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Methodology of Actuarial Modeling of Insurance Rates of Liability of Tour Operators Based on Expert Assessments

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Abstract: The development of the tourism industry and the increase in the number of cases of non-fulfillment of obligations by tour operators have necessitated professional liability insurance. However, the process of calculating insurance tariffs is complicated by the lack of statistical information on violations, since tour operators are not interested in collecting and systematizing it. To solve this problem, it is proposed to use the method of expert assessments instead of statistical data. For this purpose, it is necessary to develop mathematical models that will allow, based on the opinions of experts, to assess risks and calculate economically reasonable tariffs. To minimize the subjectivity of this approach, it is recommended to coordinate with stakeholders not only the amount of the insurance premium, but also the choice of the array of expert data used. The tariffs calculated in this way should be considered as preliminary. As up-to-date insurance statistics accumulate, they should be adjusted based on an adaptive approach, which will gradually move from expert assessments to sound statistical data and create a sustainable system for protecting the rights of consumers of travel services.

1 INTRODUCTION

As the business of selling tourist products has developed in the Russian Federation, and as cases of non-fulfillment or improper fulfillment of obligations by travel agencies to provide services in accordance with contracts for the sale of this type of product have become more frequent, there has been an objective need to provide insurance protection for the property interests of customers (tourists or other customers of the tourist product) from the consequences of poor quality work by retours who are engaged in the formation, promotion, and sale of the tourist product [1-2].

The determination of the insurance rate in the insurance of the tour operator's liability for non-performance or improper performance of obligations under the contract on the tourist product is complicated by the fact that the necessary statistical information on cases of improper performance of obligations under the contracts on tourist services is currently absent. Therefore, it is not possible to carry out an objective identification of the insurance risk associated with tour operator activities at the moment. Moreover, it is difficult to imagine that travel agencies, which are interested in advertising their services and maintaining the image of an impeccable company, would collect statistical information about the poor quality of their operators' performance of their obligations to provide tourist products for purposes other than improving the quality of their own operations.

It seems that only insurance companies, which are willing to insure the risks associated with the liability of tour operators, are interested in collecting such information, which could potentially serve as a powerful "anti-advertising" campaign against travel agencies and tour operators. However, at the stage of launching insurance programs of tour operators' liability, such information simply does not exist.

As a forced alternative to real statistical information on the frequency of occurrence of insurance cases, as well as the economic consequences of improper fulfillment of tour operators' duties in relation to the purchasers of tourist products, i.e. economic damages of tourists,

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expert information from persons familiar with the peculiarities of the tourism business can serve [3].

Thus, the task is to build mathematical models and algorithms that provide for the processing of expert information on the possible non-fulfillment (improper fulfillment) of tour operators' obligations in the implementation of tourism products in order to identify the insurance risk associated with the possible infliction of property damage to tourists (customers of the tourism product), as well as to determine insurance rates when concluding insurance contracts for the liability of tour operators [4-8].

At the same time, the insurance rates formed on the basis of expert information are subject to traditional requirements: on the one hand, the insurance rates must ensure the profitability of insurance operations within the framework of this type of insurance, and on the other hand, they must determine the economically reasonable fee for insurance services [9].

It should be emphasized here that even an experienced and unbiased expert who is willing to take responsibility for providing data on the level of insurance risk inevitably introduces a subjective view of the characteristics of such risk. Therefore, in order to increase the degree of objectivity in the selection of insurance rates, it can be recommended that, when concluding an insurance contract, the subject of the agreement between the policyholder and the insurer at the expert level would be not only the insurance rates and the conditions for the implementation of the insurance contract, but also a specific set of expert data that is used to justify the insurance rates (as opposed to statistical information, the composition and quantitative characteristics of which do not require approval from policyholders).

Finally, the insurance rates determined on the basis of expert assessments should be considered as preliminary, i.e. necessary for the launch of the tour operators liability insurance program, assuming that as insurance statistics data accumulates in the type of insurance in question, insurance rates will be refined, which means that rates under the program should be formed using the principle of adaptation [10].

