Chapter I

INTRODUCTION
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1.1 General Introduction:

Man has always been in search of security and protection from the beginning of civilization. At the same time, risk is inevitable in life and any business activity. Again risk is closely connected with ownership. It is the owners who want to save themselves from risk and it is out of this desire, the concept of insurance has originated. Risk is defined as 'the variation in potential outcomes to which an associated probability can be assigned. In statistical terms, the distribution of the variable is known, but not the value from the distribution, which will be realized. One of the common methods of handling risk is Insurance. Because risk is associated with probability, risk can be managed or accommodated through purchase of 'Insurance'. One does not know if one will be in an automobile accident next year. But because of the probability of being in an accident is known, one can buy insurance to protect against that unfortunate outcome.

Insurance may be described as a social device to reduce or eliminate risk of loss to life and property. Insurance is an arrangement where the losses experienced by a few are extended over several who are exposed to a similar risk. Insurance is a protection against financial loss arising on the happening of an unexpected event. The aim and objective of insurance is to protect the owner from financial losses that one suffers for the risks that one has taken. The basis
of insurance is sharing of losses of a few amongst many. Insurance provides financial stability and security to both individuals and organizations by this distribution of losses of a few among many by building up a fund over a period of time. Insurance sector in India is booming up but not to level comparative with the developed economies (Paramasivan, 2008).

Automobile industry is one of the key industries in Indian economy. The growth of this industry is playing key role in the country's overall industrial growth. The Indian automobile industry is the second fastest growing in the world. Indian has emerged as the third largest market in this industry in the Asia Pacific Region. Developing countries represent underinsurance status. The motor premium rates were among the lowest in the world. Research is needed to explore the factors behind this underinsurance. Insurance services represent the logical step of financial integration of the owner, drivers and passengers. Different automobile insurance company offer different insurance policy. Auto insurance company set premium according to the driver's previous performance.

In India, the Motor Vehicle Act was passed in 1938. This act provides for compulsory insurance for third party liabilities arising out of use of motor vehicle in public place. Since this insurance is compulsory as per the Motor Vehicle Act in India, the coverage of the policy is amended as per the requirements and amendments of Motor Vehicle Act. Motor insurance policy covers the liability of the vehicle owner insured arising out of use of the vehicle in public place for loss or damage to the property of third party and loss due to physical and fatal injury to the third parties (Motihar, 2007).
To have a very much beneficial future and also a very much secure life it is for sure very much necessary for each and every person living in this world to have an auto insurance policy for his/her automobile. There are hundreds of various different auto insurance companies, firms, agencies and also providers providing the people coverage for their automobile. Each and every auto insurance agency, company and also provider has its own auto insurance policy. For any type of damage to the vehicle an auto insurance policy is the best way to get rid of it. For each and every automobile it is necessary to have a policy of insurance as automobiles are prone to accidents and also damage.

No one in this whole world truly knows what might happen in the coming time. Anything can happen to your vehicle any time and at any place. So it's always better to get your vehicle insured. So that if any hazard occurs, then you do not have to worry about as the expenses will be surely paid by the auto insurance company, agency or provider. Auto insurance is thus very much crucial for each and every one. This is also true that almost each and every state is making it mandatory to have a policy of auto insurance. This is for sure a very good step taken by the government to make each and every person more and more aware about the importance of auto insurance policy.

In a competitive market, the products need to be priced equitably based on their individual risk experience which is not practiced due to tariff restrictions. It is alleged that tariffs are rigid based on out-dated statistical data, and that premium rates are not revised in response to the market dynamics. However, in order to derive the rates in a scientific manner based on market dynamics, it is essential to have accurate data on the different lines of business,
which is abysmal in the motor insurance industry. The insurers are unable to
generate adequate database to enable scientific calculations for risk assessment
and rating of different groups of vehicles.

To fill up the gap of non-availability of accurate data for proper pricing,
as a first step, Insurance Regulatory and Development Authority (IRDA) in
consultation with the insurers devises new formats for collection of past data as
well as future data in the field of motor insurance. The salient features of the
new format for collection of motor data are the introduction of various code
masters. The code masters relate to insurer, policy, class of vehicle, make of
vehicle, zone, cubic capacity or passenger carrying capacity or gross vehicle
weight, nature of loss, nature of goods, permit, road type, driver type, driver’s
age, driver’s experience, driver’s education, incurred claims experience, claims
history of the vehicle, nature of injury, occupation, reasons for court hearing
and type of summons. These formats covered the details on driver, geographical
zone of driving and the vehicle which are indispensable for rate fixing
(Paramasivan, 2008). Remembering these points and including others, the
importance of the thesis describe in the next section.

1.2 Importance of the Study:

Many concepts in applied probability and statistics those are particularly
useful for actuaries working in general or non-life insurance as well as in
automobile insurance. The topics include Bayesian theory and credibility,
simulation, run-off triangle as well as concepts of rating, Markov chain, logistic
regression, correspondence analysis and many others. This study elaborates
more on these particular topics in the next few sections and indicates why they are important for the general insurance actuary as well as in this study.

Credibility theory (Herzog, 1999) in automobile insurance is essentially a form of experience-rating, which attempts to use the data in hand as well as the experience of others in determining rates and premiums. In classical credibility theory, a linear Bayesian forecast of the premium earned or claim frequency for an individual risk is made using prior estimates of the collective premium or claim frequency and individual experience data. Estimating future claim frequency and premium earned or amount of claims are essential in any automobile insurance company to take future course of actions to run the business smoothly. Various methods are available for estimating claim frequency and amount of premium with credibility theory using Bayesian approach. The Poisson/Gamma model and Normal/Normal model are two popular models for estimating claim frequency and amount of premium earned respectively (Whiteney, 1918; Bailey, 1950; Mayerson, James and Bowers, 1968 and Hewitt, 1970). But these two models mentioned above may not be sufficient to study the behaviour of the risks in different situations. In this thesis, two more Bayesian models under different set of assumptions have been proposed.

