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ASTIN Bulletin

Volume **32**(2), 2002

Asmussen, S., Avram, F. & Usabel, M. A. *Erlangian approximations for finite-horizon ruin probabilities.* 267-281. For the Cramér-Lundberg risk model with phase-type claims, it is shown that the probability of ruin before an independent phase-type time H coincides with the ruin probability in a certain Markovian fluid model and therefore has an matrix-exponential form. When H is exponential, this yields in particular a probabilistic interpretation of a recent result of Avram & Usabel. When H is Erlang, the matrix algebra takes a simple recursive form, and fixing the mean of H at T and letting the number of stages go to infinity yields a quick approximation procedure for the probability of ruin before time T. Numerical examples are given including a combination with extrapolation.

Cordeiro, I. M. F. *Transition intensities for a model for permanent health insurance.* 319-346. The purpose of this paper is to obtain approximations to the transition intensities defined for a multiple state model for permanent health insurance (PHI) which enables us to analyse PHI claims by cause of disability.

The approximations to the transition intensities are obtained using a set of PHI data classified by 18 sickness categories and the graduations of the transition intensities defined for a simpler model proposed in the Continuous Mortality Investigation Reports, 12 (1991).

In order to derive the approximations to the recovery and mortality of the sick intensities for our model, we carry out tests of hypotheses based on the distributions of average sickness durations. The approximations to the sickness intensities are obtained by estimating a statistical model for the number of claim inceptions, which can be formulated as a generalized linear model.

Dickson, D. C. M. & Waters, H. R. *The distribution of the time to ruin in the classical risk model.* 299-313. We study the distribution of the time to ruin in the classical risk model. We consider some methods of calculating this distribution, in particular by using algorithms to calculate finite time ruin probabilities. We also discuss calculation of the moments of this distribution.

Hess, K. T., Liewald, A. & Schmidt, K. D. *An extension of Panjer's recursion.* 283-297. Sundt and Jewell have shown that a nondegenerate claim number distribution $Q = \{q_n\}_{n \in N_0}$ satisfies the recursion

$$q_{n+1} = \left(a + \frac{b}{n+1}\right) q_n$$

for all $n \geq 0$ if and only if Q is a binomial, Poisson or negativebinomial distribution. This recursion is of interest since it yields a recursion for the aggregate claims distribution in the collective model of risk theory when the claim size distribution is integer-valued as well. A similar characterization of claim number distributions satisfying the above recursion for all $n \geq 1$ has been obtained by Willmot. In the present paper we extend these results and the subsequent recursion for the aggregate claims distribution to the case where the recursion holds for all $n \geq k$ with arbitrary k. Our results are of interest in catastrophe excess-of-loss reinsurance.

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HÜRLIMANN, W. *Analytical bounds for two value-at-risk functionals.* 235-265. Based on the notions of value-at-risk and conditional value-at-risk, we consider two functionals, abbreviated VaR and CVaR, which represent the economic risk capital required to operate a risky business over some time period when only a small probability of loss is tolerated. These functionals are consistent with the risk preferences of profit-seeking (and risk averse) decision makers and preserve the stochastic dominance order (and the stop-loss order). This result is used to bound the VaR and CVaR functionals by determining their maximal values over the set of all loss and profit functions with fixed first few moments. The evaluation of CVaR for the aggregate loss of portfolios is also discussed. The results of VaR and CVaR calculations are illustrated and compared at some typical situations of general interest.

VERICO, P. *Bonus-malus systems: 'lack of transparency' and adequacy measure.* 315-318. Based on a recent contribution by Baione and others in this journal, some consequences of the decrease of the mean merit coefficient for portfolios of bonus-malus policies, and some alternative ways to measure the 'quality' of a bonus-malus system are discussed.

WANG, S. *A universal framework for pricing financial and insurance risks.* 213-234. This paper presents a universal framework for pricing financial and insurance risks. Examples are given for pricing contingent payoffs, where the underlying asset or liability can be either traded or not traded. The paper also outlines an application of the framework to prescribe capital allocations within insurance companies, and to determine fair values of insurance liabilities.

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GENEVA PAPERS ON RISK AND INSURANCE THEORY

Volume **27** (1), 2002

BORGLIN, A. & KEIDING, H. *Stochastic dominance and conditional expectation — an insurance theoretical approach.* 31-48. We show that the relation of second order stochastic dominance, which has found widespread use in models of economic behavior under uncertainty, may be described in terms of conditional expectation. If a distribution G second order stochastically dominates another distribution F, then there are random variables g and f with distributions G and F, respectively, such that g can be obtained from f by iterated conditional expectation. In terms of insurance, this shows that the less risky distribution can be obtained by a sequence of insurance contracts each one insuring against the residual risk left over from the previous contracts.