2 MODELS AND ALGORITHMS FOR CALCULATING INSURANCE RATES USING EXPERT ASSESSMENTS

2.1 Basic assumptions and assumptions

1. The calculation scheme used is based on the principle of collective balance, when, assuming the independence of the risks of individual policyholders (in this case, tour operators), the insurance risk is distributed to all participants in the tour operator insurance program. Thus, the first assumption is that the risks of improper fulfillment of their obligations by various tour operators are independent. This assumption means that it is impossible for two or more tour operators to simultaneously be unable to fulfill their obligations under a travel agreement due to a common cause - disruption of transport schedules, natural disasters, strikes in the tourist's country of residence, etc., that is, risk factors that cause the accumulation of insurance risk are not taken into account.

2. When describing the total insurance risk, an accumulation model is adopted, which is a function of distributing the total insured damage (compensation) over the entire set of insurance risks accepted by this insurance company for retention.

3. When describing the possible number of insured events in a group of insured travel contracts, a Poisson distribution is adopted.

This distribution assumes the identification of a single parameter - the average number of improper fulfillment of the terms of the tourist agreement per insured contract λ.

4. When describing the insured damage caused to a client (tourist, a person purchasing a tourist product) in a single insured event, a gamma distribution is taken. This distribution is traditionally used in property insurance tasks due to the convenience of its application, in particular, in the accumulation model. To identify this distribution, it is sufficient to have two parameters α and β. In this case, the parameter α is determined by the distribution curve algorithm and, generally speaking, can be set by an actuary expert based on the experience of calculating tariffs in property insurance. The β parameter defines the degree of stretching of the damage distribution in a single event (scaling parameter). The evaluation of this parameter should be based on expert data.

2.2 Output of calculated ratios

Due to the accepted assumptions, the identification of insurance risk involves the assessment of three parameters: λ, α and β.

To estimate the parameter λ (in the sense of the average value of the number of insured events per travel service agreement), you should use an expert's estimate of the likely number of insured events $m_{cc}^{(e)}$, for example, per thousand insured travel service agreements. Then the required parameter estimate $\hat{\lambda}$ is expressed by the formula

$$\hat{\lambda} = \frac{m_{cc}^{(e)}}{1000}. \quad (1)$$

Taking into account the found estimate of the average number of insured events per travel service contract and assuming a Poisson distribution of the number of insurance events, the distribution of the number of insurance events in the insurance of *N* contracts is expressed by the formula

$$p_k(\eta) = e^{-\eta}\frac{\eta^k}{k!} \quad (k = 0, 1, 2 \dots) \quad (2)$$

where $p_k(\eta)$ - the probability of occurrence in the group of *N* travel contracts *k* insurance cases (in case of improper fulfillment by tour operators of obligations to sell tourist products);

η - the Poisson distribution parameter calculated by the formula

$$\eta = N\hat{\lambda}. \quad (3)$$

When identifying the damage distribution function in a single insured event, by virtue of assumption 4, we will assume that the desired distribution is described by the expression

$$F_0(x) = F_\gamma(\alpha, \beta)$$

$$F_\gamma(\alpha, \beta) = \{0, if\ x \le 0; \int_0^x p_\gamma(\alpha, \beta)dy, if\ x > 0, \quad (4)$$

where

$$p_\gamma(\alpha, \beta) = \{0,\ if\ x < 0; \frac{1}{\beta^\alpha \Gamma(\alpha)} x^{\alpha-1} e^{\frac{x}{\beta}}, if\ x \ge 0. \quad (5)$$

there is a gamma distribution density.

The parameter α that determines the shape of the distribution curve (4), (5) can be selected based on the value of this parameter in property insurance models $\alpha = 1{,}5 - 2{,}5$. For the sake of certainty, we can accept $\hat{\alpha} = 1{,}5$.