In automobile insurance, claims due to physical damage to a vehicle or theft are often reported and settled reasonably quickly. However in other areas of automobile insurance, there may be considerable delay between the time of a claim inducing event and the determination of the actual amount the company will have to pay in settlement. When an incident leading to a claim occurs, it
may not be reported for some time. In the case of an accident the incident may be quickly reported, but it may be a considerable amount of time before it is determined actually who is liable and to what extent. There may be considerable delay between the time of claim inducing event and the determination of the actual amount the company will have to pay in settlement. It is very common picture in any insurance sector in India, claim due to unforeseen random event is not paid within a sort period of time and usually it takes several years to settle. To get the correct picture of its liabilities, an insurance company should set aside the correctly estimated amount of money to meet the claims arising in the future on the written policies. An insurer wants to estimate the future figures of claim to be paid to policyholders to run their business smoothly. The past data are used to construct estimate for the future payments consist of a triangle, called run-off triangle (sometimes delay triangle) of increment claim. Various methods are available for estimating amount of reserve to be kept for making timely claim paid and distribution free chain ladder (Mack, 1993) method is one of them. This thesis tries to extend this technique which allows one to evaluate fitness, variability and basic assumptions better.

No Claim Discount (NCD) systems (sometimes also called Bonus-Malus systems (BMS)) are experience-rating systems which are commonly used in motor insurance. NCD is one of the more controversial areas of automobile insurance, being a topic on which the motorist is liable to hold strong and emotive views from time to time. NCD schemes represent an attempt to categorize policyholders into relatively homogeneous risk groups who pay premiums relative to their claims experience. Those who have made few claims
in recent years are rewarded with discounts on their initial premium, and hence are enticed to stay with the company. Depending on the rules in the scheme, new policyholders may be required to pay the full premium initially and then will obtain discounts in the future as a result of claim free years. The general insurance actuary modeling an NCD scheme would frequently use Markov chain methods to investigate how premiums and movements take place over time (Boland, 2006).

This study tries to find out the probabilities of claims by different categories of policyholders (motorists) according to their driving experience as well as previous accident records. This study proposes a transition probability matrix (TPM) for different discount levels following the IRDA rules of NCD using Markov chains. It is necessary to study long run behavior of premium to be paid by different groups of policyholders and whether NCD rates are parallel with probability of making a claim by policyholders.

The life insurance is one of the main sectors within the insurance industry. The professional automobile driving population is one of the most important sections for research of this field. It is necessary identify the most influencing factors in the life insurance demand that are taken by professional automobile drivers in our country. To obtain a better understanding of affecting factors, a logistic regression analysis has been applied in this study to identify the factors that might effects of taking life insurance policy.

Professional automobile drivers are important segment of the population who are likely to be familiar with addictive drugs such as heroine, cocaine, aphim and others. Knowledge about drugs and its ill effects on human health are
important for both sound health as well as safe driving. This study gives a comprehensive explanation of the multivariate technique called correspondence analysis, applied in the context of the knowledge about addictive drugs of professional automobile drivers. This technique is applied to study socio-demographic factors that explaining the knowledge about the addictive drugs of the automobile drivers which may helpful directly or indirectly in rate fixing.

1.3 Literature Review:

1.3.1 Review on Bayesian Credibility Theory

Credibility as we know it today dates at least to 1914 (Mowbray, PCAS) and by 1918 (Whitney, PCAS) both methods used today are developed in the context of workers compensation insurance. Bailey (1950) presents the relationship between Bayes' theorem and the credibility theory in which the credibility estimator in the form of linear function can be derived from Bayes' theorem, using the combined the information of prior and likelihood, followed by the posterior which is proportional: Posterior \propto \text{Prior} \ast \text{Likelihood}. His article has been recognised and has led to various applications of the Bayesian approach to credibility theory such as Mayerson (1964) who summarizes the Bayesian view of credibility and shows the Bayes' theorem and its relevance to credibility theory. Mayerson (1964) publishes a modern Bayesian approach to credibility theory. In his discussion of Mayerson's paper, Hewitt (1965) says, 'European actuaries have outstripped us in the classical 'theory of risk.' Professor Mayerson has distilled the essence of American achievement in the area of credibility and the Bayesian approach'.
Ferguson (1972) launches the Dirichlet process (a gamma process normed to a probability) and shows that it is a conjugate prior to the non-parametric family of distributions in the case of independently and identically distributed observations. Conjugate analysis has had limited impact on credibility theory, the reason being that in insurance applications it is typically not appropriate to impose much structure on the distributions. Jewell (1974) applies Bayesian theory with the natural conjugate prior of the distribution in the exponential family, and the exact credibility estimator equal to the linear credibility estimator is created. However, Bailey's assumptions in Bayes' theorem are restricted by the prior distribution. Miller and Hickman (1975) give the following definition of credibility theory: 'Credibility theory may be thought of as involving the development of a system of weights, which are functions of the size of the insurance experience available, for estimating future claims costs as a weighted average of the actual claims for the group under consideration and the expected claims based on prior or ancillary experience'. Historical overview of credibility are described in Hickman (1975) and Miller and Hickman (1975). These papers appear in Kahn (1975) which includes several papers of interest and the Bayesian approach to credibility. The 'un-Bayesed' approach to credibility theory is described in Gerber (1982). More reviews are given in Waters (1987), Goovaerts and Hoogstad (1987) and Goovaerts et al (1990).

A recent account of Bayesian Statistics in actuarial science can be found in Klugman (1992) which emphasizes in particular the Bayesian approach to credibility. Klugman singled out two important actuarial problems that can be successfully solved by the Bayesian approach. Examples of such models are

Bühlmann (1972) provides the linear approximation of the credibility estimator. Bühlmann's approach does not depend on the prior distribution that is often called empirical Bayesian procedure. Bühlmann's generalized approach is called Bühlmann-Straub modeling or Traditional credibility modeling. Bayesian methodology enters into actuarial science in a big way in the late 1960s by Bühlmann and Straub (1970) which laid down the foundation of empirical Bayes credibility premium formulae. In the classical model of Bühlmann (1967) the risk parameter is homogeneous in time. The Bühlmann and Straub (1970) model generalizes this model by the introduction of weights which could be interpreted as the amount of business in a given year. The notion of hierarchies is introduced in credibility theory by Gerber and Jones (1975), Taylor (1974), and Jewell (1975). The Hachemeister (1975) regression model extends the Bühlmann-Straub model by introducing a regression component. In the spirit of empirical Bayes estimation parameters are estimated from the data. DeVylder (1981) suggests forms of unbiased estimates.

