A C T A U N I V E R S I T A T I S L O D Z I E N S I S
FOLIA OECONOMICA 285, 2013

Tomasz Zapart[*]

THE ROLE AND IMPORTANCE OF AN ACTUARY IN THE INSURANCE

Abstract. Actuary on the basis of the tasks arising from the audit process of an insurance undertaking is obliged to submit their opinion on all activities of that establishment which could have an impact on the financial position of an insurance undertaking and consequently affect your ability to meet long-term liabilities of the undertaking by providing professional analysis of the internal and external insurance for the governing bodies. The knowledge and perspective on actuarial topics of particular importance in the insurance business, where its implementation entails certain financial impact. The article discusses the basic tools and techniques in the field of probability and statistics, which are conical to practice as an actuary and presentation methods used by the actuary and statistical principles in the insurance companies and their importance to the financial situation of an insurance company.

Key word: actuary, insurance, insurance statistics, decision theory and game, credibility theory, Bayesian statistics, Markov chains, bonus-malus, Generalized Linear Models.

I. INTRODUCTION

Risk accompanies every human activity (Ronka-Chmielowiec, 1997, p. 10). A specialist in risk estimation is an actuary. Actuary employment places can be all financial institutions where the risk is managed. Undoubtedly it is an occupation which is connected with the necessity of long and arduous work. In order to become the actuary in Poland one has to:

- graduate from university
- pass the actuarial exam
- perform activities concerning actuarial and financial mathematics and statistics under actuary guidance during at least 2 years

A basic but not the only actuary employment place is an insurance company. Every insurance company, according to The Act of 22nd of May 2003 on insurance activity has an obligation to appoint an actuary. In case of life insurance (so called Section I) the actuary is responsible for technical- actuarial (Wieteska, 2004, p. 128) reserves calculation whereas in case of property and life insurance (Section II) his opinion published in an annual report is essential.

[*] M.Sc. PZU SA Headquarter in Warsaw.

The purpose of the article is to present the statistical rules used by actuarial in insurance enterprises and their impact on the financial situation of the insurance undertaking. Actuary on the basis of the tasks arising from the financial control of the insurance undertaking is required to submit his own opinion as any action of that plant, which may have an impact on the financial situation of the insurance undertaking and consequently affect the ability to meet long-term obligations. By providing professional analysis of the internal and external situation of the establishment and, based on this analysis, the Council for the management bodies undertaking, an actuary may assist the activities of the insurance undertaking, in order to achieve healthy financial condition and through this ensure the satisfaction of the expectations of the insured and the insured under insurance contracts.

Additionally in this article there will be discussed basic tools and techniques from calculus of probability and statistics, which are essential for working as the actuary who is going to work in insurance.

II. INTRODUCTION TO THE ACTUARY JOB

Actuary job roots reach the turn of the centuries XVII and XVIII and were connected mainly with life insurance development, but the job gained meaning not before the XIXth century. The actuarial mathematics began at the end of the XVIIth century with English astronomer E. Halley studies on chosen population mortality and in 1948 in London there was established Actuaries Institute –a first scientific unit doing research on actuarial mathematics.

In Poland as this job beginning there can be taken year 1920, when Polish Actuaries Institute began its activity. Since 1990 on Warsaw University Economy Sciences Department there has functioned Summer Actuarial Sciences School. Now many units at Polish universities also teach actuarial education. The actuaries environment in 1991 brought Polish Actuaries Association into being. The Association task is supporting this job group and also taking part in legislative works on insurance. The Association is an International Actuaries Association member. There is a necessity of introducing a national actuary who would lead the social insurance system.

Most actuaries work in life insurance, actuary assistance, investments or in property insurance but all have to know investment strategies well. Life insurance companies deliver pension benefits, life insurance and other financial services in order to meet long-term financial client needs and to give the client a real financial security feeling. In actuarial assistance partnerships actuaries assist organizations in all important matters concerning employee benefits, particularly in creating, calculating premiums and working out investment strategies to fulfill payment in a pension system. Investment actuaries may specialize in funds management, results tracking and investment decisions assistance. They can work for investment banks or assist them, work for brokers, or in investment and/or HR departments in big companies. Work in property insurance may be the most dynamically developing for actuaries and also includes health insurance, property insurance (e.g. houses and mechanical cars insurance), and also high companies risks and employers responsibility.

