommended that further research should be conducted to delve into more appropriate models that give best estimate and variability of claim reserves. The models developed here does not use any information from claim numbers. We recommend that if these were available, different actuarial models could be considered to take into account such parameters.

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Appendix

A.1 Estimating Future Liabilities Using the Basic Chain Ladder

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In order to produce forecasts of future values or liability of cumulative claims j + 1 we need to apply development factors or ratio to the latest cumulative claims in each row, that is $S_{i,j+1}$ or $S_{i,n}$ must be obtain by multiplying $S_{i,j}$ or $S_{i,n-1}$ by b_j, where b_j is the development factor or ratio, $j = \{1,2,...,n-1\}$, The outstanding forecast liability cumulative claims in development year j +1 is given by $S_{i,j+1} = S_{i,j} \times b_j$ where $i = \{1,2,...,n\}$ and $j = \{1,2,...,n\}$. The 2015 future liability is GHS 358275.15 and total future liabilities are GHS 1055440 also shown in Table 5.1 and 5.2 below.

Table 5.1: Cumulative Reserves and Development Ratios of Chain Ladder.

Accident	Dev't yr (j)					
Year(i)	0	1	2	3	4	5
2009	40415.47	50853.57	91652.43	141529.66	174947.7	179447.7
2010	206424.2	241657	274424.1	282624.1	327424.1	**57921.32**
2011	110783.5	318519.9	369754.9	448079.9	**82625.93**	**93881.86**
2012	111261.6	267097.4	322609.2	**59811.746**	**70518.42**	**80124.97**
2013	186789.3	312524.1	**64161.2**	**69837.461**	**82338.8**	**93555.62**
2014	114909.8	**93754.94**	**42838.88**	**46628.778**	**54975.62**	**62464.82**
Total	770584	1190652	1058441	872233.66	502371.8	179447.7
Total-last no.	655674.1	878127.8	735831.4	424153.76	152476.4	
Dev.Ratio(r)	1.8159	1.2053	1.1854	1.1844	1.1769	1

Source: NIC(2014).