Herzog (1990) examines the compatibility of the Bayesian and the Bühlmann models and show that the Bühlmann credibility estimate is the best linear approximation to the Bayesian estimate of the pure premium. Following Jewell (1974), it is shown that the Bühlmann credibility estimate is equal to the
Bayesian estimate for a large class of problems (linear exponential family and conjugate priors). Herzog (1999) presents an instance of credibility approach that is a technique for predicting future expected claims using the past experience claims of a risk class or related risk classes. Gau et al (2008) shows the credibility factor calculated by the Bayesian approach and compared to the Traditional credibility modeling in which the exposure numbers of risk in each policy year are known as one.

1.3.2 Review on Loss Reserves and Run-off Triangle

The most venerable and most famous of loss reserving methods are certainly the chain-ladder method and the Bornhuetter-Ferguson (B-F) method. It appears that the basic idea of the chain-ladder method was already known to Tarbell (1934) while the B-F method was first described almost forty years later in the paper by Bornhuetter and Ferguson (1972). The chain-ladder method proposes predictors of the ultimate (cumulative) losses and every predictor is obtained sequentially by multiplying the current (cumulative) loss by the chain ladder factors which are certain development factors (or link ratios) obtained from the runoff triangle. The B-F method proposes predictors of the outstanding losses and every predictor is obtained by multiplying an estimator of the expected ultimate (cumulative) loss by an estimator of the percentage of the outstanding loss with respect to the ultimate one.

In basic chain ladder method the development factors calculated based on payments from many different calendar periods; so whilst inflation is implicit in the factors derived, it is not clear what assumption for future inflation is actually made, other than that it is a weighted average of past values.
Inflation-adjusted chain ladder method adjusts the influences for the calendar year. This model adjusts the basic chain ladder to include an explicit allowance for inflation. The average cost per claim method takes into account the number of claims made in addition to claim amounts. The combination of number of claims and amounts of claims leads naturally to the consideration of average costs per claim. The chain ladder and related methods assume that the claim amounts, the number of claims incurred, and the rate of settlement remain stable from year to year. The method can be adapted to allow for the variations in the former, but not the latter (Booth et al, 2005).

The separation technique (Toylor, 1977) focuses on the derivation of calendar-year factors from the data. This model is identical to the inflation-adjusted chain ladder method. Here, the year of origin effect is removed by scaling the data using an appropriate exposure measure. The ultimate aggregate claim amount per unit of exposure is assumed to be constant. Operational time model (Reid, 1978) attempts to deal with variations in the speed of settlement of a cohort of claims. The data requires for this model are claim amounts, number of claims settled and number of claims incurred. Bootstrap method (Efran, 1982) is a simple and powerful method which enables the calculation of a number of different estimates of a random variable, using empirical data as an approximation for the true distribution of a (related) random variable. It provides a simple approach for calculating estimates of the error associated with the claims reserves. For a description of the bootstrap technique to claims reserving one refers to Lowe (1994), Taylor (2000) and England and Verrall (2002).
Apart from the chain ladder linear model, other models which have been suggested as suitable for claims data include a gamma curve (Zehnwirth, 1985) and an exponential tail (Ajne, 1989) in which the first few delay years follow the chain ladder model and the later delay years follow an exponential curve. With reference to the computing aspects, Renshaw (1989) has shown how these models can be implemented in GLIM, and Christofides (1990) has used the spread-sheet package SuperCafc.5. For a general model with parameters in the three directions, one refers to de Vylder and Goovaerts (1979). The probabilistic trend family (PTF) model (Barnett and Zehnwirth, 1998) which combines the effects of monetary inflation and changing jurisprudence. The Hoerl curve (Zehnwirth, 1985) has the advantage that one can predict payments by extrapolation for \( j > n \), because development year \( j \) is considered as a continuous covariate. This is useful in estimating tail factors. A mixture of above two models is described in England and Verrall (2001).

Verrall (1991) considers estimating claim reserves and outstanding claims by means of log-linear models. He compares these with maximum likelihood estimates. Renshaw and Verrall (1994) carry out the analysis assuming a Poisson model both for number of claims and claim amounts, while indicating that if a quasi-likelihood approach is taken then its use will be justified for data that are not positive integers. Verrall (2000) further explores the relation between the chain-ladder technique and some stochastic models. Again he assumes a Poisson distribution for claim amounts and indicates that this model should not necessarily be used for all data. Wright (1990) models claim number, claim magnitude and payment delay separately. He claims that
mean severity is not necessarily the same for all development periods and proposes a model in which expected payment is a function of the delay.

Verrall and Li (1993) consider the application of log-linear models to claims run-off triangles which contain negative incremental claims. Maximum likelihood estimation is applied using the three parameter lognormal distribution. The method can be used in conjunction with any model which can be expressed in lognormal form. Halliwell (2007) suggests that the bias of chain ladder method could be tested by comparing the more general linear model where the intercept was not forced to pass through origin.

Rietdorf (2008) point out that diagonal effects in non-life claims reserving based on run-off triangles usually come from two sources: (a) economic inflation; i.e. claim payments follow a relevant price index which again follows the calendar time and (b) claims inflation i.e. legal issues, changes in the way claims are handled or similar give diagonals effects in the number of payments. Jessen and Rietdorf (2009) present two different approaches to how one can include diagonal effects in non-life claims reserving based on run-off triangles. Empirical analyses suggest that the approaches in Zehnwirth (2003) and Kuang et al (2008a, 2008b) do not work well with low dimensional run-off triangles because estimation uncertainty is too large. To overcome this problem Jessen and Rietdorf consider similar models with a smaller number of parameters. These are closely related to the framework considered in Verbeek (1972) and Taylor (1977, 2000); the separation method. Jessen and Rietdorf explain that these models can be interpreted as extensions of the multiplicative
Poisson models introduced by Hachemeister and Stanard (1975) and Mack (1991).