III. ACTUARIAL EXAMS

According to

The Finance Minister ordinance from 20th of November 2003 on valid actuarial exams scope and these exams carrying out procedure (Journal of Laws, No.211, item 2054) this exam scope includes four sections:

1. financial mathematics,
2. life insurance mathematics,
3. other life and property insurance,
4. probability and statistics.

Financial mathematics allows on using mathematical methods to calculate different money values, among other things: interest theory, money flow calculation, debts paying off, investment decisions analysis, financial instruments pricing. It can be stated that these problems knowledge enables efficient finances management and is useful not only for the actuary.

Life and property insurance mathematic allows in turn mainly on premiums , benefits and indemnities calculation. Only an insurance type is different. In order to do this in life insurance it is essential to know principles and regularities governing mortality processes and methods allowing to measure them. In property insurance it is essential to know methods allowing on probability of damage and its amount estimation. Additionally both in life and property insurance mathematics it is essential to calculate insurance reserves gathered to benefits and indemnity payment, and estimate insurance costs.

Many of these exams require both good statistics and probability understanding. These exams include basic problems connected with probability and statistics (exploratory data analysis, a probability definition, random variables and their basic properties, generating different probability functions, normal discrete and constant distributions, independence concepts, two-dimensional distributions, independently variable sums (random), central theorems limits and their applications, basic trying definitions and example distributions, estimators and confidence interval estimation, hypotheses testing grounds, linear relations between variables using correlation and regression

(Zehnwirth, 1989, p. 1–8), basic variance analysis definitions, conditional expectancies and complex distributions with applications.

Basic knowledge on valid exam subjects for actuaries includes many ideas using probability and statistics which are particularly useful for actuaries working in property and life insurance. These subjects include: decisions theory, losses distribution, risk theory, ruin theory, Bayes statistics and plausibility, estimation concepts, general linear models, time series methods and Monte Carlo simulations.

IV. STATISTICAL SKILLS FOR THE INSURANCE ACTUARY

Decision Theory

Decision Theory interprets statistics as a game of a "statistician" with "nature" and allows on uniform treating of estimation tasks, hypotheses testing, prediction and others. Theory- decision making are nowadays commonly accepted mathematical statistics language. The actuary will often be called to give advice or make decisions facing insecurity. An action or a strategy which a deciding person will finally make, will obviously depend on criterion, which is accepted in decisions making. In any given situation there can be a few possible criteria to consider. Some situations may be seen as games (with an intelligent and competing opponent as an insurance company), whereas in others the opponent may be seen as an uncompetitive opponent, which will be named „nature" (as future economy condition which will have an influence on that if a new insurance product will be at an affordable price or accepted by insurance companies clients). Decisions and games theory grounds knoowledge undoubtedly will be helpful in understanding both how people make decisions and why. Good games with a zero sum and a variable understanding may be useful along with minimax concepts, for applying appropriate strategies. Variable games sums examples, where cooperation could be useful for both sides are important in understanding compromise advantages. In some of these situations, an uncertainty level, because of its nature may be decreased by experiments or gaining additional example information, (although it can often be connected with costs). Finally a public utility definition, as an alternative values system to a monetary system has a key meaning for successful economic activity functioning.

Losses Distribution

The actuary must particularly model both damages frequency, losses and demands amount. Techniques in exploratory data analysis such as histograms, quantile divisions and total statistics including example skew and curtosis estimations may be a very useful tool in approval obtaining for *a typical insurance claims amount*. Relatively high insurance claims, which can occur rarely, are a matter of a particular analysis, and that is why it is essential to find and use distribution with relatively thick tails such as Pareto, Weibull and lognormal distribution.

The actuary while modelling insurance claims will also take into consideration deductions, reinsurance and inflation influence on this insurance claim part, which will be managed by the insurance company. It requires good understanding of probabilities and distribution. For example if X is a typical insurance claim this year, and ‘ i ‘ inflation is expected next year so what is distribution $(1+i)\ X$? If any insurance claims excess over M is to be managed by a reinsurer, so what is a typical disttribution insurance claim for a main insurer?

Risk Models

Harold Cramer in 1930 stated that "The aim of the risk thoery is introducing a mathematical analysis of random fluctuations in insurance activity and defining different protective means against their arduous results." The insurance actuary has to know different risk models, consisting of entirely or claims amount aggregate S payable by a company during defined time. Such models inform insurance companies and will enable them to make decisions on among other things: expected profits, premium debiting, reserves essential for securing (with high probability) profitability, and reinsurance and deductions influence.