HERAS, A., VILAR, J. L. & GIL, J. A. *Asymptotic fairness of bonus-malus systems and optimal scales of premiums.* 61-82. In this paper we try to evaluate the asymptotic fairness of bonus-malus systems, assuming the simplest case when there is no hunger for bonus. The asymptotic fairness has to be understood as the bonus-malus system ability in assessing the individual risks in the long run. Firstly we define the asymptotic fairness of a bonus-malus system following an expression that can be found in J. Lemaire [1985]: *Automobile Insurance.*

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Actuarial Models, p168. Secondly, we define a measure of the global asymptotic fairness considering the structure function of the risk group. Finally we try to calculate, for each set of transition rules and a given structure function, the scale of premiums that brings the global asymptotic fairness closest to the ideal situation where each insured pays in the long run a premium corresponding to its own claim frequency. This is possible thanks to the application of a multiobjective optimization technique named Goal Programming.

HEY, J. D. *Experimental economics and the theory of decision making under risk and uncertainty*. 5-21. Following a brief review of the main experimental work into the economics of risk and uncertainty, both static and dynamic, this paper reports the results of an experiment testing one of the key assumptions of the theory of dynamic economic behaviour — that people have a plan and implement it. Using a unique design which enables the plan (if one exists) to be revealed by the first move, the experiment was implemented via the Internet on a subset of the University of Tilburg's ongoing family expenditure survey panel. The advantages of using such a set of subjects for the experiment are twofold: the demographic characteristics of the set are known and therefore demographic inferences can be made; the representativeness of the set is known and therefore inferences about populations can be made. The results suggest that at least 36% of the subjects had behaviour inconsistent with the hypothesis under test: that people formulate plans and then implement them. Interestingly demographic variables are unable to explain the consistency or inconsistency of individuals. One conclusion is that subjects simply make errors. An alternative conclusion, consistent with previous experimental research, is that people are unable to predict their own future decisions. The implications for dynamic theory (particularly relating to savings and pensions decisions) are important.

LAJERI-CHAHERLI, F. *More on properness: the case of mean-variance preferences.* 49-60. This paper focuses on the situations where individuals with mean-variance preferences add independent risks to an already risky situation. Pratt and Zeckhauser (*Econometrica*, 55) define a concept called *proper risk aversion* in the expected utility framework to describe the situation where *an undesirable risk can never be made desirable by the presence of an independent undesirable risk*. The assumption of mean-variance preferences allows us to study *proper risk aversion* in an intuitive manner. The paper presents an economic interpretation for the quasi-concavity of a utility function derived over mean and variance. The main result of the paper says that quasi-concavity plus decreasing risk aversion is equivalent to *proper risk aversion*.

WILLINGER, M. *On the observability of plans in dynamic choice problems involving risk: comment about J Hey.* 23-30. We show that in dynamic choice problems, the observability of a decision maker's first move does reveal his plan for the dynamic choice problem, only under strong restrictions about the structure of his preferences. These restrictions imply consequentialism which in turn implies dynamic consistency, a condition which is not necessarily satisfied by experimental subjects.

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JOURNAL OF RISK AND INSURANCE

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ARTÍS, M., AYUSO, M. & GUILLÉN, M. *Detection of automobile insurance fraud with discrete choice models and misclassified claims.* 325-340. The insurance industry is concerned with the detection of fraudulent behavior. The number of automobile claims involving some kind of

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suspicious circumstance is high and has become a subject of major interest for companies. This article demonstrates the performance of binary choice models for fraud detection and implements models for misclassification in the response variable. A database from the Spanish insurance market that contains honest and fraudulent claims is used. The estimation of the probability of omission provides an estimate of the percentage of fraudulent claims that are not detected by the logistic regression model.

BROCKETT, P. L., DERRIG, R. A., GOLDEN, L. L., LEVINE, A. & ALPERT, M. *Fraud classification using principal component analysis of RIDITs.* 341-371. This article introduces to the statistical and insurance literature a mathematical technique for an a priori classification of objects when no training sample exists for which the exact correct group membership is known. The article also provides an example of the empirical application of the methodology to fraud detection for bodily injury claims in automobile insurance. With this technique, principal component analysis of RIDIT scores (PRIDIT), an insurance fraud detector can reduce uncertainty and increase the chances of targeting the appropriate claims so that an organization will be more likely to allocate investigative resources efficiently to uncover insurance fraud. In addition, other (exogenous) empirical models can be validated relative to the PRIDIT-derived weights for optimal ranking of fraud/nonfraud claims and/or profiling. The technique at once gives measures of the individual fraud indicator variables' worth and a measure of individual claim file suspicion level for the entire claim file that can be used to cogently direct further fraud investigation resources. Moreover, the technique does so at a lower cost than utilizing human insurance investigators, or insurance adjusters, but with similar outcomes. More generally, this technique is applicable to other commonly encountered managerial settings in which a large number of assignment decisions are made subjectively based on "clues," which may change dramatically over time. This article explores the application of these techniques to injury insurance claims for automobile bodily injury in detail.