Bayes estimates for the linear model investigate by Lindley and Smith (1972) and also Smith (1973). In the actuarial literature, Klugman (1989) has studied the use of hierarchical linear models in a rating context. The historical requirement that credibility estimators be linear will also be considered and one could claim to have credibility formulae. The situation has some similarities with credibility estimators of risk premiums in that one can regard the rows in a runoff triangle as a set of risks and proceed as Bühlmann (1967) – one refers to Goovaerts and Hoogstad (1987) for a full description of Bühlmann's method, in the case of claims runoff triangles the rows contain different numbers of elements, and there are also the column parameters to contend with. This approach, starting from credibility premiums and working through to a credibility theory for loss runoff triangles, suggests by de Vylder (1982) - again one refers to Goovaerts and Hoogstad (1987) for an exposition of the method.

This study does not intend to give here an extensive review of Bayesian methods. Rather this study will describe them very briefly and discuss their applications in loss reserving. For general discussion on Bayesian theory and methods one may refer to Berger (1985), Bernardo and Smith (1994) or Zellner (1971). For a discussion of Bayesian methods in actuarial science one refers to Klugman (1992), Makov et al (1996), Makov (2001) and Scollnik (2001). Bayesian analysis of IBNR reserves has been considered before by Jewell (1989, 1990), Verrall (1990) and Haastrup and Arjas (1996). Verrall (1990) approaches 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. More recently, Bayesian results are provided in England and Verrall (2002), notably for the B-F technique. In the traditional B-F method use is made explicitly of perfect prior (expert) knowledge of 'row' parameters. This is clearly well suited for the application of Bayesian methods when knowledge is not perfect, England and Verrall (2002). Ntzoufras and Dellaportas (2002) consider various competing models using Bayesian theory and Markov chain Monte Carlo methods.

1.3.3 Review on NCD/BMS

No-claim problems have been discussed since the fifties. Several Actuarial Studies in Non-life-insurance (ASTIN) meetings paid attention to this subject. Bonus-Malus systems (BMSs) or No Claim Discount (NCD) systems are introduced in Europe in the early 1960s, following the seminal works of Delaporte (1965), Bichsel (1964), and Bühlmann (1964). There exists a vast literature on BMSs in actuarial journals, mainly in the ASTIN Bulletin, the Scandinavian Actuarial Journal and the Swiss Actuarial Journal.

Derron (1965) states 'that a subsequent adjustment of premiums according to the past claim record may well be a suitable way of obtaining a fair premium'. Gürtler (1960, 1961 and 1962) introduces a standard for evaluating the fairness of a premium. Derron (1965) extends and complements the results obtained by Gürtler.

Welten (1969) points out that the bonus a policy holder obtains usually consists of at least three components which depend on the length of time
preceding the current insurance period: a component concerning the individual claim frequency, an individual random factor and a collective random factor. The last two components tend to zero for increasing length of time. The sum of these last two components, called ‘unearned bonus’, should be taken into account by insurance companies in the short run, and would lead to a bonus reserve.

Alting von Geusau (1968) investigates ‘to what extent it is possible to develop a theoretical framework to test that a no-claim-discount-system will prevent the insured from submitting small claims to the claims made during that year or to take for his own account the costs of one or more claims. insurance company’, and ‘that the insured who has just lost his no-claim discount will use every possibility for submitting claims with in his mind the idea that in this way he will earn back his higher non-reduced premium’.

Loimoranta (1972) develops formulas for some asymptotic properties of bonus systems, where bonus systems are understood as Markov chains. Lemaire (1976) defines an efficiency concept for a bonus-malus system, which differs from the concept given by Loimoranta (1972). De Pril (1978) presents a more general concept of efficiency, which includes both earlier ones as special cases.

Grenander (1957) derives equations to determine a rule of the form ‘pay the damage if its amount is smaller than a critical value and claim it otherwise’. However, the equations are generally difficult to solve, and it is not proved that they really determine an optimal policy in the sense that the total expected discounted cost of premiums and payments during a long future planning period is minimized. Haehling von Lanzenuer (1969, 1972a and 1972b) analyses the
problem on the assumption that a policy holder can cause at most one accident per year.

De Leve and Weeda (1968) develop a mathematical model, called generalized Markov programming, that yields an optimal strategy, which is a function $s(t)$ that minimizes the expected costs for the policy holder. This function $s(t)$ is such that “if at any time $t$ an accident occurs with damage ‘$s$’ and no damages have been claimed since the last payment of premium, then ‘$s$’ should be claimed if ($s > s(t)$)”. In this approach the decision depends on the point of time during the year and the premium paid at the beginning of that year. De Leve and Weeda allow more than one accident per year, but restrict their analysis to the case where, after making one claim during an insurance period, the policy holder is placed in the class with the highest premium. Weeda (1975) extends the analysis of the same model to the case where the damage distribution is given by an arbitrary distribution and focuses on the theoretical aspects of the derived iteration scheme. However, although the model is continuous with respect to the time axis, he discretizes time for computational purposes.

Johnson and Hey (1971) describe the use of a simple mathematical model to study the influence of a single risk factor after largely eliminating the effects of other risk factors represented in the model. This can be done for NCD. If the portfolio is grouped according to NCD category we can calculate for each group the claim cost per vehicle year, having largely eliminated the effects of the rating factors, other than NCD, which are used as a basis for the model. Martin-Löf (1973) shows that a decision rule of the form formulated by
Grenander is optimal in the sense that it minimizes the total expected costs. The decision rule is derived by applying the general theory of Markov decision processes, which uses dynamic programming to find an optimal control iteratively. Martin-Löf, however, restricts the analysis to the case where the policy holder takes a decision only at the end of an insurance period for the total amount of damage sustained during that insurance period.