In a collective risk model for S, there is used a random variable, in order to define a number of applied claim applications $S= X1 +... + XN$, where Xi means this claim amount, which is actually made during analysed time. In collective risk models for aggregated claims, S has so called double-barrelled distribution. Another typical model for claims aggregate, S is a risk model unit, where $S = Y1 +... + Yn$. Here n means a number of insurance policies (in some cases it can be the same as insured people number) in a portfolio, and Yi is a random variable being insurance claims amounts resulting from the insurance policy (or the insured). Because usually in a short period of time only a few insurance policies lead to claims, then in most of definitions Yi will equal to 0. It is an individual risk model for S, because it is defined overall for every insurance policy or the insurer. From the actuary good understanding of statistical properties of both these models for aggregated claims is required and particularly in which way they can be brought nearer and in some cases recursively calculated, and also how they are realised through insurance claims frequency and intensity. Moreover, it is important to know how different deductions and reinsurance agreements (proportional, losses excess and without losses) influence due claims.

Ruin Theory

If one allows *U*(*t*) to be a net value of a risk portfolio or insurance policies in time *t*, then the actuary will for sure test a possibility of keeping *U*(*t*) in time. From technical point of view it can be said that the ruin occurs if at the specific moment *t* in the portfolio, portfolio net value becomes negative. Such event probability is often called "ruin probability" and is often used as security means. *U*(*t*) considers relatively predictable amounts such as initial reserves *U* and premiums income to time *t*, but also has to consider (demanding) payments,which are more variable and random and of course much more difficult to predict. That is why one has to test and understand stochastic (Renshaw, Verrall, 1994, p. 904) models from so called excess process $\{U(t)\}t$, that as time passes by are an excess or a net value of the insurance portfolio. In most cases it is not possible to give a precise formula for excess process ruin probability, however standard Lundberg inequality (1909) is an upper limit and so called adaptable coefficient is a useful substitute security mean for this process. Simulation may be a useful tool in estimating ruin probability and in many complex cases it is the only way of understanding this probability. It is important for the actuary to test ruin probability in the excess process (in finished and unfinished time) which is inflenced by such factors as premium amount, initial reserves *U*, typical claims *X*, claim arrival rates $\lambda(t)$, and different levels and types of reinsurance.

Bayes approach to statistics and credibility theory

Insurance credibility theory is in principle a form of experience – estimation which tries to use data at hand, and also other people experience in order to arrange prices and premiums. The actuary often has to estimate expectations of future claims amounts and/or total claims for a policies portfolio, on the grounds of quite limited and example or current information *x*. Let's assume there exists a key meaning of parameter of interest θ, which for example can be an annual claims premium or total claims expected aggregate. There often exists another or earlier information from a company or portfolio of a similar type, which can be useful while estimating θ. Let's mark with θs estimation θ basing on samples information *x* and with θc estimation θ basing on another available information. If θ is the average value, θs can be an example average value *x* and θc a kind of earlier estimation (e.g. μ0) of this average. The key question is often "How can we connect two (example and simultaneous) information sources, in order to obtain good estimation θ, and particularly how much importance or credibility *Z* our estimation should have on the example estimator θs?"

For sure value *Z* should be both a growing function of the quantitative example information received in time and should consider a relevant value of example and simulataneous available information.

Estimation of θ credibility is a linear combination of an example θs estimator and estimation of the additional evaluation θc of the form Z θs +(1-Z) θc where Z is "credibility" we iclude an example estimator θs. This general term is often called "a premium credibility formula ". Traditionally the emphasis is put only on applying estimation θs, which are linear in premium credibility formula observations, and even such estimations are very successful so there is no theoreticla reason why other estimations can't be used.

General linear models

If Y is an observation, where Y is an element of index distribution group, the insurance actuary has to know relations between $\mu i = E(Yi)$ and other variable explanations $xi1$, $xi2$, ... xip through a linear predicator $\eta i = \beta 1 xi1 + \beta 2 xi2 + ... + p\ xip$, where $g(\mu i) = \eta i$ (Nedler, Wedderburn, 1972, p. 372–374).

Is a number of road accidents connected with age, education, sex, a vehicle type and motor size? How employer responsibility is connected with personal employee qualities (age, sex, salary) and work environment (security norms, working hours)? We can test how applications number filed by the insured depends on different variable explanations or predictive (Pinheiro, Andrade e Silva, de Lourdes Centeno, 2000, p. 2–4) factors, or to which extent junction road accidents number depends on weather, traffic load or days of the week.