As for the parameter β, its value can be found based on the expert's assessment given by him when answering a specially posed question. Let's say, for example, an expert is asked a question: what, in your opinion, is the significance of the maximum possible damage caused to tourists by tour operators in a series of insurance cases. If the expert agrees to name the amount of maximum damage, then his answer can be interpreted as the result of the following experiment.

Independent tests were conducted on a random value described by the distribution function (4), (5). We will consider W_{max} to be a certain quantile of the insurance damage distribution function $F_\gamma(x|\alpha, \beta)$, the order of which $P_0 = F_\gamma(W_{max}|\alpha, \beta)$ is not known to us. To assess the significance of P_0, we will use the expert's judgment that at least one of the *n* damages that occurred turned out to be at least W_{max}. If the order of the quantile P_0 were known, then the probability that the random variable *X*, when tested *n*-multiple times under conditions of test independence, would never exceed the value X_{max}, would obviously be equal to

$$P_1 = (p_0)^n. \quad (6)$$

Here it is natural to assume that the expert, calling the maximum amount of insured damage W_{max}, assumes that this maximum value from a series of *n* tests can either be reached or not reached, and both of these events are approximately equally likely. Since the probability of the opposite event, that is, that at least once the random variable *X* will exceed the value W_{max}, is $1 - P_1$, we can write an approximate equality

$$P_1 \approx 1 - P_1, \quad (7)$$

therefore

$$P_1 \approx 0{,}5. \quad (8)$$

Taking into account equality (6), the unknown quantile order P_0 is expressed by the formula

$$P_0 = (0{,}5)^{\frac{1}{n}}. \quad (9)$$

Assuming that the order of the quantile *P0* is known, we will formulate an equation with respect to the parameter β using the definition of the quantile

$$F_\gamma(\alpha, \beta) = P_0. \quad (10)$$

By solving equation (10) relative to β, using standard tools of well-known software and mathematical packages, we obtain the desired value of the parameter $\hat{\beta}$, which allows us to determine the distribution function of insured damage in a single insured event ($\hat{\alpha} = 1{,}5$).

Further, based on the accepted assumptions about the nature of the insurance risk, as well as using the closure property of the gamma distribution according to the convolution operation, we write down the expression of the distribution function of the total insured damage for a group of *N* insurance contracts (accumulation model)

$$R(x) = p_0(\eta)h(x) + \sum_{k=1}^{\infty} p_k(\eta)F_\gamma(k\alpha, \hat{\beta}), (11)$$

where $p_k(\eta)$ are calculated using formulas (2), (3).

Further calculations related to the determination of the insurance tariff include the following operations:

- the definition of a net premium that provides with the required reliability $\tilde{P}$coverage of possible insurance reimbursements (payments) for a group of insured travel service contracts as a solution to an equation of the form

$$R(x) = \tilde{P}. \quad (12)$$

Solving equation (12) in symbolic form, it is written

$$\tilde{x}(\tilde{P}) = R^{-1}(\tilde{P}). \qquad (13)$$

- determination of the net rate of the insurance tariff

$$Tr_n = \frac{\tilde{x}(\tilde{P})}{N\underline{S}} 100\%, \qquad (14)$$

where $\underline{S}$ is the average insurance liability for a group of insured contracts (estimated by the insurance company's underwriter);

- determination of the gross rate of the insurance tariff, taking into account the insurance burden f (set by the underwriter of the insurance company)

$$Tr_{br} = \frac{Tr_n}{1-f}\%. \qquad (15)$$

The development of a mathematical model for calculating insurance rates under the tour operator insurance program using expert assessments has been completed.

3 RESULTS AND DISCUSSIONS

We will calculate insurance rates under the tour operator insurance program using the developed mathematical model. Let's say $5 \cdot 10^6$ rubles is the insured amount under the contract (the insurance liability under the contract of the insurer with the system tour operator), the maximum compensation from the insurance company, 15000 rubles is the average cost of the trip.