Haehling von Lanzenauer and Lundberg (1973) develop a model which can be used in deriving the distribution of the number of claims for insurances with merit-rating structures. The problem is formulated and solved as a regular Markov process with the claim behaviour integrated in the analysis. Haehling von Lanzenauer (1974) develops an optimal decision rule for situations where the policy holder takes a decision more than once a year - which is valid for any merit-rating system. He splits up a year into a number of periods, which results in a discrete model in which the optimal critical claim size can be determined by dynamic programming. However, his derivation of an optimal critical claim size is obscure.

Almost all studies mentioned above have in common that they assume a discrete time axis. De Pril (1979) gives a formulation based on a continuous time axis, where the optimal critical claim size can be determined by solving a set of recurrent differential equations. However, for solving these equations, a discretization is needed, giving rise to the same results as in Haehling von Lanzenauer (1974). Norman and Shearn (1980) build on Hastings' model, where they drop the restriction of a constant optimal critical claim size. Moreover, they present a much simpler state description than the one used by
Haehling von Lanzenauer (1974). The optimal decision rule has been compared with rules of thumb that appear to produce remarkably good results. Tijms (1986) gives a model that is equal to that presented by Norman and Shearn as an illustration.

Lemaire (1985) describes a simple model with the assumption that all claims are reported in the middle of the insurance period. Menist and Volgenant (1986) compute the optimal critical claim size by considering the difference between the expected costs in case of claiming and that of not claiming damage. They restrict the analysis to a finite horizon.

Bonsdorff (1992) states that under certain conditions, a Bonus-Malus system can be interpreted as a Markov chain whose n-step transition probabilities converge to a limit probability distribution. The rate of the convergence is studied by means of the eigenvalues of the transition probability matrix of the Markov chain making the standard assumption that for each policy the number of claims (per year) is Poisson distributed with intensity 2. For each fixed policy the intensity is assumed to be independent of time.

Coene et al (1996) are studied the premiums for a BMS which stays in financial equilibrium over the years are calculated. This is done by minimizing a quadratic function of the difference between the premium for an optimal BMS with an infinite number of classes and the premium for a BMS with a finite number of classes, weighted by the stationary probability of being in a certain class, and by imposing various constraints on the system.

The traditional method of obtaining optimal claim limits for vehicle insurance is to discretise the state space and use successive approximations.
Dagpunar (2000) show how the stochastic dynamic programming equations reduce to a set of differential equations, in which these are easily solved to provide exact continuous time solutions. The resulting model can be used for evaluating alternative levels of excess. Operational Research has played a part in the development of mathematical models within insurance. This is not surprising since decision making and risk assessment figure prominently in such problems.

Baione et al (2002) have studied the BMS in force show a progressive reduction of the observed average premium, which causes a financial imbalance in the system. As a consequence, frequent premium adjustments become necessary and result in a discrepancy between the reduction defined in the policy contract and the effective discount applied to the driver. Most policyholders are not aware of this "lack of transparency". This paper deals with the problem of designing an optimal tariff structure so that the designed BMS is adequate and satisfies both transparency and financial balance conditions.

Pitrebois et al (2006) design of Bonus-Malus scales involving different types of claims. Typically, claims with or without bodily injuries, or claims with full or partial liability of the insured driver, are distinguished and entail different penalties. Under mild assumptions, claim severities can also be taken into account in this way.

Yaniv Zaks (2008) considers the classical BMS having several premium levels (M), a premium level ‘i’ consists of a premium (p_i) and a deductible (d_i). He considers the expected cost for a horizon of n periods of a policyholder in level ‘i’. This expectation is denoted by E_n(i).
occurs, the policyholder should decide whether or not to claim. The minimum damage for which the policyholder will claim should be the solution of

$$\min_{d_i \leq x} \{x + E_{n-1}(i-1), d_i + E_{n-1}(i+1)\}.$$ 

He shows that

$$E_{n-1}(i-1) \leq E_{n-1}(i+1) \text{, hence } x = d_i + E_{n-1}(i+1) - E_{n-1}(i-1)$$

is a valid solution.

For each level 'i' and horizon 'n', the policyholder should determine the threshold $s_{n,i}$, for claiming. The set $S = \{s_{n,i}\}_{i=1}^{\infty}$ is called the strategy of the policyholder. The policyholder will seek a strategy with minimum discounted expected cost. Such a strategy is called an optimal strategy. Zacks and Levikson (2004) find the optimal strategy using methods of Markov chains and dynamic programming, both to the discrete and continuous models. Kliger and Levikson (2002) find a strategy in a model in which the policyholder should submit no claims for two time periods in order to deserve a bonus.

1.3.4 Review on Factors Demand's for Life Insurance

There is a considerable research devoted to analyzing these types of problems i.e. study about the affecting factors of demand of life insurance. But not much literature is available on driving population. However, previous studies have provided some conflicting results. Most research on life insurance demand determinants is based on empirical data. The demographic, economic and psychographic factors found to be the most robust in predicting life insurance demand will be the focus of this review. Literature review of affecting covariates on purchasing of a life insurance policy describes separately in next few sections.
Age

There are contradictory conclusions about the effect of age on the demand for life insurance. Berekson (1972), Showers and Shotick (1994), Baek and DeVaney (2005) found that the effect of age was positive and significant, but Ferber and Lee (1980), Bernheim (1991) and Chen et al (2001) found a negative significant relationship between age and life insurance demand, whereas Hammond et al (1967), Duker (1969), Anderson and Nevin (1975), Burnett and Palmer (1984), Gandolfi and Miners (1996) argued that age was not a significant factor in purchase of life insurance. Bernheim (1991) used a probit, a Tobit and a Heckman model, respectively to investigate the impact of bequest motives on savings based on the estimates of the demand for life insurance. The effect of age on life insurance holding was also examined in these models. The results of all three models showed that the probability of life insurance holdings fall with age. Bernheim pointed out that this negative relationship could reflect dissaving behavior after retirement of the respondent. Using the 1984 Life Insurance Marketing Research Association (LIMRA) data, Gandolfi and Miners (1996) found that age was negatively associated with the demand for life insurance for husbands, while the age variable was not significant in the model when studying life insurance demand for wives.