Time series methods

Every actuary should keep abreast of investments and economic trends, should know basic definitions of univariate time series, therein stationarity, autoregression and moving averages models and also more general ARIMA models. Knowledge of basic thories of random walk and time series integration is also important along with a skill of applying these concepts in investment models.

V. ESTIMATION CONCEPTS

In property insurance, claims on damage e.g. of a vehicle, building and theft are also applied and calculated very fast. However in other property insurance . However in other property insurance types there can be considerable delays between time causing a claimand defining a real sum which the insurance company will have to pay. In case of the accident (e.g. toxic organism poisoning), the event can be very fast recorded but there can go by a lot of time before it will be arranged who is responsible for it and to which extent.

Obviously insurance companies have to keep abreast of how much they should put aside for reserves in order to serve claims resulting from accidents which took place, but for which they don't know a full range of their responsibility. Claims concerning events which already took place and which weren't applied for an assurer are defined as IBNR (Tarbell, 1934, p. 181) claims (took place but weren't applied). Claims whioch were apllied but for which the final calculation wasn't arranged are called overdue. A process of reserving for claims is a challenge in property insurance and does not belong to easy in creating reserves and estimating final losses resulting from insurance (Wolny, 2005).

During the reserving process because of claims, one has to consider a three-cornered representation of claims accrual born and given in table 1 for insurance portfolio. The origin year refers to the year when the event causing a claim took place, and the development year refers to delay in reporting in relation to the origin year. For example incremental claims 128,561-101,892 = 26 669 were made in 2008 referring to claims from 2006 (so delayed by 2 years). This type of three-cornered presentation in claim matters is often called a delay triangle. There are many questions for which the insurance company would like to get the answer and for sure on of them concerns setting which reserves should be made for the end of 2009 to serve the nearest indemnities payouts from 2005-2009.

Table 1. Accumulated paid claims in a property insurance portofolio

	Development year				
Year of origin	0	1	2	3	4
2005	39,890	85,160	108,465	116,910	124,588
2006	47,597	101,892	128,561	138,538	
2007	50,230	105,962	132,952		
2008	51,423	108,390			
2009	54,567				

Source: Scollnic, 2001, p. 96–124.

Obviously every good analyst would question quality of available data and additionally use other information owned by him.

For example in this situation is it fair to assume that all claims will be decidedat the end of the fourth development year for every origin year? Can we assume that the way of claims developing is more or less similar to these from different years? Should inflation be taken into consideration? Do we have information on claims amount applied all these years (is there a delay triangle for applied claims amount)? Which knowledge do we have on losses born in the past (for example referring to premiums payment) for a given activity type? In many situations the best way is to use many methods in order to obtain reliable reserves estimations.

One of the most often used techniques to estimate reserves is Markov chain method. In this method we analyse how claims resulting from different years, and then there are used appropriate rates to predict how future amounts from these years will develop. The question is how to cope with past and future inflation in reserve estimation which we have to consider. A method of average costs for every claim is a popular tool which considers an amount of filed applications. Bornhuetter-Ferguson (Christofides, 1990, p. 214) method uses additional information, such as losses rates (losses in relation to premiums) along with Markov chain technique to estimate reserves. All these techniques are very deterministic, but also one can take into consideration statistic models which allow on better suitability, changeability and basic assumptions.

Bonus-malus is a sytem determining an individual loss ratio history of a given driver. According to this system in insurance premiums may increase in next insurance period or decrease. In other words it is a system remunerating drivers for no claims drive and punishing for damage causing. Every insurance company applying bonus-malus system defines own discounts and advancements. The table is divided into classes to which a given discount is assigned. For every year of no claims drive we move to a lower class, gaining next discounts. Usually it is however like that that for every full no claims year (we gain a discount so -10% and for every indemnity payout we get advancement so +10%. A maximum discount we can have is -60%, whereas in advancement there is no such limit. A longer break in insurance may cause discounts decreasing and also relatively advancements decreasing even to 0. The insurance actuary modelling BM system will often use Markov chains method.

Monte Carlo simulation

Monte Carlo method is applied in different numerical mathematics sections. It is used for mathematic modelling of too complex processes (integrals and statistical processes chains calculation), in order to anticipate their results using an analytical approach. The method can be applied everywhere where the analysed problem may be described theoretically and stochastically although the problem itself may have at the same time strictly deterministic character. An important role in Monte Carlo method is random amounts drawing describing a process, it concerns both simple and complex processes distributions. It consists of the following main parts: stochastic models defining of tested real processes, modelling of random variables with a given probability distribution, solving a statistical problem from the estimation theory.