DERRIG, R. A. *Insurance fraud.* 271-287. Insurance fraud is a major problem in the United States at the beginning of the 21st century. It has no doubt existed wherever insurance policies are written, taking different forms to suit the economic time and coverage available. From the advent of "railway spine" in the 19th century to "trip and falls" and "whiplash" in the 20th century, individuals and groups have always been willing and able to file bogus claims. The term *fraud* carries the connotation that the activity is illegal with prosecution and sanctions as the threatened outcomes. The reality of current discourse is a much more expanded notion of fraud that covers many unnecessary, unwanted, and opportunistic manipulations of the system that fall short of criminal behavior. Those may be better suited to civil adjudicators or legislative reformers. This survey describes the range of these moral hazards arising from asymmetric information, especially in claiming behavior, and the steps taken to model the process and enhance detection and deterrence of fraud in its widest sense. The fundamental problem for insurers coping with both fraud and systemic abuse is to devise a mechanism that efficiently sorts claims into categories that require the acquisition of additional information at a cost. The five articles published in this issue of the *Journal of Risk and Insurance* advance our knowledge on several fronts. Measurement, detection, and deterrence of fraud are advanced through statistical models, intelligent technologies are applied to informative databases to provide for efficient claim sorts, and strategic analysis is applied to property-liability and health insurance situations.

MAJOR, J. A. & RIEDINGER, D. R. *EFD: a hybrid knowledge/statistical-based system for the detection of fraud.* 309-324. Electronic Fraud Detection (EFD) assists investigative consultants in the Managed Care & Employee Benefits Security Unit of The Travelers Insurance Companies in the detection and preinvestigative analysis of health care provider fraud. The task EFD performs, scanning a large population of health insurance claims in search of likely

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fraud, has never been done manually. Furthermore, the available database has few positive examples. Thus, neither existing knowledge engineering techniques nor statistical methods are sufficient for designing the identification process. To overcome these problems, EFD uses knowledge discovery techniques on two levels. First, EFD integrates expert knowledge with statistical information assessment to identify cases of unusual provider behavior. The heart of EFD is 27 behavioral heuristics, knowledge-based ways of viewing and measuring provider behavior. Rules operate on them to identify providers whose behavior merits a closer look by the investigative consultants. Second, machine learning is used to develop new rules and improve the identification process. Pilot operations involved analysis of nearly 22,000 providers in six metropolitan areas. The pilot is implemented in SAS Institute's SAS System, AICorp's Knowledge Base Management System, and Borland International's Turbo Prolog.

Tennyson, S. & Salas-Forn, P. *Claims auditing in automobile insurance: fraud detection and deterrence objectives.* 289-308. Research on insurer management of opportunism in claiming has developed in two parallel literatures. One is a theoretical literature on insurance contracting that yields predictions about the nature of optimal auditing strategies for the deterrence of fraud. The other is a literature based upon statistical analysis of claims that yields empirical strategies for the detection of fraudulent claims. This article links the two literatures by providing an empirical assessment of insurers' auditing practices in relation to theoretical predictions. The analysis makes use of a data set on the disposition of more than 1,000 randomly selected automobile personal injury protection claims settled in the state of Massachusetts. The findings of the article are consistent with the use of rational auditing strategies by insurers and with the use of audits for both deterrence and detection.

Viaene, S., Derrig, R. A., Baesens, B. & Dedene, G. *Comparison of state-of-the-art classification techniques for expert automobile insurance claim fraud detection.* 373-421. Several state-of-the-art binary classification techniques are experimentally evaluated in the context of expert automobile insurance claim fraud detection. The predictive power of logistic regression, C4.5 decision tree, *k*-nearest neighbor, Bayesian learning multilayer perceptron neural network, least-squares support vector machine, naive Bayes, and tree-augmented naive Bayes classification is contrasted. For most of these algorithm types, we report on several operationalizations using alternative hyperparameter or design choices. We compare these in terms of mean percentage correctly classified (PCC) and mean area under the receiver operating characteristic (AUROC) curve using a stratified, blocked, ten-fold cross-validation experiment. We also contrast algorithm type performance visually by means of the convex hull of the receiver operating characteristic (ROC) curves associated with the alternative operationalizations per algorithm type. The study is based on a data set of 1,399 personal injury protection claims from 1993 accidents collected by the Automobile Insurers Bureau of Massachusetts. To stay as close to real-life operating conditions as possible, we consider only predictors that are known relatively early in the life of a claim. Furthermore, based on the qualification of each available claim by both a verbal expert assessment of suspicion of fraud and a ten-point-scale expert suspicion score, we can compare classification for different target/class encoding schemes. Finally, we also investigate the added value of systematically collecting nonflag predictors for suspicion of fraud modeling purposes. From the observed results, we may state that: (1) independent of the target encoding scheme and the algorithm type, the inclusion of nonflag predictors allows us to significantly boost predictive performance; (2) for all the evaluated scenarios, the performance difference in terms of mean PCC and mean AUROC between many algorithm type operationalizations turns out to be rather small; visual comparison of the algorithm type ROC curve convex hulls also shows limited difference in performance over the range of operating conditions; (3) relatively simple and efficient techniques such as linear logistic regression and linear kernel least-squares support vector machine classification show excellent overall predictive capabilities, and (smoothed) naive Bayes also performs well; and (4) the C4.5 decision tree operationalization

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results are rather disappointing; none of the tree operationalizations are capable of attaining mean AUROC performance in line with the best. Visual inspection of the evaluated scenarios reveals that the C4.5 algorithm type ROC curve convex hull is often dominated in large part by most of the other algorithm type hulls.

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