Education

Most researchers such as Hammond et al (1967), Ferber and Lee (1980), Burnett and Palmer (1984), Gandolfi and Miners (1996), and Baek and DeVaney (2005), agreed in their research that there is a positive relationship between education and life insurance demand. They recognized that those who
have a better education will purchase more life insurance, potentially due to the fact that households with greater education can expect their incomes to continue to increase at a faster rate and for a longer period of time. Baek and DeVaney (2005) examined the effect of human capital, bequest motives, and risk on term and cash value life insurance purchased by households. They explain this positive relationship was due to a greater loss of human capital when the household head dies. Households with a head with greater education have potentially higher incomes. The death of such a household head will bring more financial loss to the family as compared with those with lower education. Hence, the purchase of life insurance for those with greater education increases as the value of the lost human capital increases. Anderson and Nevin (1975), however, found a negative association between education and the amount of life insurance purchased. The authors explained that higher educated people may believe that inflation often decreases the cash value of life insurance from a savings standpoint and hence declines their need for life insurance.

**Family size and number of children**

Family size and number of children were found to be significant explanatory variables for determining the demand for life insurance in many studies (Hammond et al, 1967; Ferber and Lee, 1980; Burnett and Palmer, 1984; Showers and Shotick, 1994). Burnett and Palmer (1984) employed a dollar amount of total individual life insurance including term, whole life and endowment as a dependent variable. Using Multiple Classification Analysis (MCA), three demographic variables were found to be statistically significant in their association with the amount of life insurance. Number of children was one
of positive significant variables. Burnett and Palmer noted that as the number of children increased, the amount of insurance purchased also increased. This is as expected with households with more children having a greater demand for financial resources if the household head dies. Showers and Shotick (1994) examined the positive relationship between family size and life insurance purchased in their 1994 study. In contrast, Anderson and Nevin (1975) obtained the result that there is no significant association between family size and the purchase of life insurance.

**Employment**

Previous studies have consistently conclusion that, if household heads or husbands are employed, more life insurance will be purchased by individuals or households. These studies' authors include Hammond et al (1967), Mantis and Farmer (1968), Duker (1969), Ferber and Lee (1980), and Fitzgerald (1987). Fitzgerald (1987) developed a one period model of the amount of life insurance purchased by a married couple. The dependent variable in this study was the face amount of life insurance held by the husband. The results showed that occupation of husband had a positive impact on the amount of life insurance purchased. Gandolfi and Miners (1996) found that the wife’s employment status has a negative impact on the husband’s life insurance ownership. They argued that full-time labor force participation by the wife reduces the husband’s life insurance demand. The analysis of Baek and DeVaney (2005), however, indicated that labor force participation by the wife enhanced the purchase of both cash value and term life insurance of the household.
Other demographic factors

Very few research articles have examined the influence of health status or life expectancy on the life insurance purchase. Zhu (2007) studied an individual's choices on the purchase of life insurance and the purchase of stocks using one-period and two-period models. Zhu argued that when an individual decided the purchase of life insurance and stocks, he or she would consider his or her personal circumstances, such as wealth, future income, health status and survival probability, attitudes toward risk and bequest. Zhu found that an increased survivor probability encouraged the individual to hold more life insurance. Similarly, Baek and DeVaney (2005) showed that a household with a healthy head spends more on life insurance expenditures.

Marital status has also been found to strongly affect both household and individual life insurance demand in previous studies (Hammond et al, 1967; Mantis and Farmer, 1968). Mantis and Farmer (1968) were among the first to examine how marital status influences life insurance demand of households using multiple linear regression analysis. Premium expenditures were used as the dependent variable to see if there was an association with demographic independent variables. They expected that married men would spend more money on life insurance than single men. But the analysis showed a negative association between marriage and life insurance premium expenditures.

Hammond et al (1967) also investigated the relationship between life insurance premium expenditures and various demographic characteristics of households. Marital status and race were included among the independent variables. The authors believed that race mirrored some cultural differences,
such as attitudes toward death, family, individualism, and risk aversion. These differences may explain some variation in premium expenditures among households. They found that marital status was negative and significant and race was not significant in the multiple linear regression analysis where premium expenditure was the dependent variable.

**Income**

Income is commonly found to be positively related to the demand for life insurance, holding other factors constant. The effect of current income on life insurance demand is examined in numerous studies (Duker 1969; Ferber and Lee, 1980; Truett and Truett, 1990; Showers and Shotick, 1994; Gandolfi and Miners, 1996). Showers and Shotick (1994) used a tobit analysis to analyze the effect of household characteristics on the demand for total life insurance. The dependent variable used was premium expenditures on life insurance products. They assumed that life insurance was a normal good. The tobit analysis indicated that a positive relationship existed between income and expenditures on life insurance premiums. They explained that as income increased the household has a motive to buy more life insurance because life insurance is bought as a function of the income replacement needed, in the event of an unexpected death of the major wage earner.

**Net worth or wealth**

There are inconsistent conclusions in previous research regarding how net worth or wealth affects life insurance purchase decisions. Some authors believed there is a positive relationship between net worth or wealth and the demand for life insurance (Duker, 1969; Anderson and Nevin (1975); Hau,
since life insurance might provide protection for households' wealth. Anderson and Nevin investigated the variables associated with the amount and type of life insurance purchased by a sample of young newly-married couples using MCA. There were two dependent variables in their study. One was the amount of life insurance purchased which was a continuous dependent variable measured. The other dependent variable was the type of life insurance purchased which is a dummy dependent variable. The results of MCA showed that net worth was a positive and significant factor in explaining both the amount of life insurance purchased and the purchase of term life insurance.

Conversely, some studies support the conclusion of negative association between net worth and the purchase of life insurance arguing that the households with higher net worth or wealth have greater capability to hedge against the financial loss that may follow the primary earner's premature death (Fortune, 1973; Lewis, 1989). Lewis viewed household demand for life insurance from the perspective of the beneficiaries. He thought that life insurance was chosen to maximize the beneficiaries' expected lifetime utility. Lewis found that net worth of the household was negatively associated with the demand for life insurance, when premiums for life insurance were the dependent variable.