VI. CONCLUSIONS

The insurance actuary should have knowledge of decision and games theory in order to be competitive on the insurance market. Understanding probability and distribution statistics it is essential to take up and estimate risk and ruin during balancing claims, reserves and premiums. In introducing and developing of new products Bayes (Verrall, 1990, p. 222) credibility theory and statistics play an important role in estimating the example and additional information. Markov chains are an important element in success anticipating a success of estimation methods including bonus-malus systems and claims estimation. General linear models are essential tools in looking for risk factors to calculate premiums. Series methods have two main aims: (a) discovering phenomenon nature represented by observation sequence and (b) forecasting (anticipating future time series values). These both aims require identifying and describing, in a more or less formal way, of time series elements. Once arranged standard may be applied to other data (that is used in tested phenomenon theory for example seasonal insurance prices).

Summing up above mentioned considerations the insurance actuary has to be a practising statistician.

REFERENCES

Nedler J.A., Wedderburn R.W.M. [1972], *Generalized Linear Models*, Journal of the Royal Statistics Society, Series A.

Pinheiro P. J. R., Andrade e Silva M., M. de Lourdes Centeno [2000], *Bootstrap Methodology in Claim Reserving*, Centre for Applied Maths to Forecasting & Economic Decision, FCT PRAXIS XXI.

Renshaw A. E., Verrall R. J. [1994], *A stochastic model underlying the chain ladder technique*, Proceedings of the XXV ASTIN Colloquium, Cannes.

Ronka – Chmielowiec W. [1997], *Ryzyko w ubezpieczeniach – metody i oceny*, Wyd. Akademii Ekonomicznej im. Oskara Langego we Wrocławiu, Wrocław

Scollnic D.P.M. *Actuarial Modeling with MCMC and BUGS*, North American Actuarial Journal 2001, 5(2).

Christofides S. [1990], *Regression models based on log-incremental payments*, [w:] *Claims reserving manual, vol 2. More advanced method,* the Staple in Actuarial Society 06/90.

Tarbell T.F. [1934], *Incurred But Not Reported Claims Reserves*, Proceedings of the Causality Actuarial Society, Vol. XX, 1934.

Verrall R. J. [1990], *Bayesian and empirical Bayes Estimation for Chain Ladder Model*, ASTIN Bulletin 20(2).

Wieteska S. [2004], Rezerwy *techniczno-ubezpieczeniowe zakładów ubezpieczeń majątkowo-osobowych*, Wyd. Branta, Bydgoszcz – Łódź.

Wolny A. [2005], *Podejście Aktuarialne do kalkulacji rezerwy szkodowej, Statystyczne zaawansowane metody kalkulacji rezerwy szkodowej,* [w:] *Metody kalkulacji ryzyka rezerw szkodowych w ubezpieczeniach majątkowo-osobowych*. Seria: Statystyka ubezpieczeniowa pod redakcją W. Szkutnika, Wyd. Akademii Ekonomicznej im. Karola Adamieckiego w Katowicach, Katowice.

Zehnwirth B. [1989], *The Chain Ladder Technique – a stochastic model* [w:] *Claims reserving manual, vol 2. More advanced method* (02/89), Institute of Actuaries, London.

Tomasz Zapart

ROLA I ZANACZENIE AKTUARIUSZA W UBEZPIECZENIACH

ktuariusz na podstawie zadań wynikających z procesu kontroli finansowej zakładu ubezpieczeń ma obowiązek przedstawienia własnej opinii co wszelkich działań tegoż zakładu, które mogą mieć wpływ na sytuację finansową zakładu ubezpieczeń a w konsekwencji wpłynąć na możliwość zaspokojenia długoterminowych zobowiązań zakładu poprzez dostarczenie profesjonalnej analizy sytuacji wewnętrznej i zewnętrznej zakładu ubezpieczeń dla organów zarządzających. Wiedza oraz spojrzenie na tematykę aktuarialną nabiera szczególnego znaczenia w działalności ubezpieczeniowej, gdzie jego realizacja pociąga za sobą określone skutki finansowe. W artykule omówione zostały podstawowe narzędzia i techniki z zakresu rachunku prawdopodobieństwa i statystyki, jakie są konieczne do wykonywania zawodu aktuariusza oraz przedstawienie wykorzystywanych przez aktuariat metod oraz zasad statystycznych w zakładach ubezpieczeń oraz ich znaczenie na sytuację finansową zakładu ubezpieczeń.