The rate of interest and inflation

Several researchers have examined whether consumers are sensitive to market rates of interest when making life insurance purchases. Headen and Lee (1974) indicated that the interest rate has a different effect on the demand of insurance depending on whether it is in a short or a long run situation. In the
short run, the demand increases with higher interest rates, whereas in the long run, the interest rate has no obvious influence on the demand for life insurance.

In another paper, Pliska and Ye (2007) found that a wage earner buys less life insurance as the interest rate increased. They reasoned this result was due to the wage earner tending to spend less on consumption including buying life insurance and saving more money for the future as interest rates increase.

Inflation has also been studied as a factor in the life insurance purchase decision and has been found to not be significant factor in the demand for life insurance (Neumann, 1969; Chang, 1995).

**Homeownership**

It is widely believed that homeownership is positively related to the amount of life insurance held (Anderson and Nevin, 1975; Ferber and Lee, 1980; Gandolfi and Miners, 1996). Gandolfi and Miners estimated the influence of income and the value of household production on the amount of life insurance purchased for both husbands and wives and investigated whether the influence differed by gender. Husbands and wives were examined separately and total, group, and individual life insurance were used as three separate dependent variables in the Tobit model. They did not separate term policies from cash value policies due to the data limitations. The analysis indicated that home ownership was strongly positive in all the equations for both husbands and wives.

**Risk aversion**

The research on how risk aversion relates to the demand for life insurance is varied. It is expected that the greater a household’s risk aversion,
the greater their incentive to buy life insurance. This point is supported in the studies of Burnett and Palmer (1984), Baek and DeVaney (2005), and Zhu (2007). In Baek and DeVaney’s study, attitude toward risk was measured by the question: “Which of these statements comes closest to the amount of financial risk that you are willing to take when you save or make an investment?” The analysis of Baek and DeVaney showed that above-average risk takers were more likely buy term life insurance than those who preferred taking average risk. Also, those who take average risk hold 10% more cash value life insurance than those who take no risk. However, Greene (1963) measured the attitude toward risk by twenty questions and used the index for these questions. He found no significant relationship between risk attitude and insurance purchase behavior.

**Other psychographic factors**

Burnett and Palmer (1984) explored 14 psychographic factors, such as work ethic, self esteem, community involvement, fatalism, socialization preference, religious salience, and so on, as influential in determining life insurance demand. They found that life insurance is related with personality traits of individuals. The results showed that if people are self-sufficient and believe that they are in control of their own well being, they will buy more life insurance. Other interesting results include: people who are more likely to own life insurance purchase are individuals who are not opinion leaders, are not price conscious, are not information seekers, and are low in self esteem.
1.3.5 Review on Correspondence Analysis (CA)

The analysis of the contingency table is a very important component of Multivariate Statistics with many different types of analysis dedicated solely to this type of data set. Fienberg (1982) points out that the term contingency seems to have originated with Karl Pearson (1904) who used it to describe the measure of the deviation from complete independence between the rows and columns of such a data structure. More recently, the term has come to refer to the counts and the marginal frequencies in the contingency table. As a result, a contingency table contains information which is of a discrete or categorical nature. One of the most influential techniques developed to measure the association between two categorical variables is the Pearson chi-squared statistic. Pearson (1900) developed the ground work for the chi-squared statistic which is used to compare the observed counts with what is expected under the hypothesis of independence between the two variables. The theoretical issues associated with correspondence analysis (CA) date back to the early 20th century and its foundation is algebraic rather than geometric.

The technique apparently has many independent beginnings (for example, Richardson et al, 1933; Hirshfeld 1935; Horst 1935; Fisher 1940; Guttman 1941; Burt 1950; Hayashi 1950). It has had many other names, including optimal scaling, reciprocal averaging, optimal scoring, and appropriate scoring in the United States; quantification method in Japan; homogeneity analysis in the Netherlands; dual scaling in Canada; and scalogram in Israel. CA is analysis described in more detail in French in Benzécri (1973a, 1973b) and Lebart, Morineau, and Tabard (1977). In Japanese, the subject is
described in Komazawa (1982), Nishisato (1982), and Kobayashi (1981). In English, CA is described in Lebart, Morineau, and Warwick (1984), Greenacre (1984), Nishisato (1980), Tenenhaus and Young (1985); Gifi (1990); Greenacre and Hastie (1987); and many other sources.

The foundation of the technique was nearly laid with the 1904 and 1906 papers of Karl Pearson, as argued by de Leeuw (1983), when he developed the correlation coefficient of a two-way contingency table using linear regression. As Pearson (1906) states: “The conception of linear regression line as giving this arrangement with the maximum degree of correlation appears of considerable philosophical interest. It amounts primarily to much the same thing as saying that if we have a fine classification, we shall get the maximum correlation by arranging the arrays so that the means of the arrays fall as closely as possible on a line”. de Leeuw (1983) then notes: “this is exactly what CA does. Pearson just ... was not familiar with singular value decomposition, although this had been discovered much earlier by Beltrami, Sylvester and Jordan”. However, the original algebraic derivation of CA is often accredited to Hirschfeld (1935) who developed a formulation of the correlation between the rows and columns of a two-way contingency table. Others to contribute to such developments include Richardson and Kuder (1933) and Horst (1935). In fact, Horst, who discussed his findings in early 1934 before the Psychology Section of the Ohio Academy of Science, was the first to coin the term "method of reciprocal averaging", an alternative derivation of CA. The simplest derivation of CA was made by the biometrician R.A. Fisher in 1940 when he considered data relating to hair and eye colour in a sample of children from Caithness,
Scotland. While the original development of the problem aimed at dealing with two-way contingency tables, a more complex approach dealing with multi-way contingency tables was not discussed until 1941 when psychometrician Louis Guttman discussed his method, called dual (or optimal) scaling, which is now referred to as the foundation of multiple correspondence analysis (MCA). Later applications of MCAs were considered using the Burt matrix of Burt (1950). In fact Guttman (1953) writes of Burt: "... it is gratifying to see how Professor Burt has independently arrived at much the same formulation. This convergence of thinking lends credence to the similarity of the approach”. Fisher and Guttman presented essentially the same theory in the biometric and psychometric literature. Thus biometricians regard Fisher as the inventor of CA, while psychometricians regard it as being Guttman.

In the 1940's and 1950's further advances were made to the mathematical development of correspondence, particularly in the field of psychometrics, by Guttman and his researchers. In Japan, a group of data analysts led by Chikio Hayashi also further developed Guttman's ideas, which they referred to as the quantification of qualitative data. The 1960's saw the biggest leap in the development of CA when it was given a geometric form by linguist Jean-Paul Benzécri and his team of researchers at the Mathematical Statistics Laboratory, Faculty of Science in Paris, France. This work culminated in two volumes on data analysis; Benzécri (1973a, 1973b). As a result the method of l'analyse des correspondances, as coined by Benzécri, is very popular in France.
In 1974, this new method was widely exposed to English speaking researchers with the popular paper by Hill (1974). He was the first to coin the method's name correspondence analysis which is the English translation of Benzécri's l'analyse des correspondances. Hill showed that the method is mathematically similar to already popular methods of data analysis such as principal components analysis, canonical correlation analysis and reciprocal averaging. Since Hill's contribution, the theory of CA, especially its application to multivariate data, has been reinvented many times and given different names, such as homogeneity analysis (Gifi, 1990) and dual scaling (Nishisato, 1980, 1994).

Goodman (1986) presents a comprehensive and most stimulating discussion on modified CA and the analysis of association in contingency tables via the log-linear approach. Gilula and Haberman (1986 and 1988) developed inferential canonical correlation techniques based on maximum likelihood which allow the consideration of restricted models. These techniques are straightforwardly applicable to correspondence models. The development of the inferential aspects makes the already appealing CA a meaningful tool within the statistical modeling paradigm. Goodman (1985 and 1986) also discusses the suitability of correspondence models to the analysis of ordered tables.
1.4 Objectives of the Study:

Keeping in view the importance of the study, the present work has been undertaken with the following objectives:

- To propose alternative Bayesian Credibility models and to test these with conventional approach to explore the claim frequency as well as premium.
- To modify the loss reserving model and to compare it with existing one to know the loss reserve pattern.
- To study the stochastic behavior of NCD system of professional automobile drivers and to know the long run claim pattern.
- To identify the socio-economic and demographic factors affecting the life insurance policy of professional automobile drivers.
- To observe prevalence of the risk factors of driving among the professional automobile drivers.

1.5 Data Sources:

In this thesis, the required data have three sources, viz. primary data, secondary data and simulated.

The secondary datasets are obtained from regional office of The New India Assurance Company Limited (NIACL), Guwahati, India and from year books published by the company time to time. This regional office of NIACL comprised mainly eight divisional offices. These divisional offices are Dibrugarh, Guwahati-I, Bangaigon, Shillong, Dimapur, Silchar, Guwahati-II and Tinsukia. These divisional offices cover insurance of all the eight North-
Eastern States (Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikim) of Indian territory.

The secondary data (mid-year) on number of claims, amount of Own Damage (OD) and amount of Third Party (TP) premiums earned by the NIACL per year from automobile policyholders, are taken from Regional Office of NIACL, Guwahati having eight divisional branches for the years 2004 to 2008.

The motor insurance paid claims in two ways. They are paid claims for motor own damage and paid claims for motor third party liability. But these cases are considered without separation. The payments in the period might be subdivided into payments on previously existing claims or payments on newly advised claims. These values would normally be available by reference to a period of origin and a calendar period of transaction. The origin period is the opening reference point for a claims cohort and is commonly an accident or underwriting period. The paid claims of all eight divisions consider together.

Primary data using cluster sampling on socio-economic and socio-demographic of professional automobile drivers from Karimganj district of Assam, North Tripura and West Tripura districts of Tripura. Karimganj situates between longitudes 92°15'-92°35'E and latitudes 24°15'-25°55' N. It occupies an area of 1809 Sq. km. Located in the southern part of Assam in North-east India. North Tripura occupies an area of 2469.90 Sq. km. It is located between 24° 19' Latitude and 92° 01' Longitude. West Tripura district covers an area of 3544 Sq. km. and lies between 23°16' to 14° 24°14' north latitude and between 91° 09' east to 91° 47' east longitude. The primary data for this study has been collected from various small urban areas of the three districts at the end of the
year 2007. The drivers found are mainly belongs to age group (18–59) years. This study have only considered 521 automobile drivers due to time and cost reasons. In these area only male are belongs to professional automobile drivers.

During the survey, the information about some characteristics of the vehicles, such as their nature of use, types of vehicle driving as well as own characteristics of the professional automobile drivers, like age, marital status, religion, caste, educational status of drivers as well as of family, geographical area of driving as well as area where he originally belongs, health status, drinking behavior, smoking habit, knowledge about addictive drug such as heroine, cocaine, ganja etc., whether the driver is trained mechanic or not, accident records of last two years and of whole driving span, type of family, family size, number of earning member in the family, owner of the car, income of the driver as well as of family, having life insurance or not, number of close driving friends, year of driving or driving experience and many more have been collected.

In this thesis, Bayesian models have been demonstrated through simulated data when required.

1.6 Chapters of the Thesis:

In view of the outlined objectives, this present research is organized into seven chapters as follows:

Chapter I, which is introductory in nature, presents brief conception of insurance, some literature review, importance as well as objectives of the study and sources of data. Chapter II looks at the Bayesian credibility models for
automobile insurance and its applications in automobile insurance. In this chapter, some new Bayesian credibility models have been offered.

Chapter III, deal with the development of loss reserving models and its applications to automobile insurance. This chapter tries to extend some previous models of loss reserving based on run-off triangle in this chapter.

Chapter IV is devoted to Markovian study of no claim discount systems. Using no claim discount rule of IRDA, a transition probability matrix to study the long run behaviour of claim pattern be proposed here.

Chapter V isolates the factors influencing professional automobile drivers' demand for life insurance and Chapter VI is devoted for measuring the levels of knowledge about drugs of professional automobile drivers.

Chapter VII summarizes and concludes the thesis pointing out the main findings, possible future work, limitations and message to the policy makers.