To identify the damage distribution function from a single insurance event in the form of a gamma distribution, taking the value $\alpha = 1{,}5$, we find the parameter β using the following expert estimates:

during the observation interval T = 20 years, n =100 insurance events occurred due to the fault of the tour operator, one of which with the maximum insured damage $W_{max} = 5 \cdot 10^5$ rub. We take the β parameter by solving equation (10) in which $P_0 = (0{,}5)^{\frac{1}{n}}$. Using the found value $\beta = 1{,}214 \cdot 10^{-5}$, we construct the damage distribution function from a single insured event in the form of a gamma distribution with parameters α and β

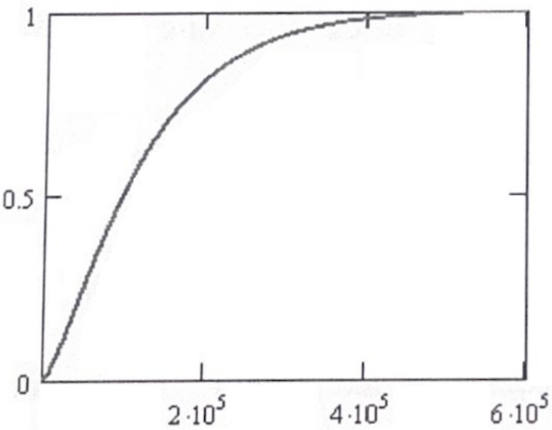

Figure 1

To estimate the parameter λ (meaning the average number of insured events per travel service agreement), we use an expert's estimate of the likely number of insured events $m_{cc}^{(e)}$ for N insured travel service agreements (N is the annual number of tourists served).

For example, for N=2000 it is expertly accepted $m_{cc}^{(e)}$ =3. Then $\lambda = 1{,}5 \cdot 10^{-3}$.

Based on expert estimates $m_{cc}^{(e)}$ for various N, we will plot a graph of the regulatory dependence of the intensity of occurrence of contracts with insurance events due to the fault of the tour operator λ on the number of tourists served N

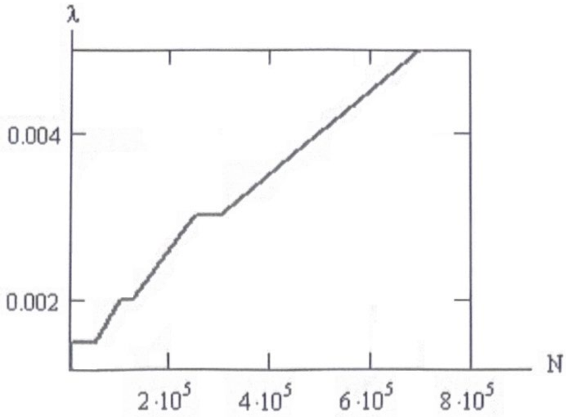

Figure 2

Next, using formula (11), we construct the distribution function of total insured damage for a group of N=100000 insurance contracts $R(x)$ (accumulation model) (Fig. 3).

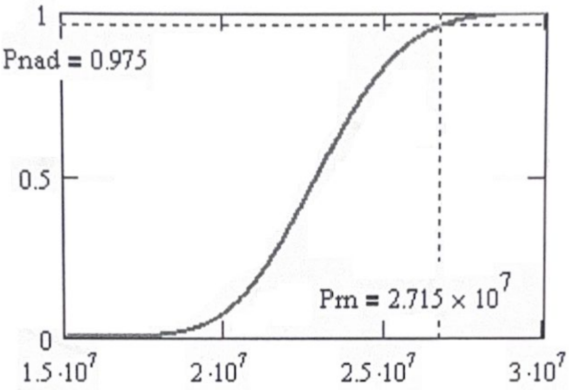

Figure 3: Cumulative insurance damage distribution function

Using the cumulative insurance damage distribution function (Fig. 3), we determine the value of the total insurance premium, which provides, with a given probability of P_{nad}, coverage of possible insurance payments for insured objects. The required value of the total insurance premium Prn is defined as the root of the equation $R(Pr\ Pr\ n) = P_{nad}$, where from Prn= Pr$n(P_{nad})$. Knowing the Prn and the load of the insurer δ, we calculate the net and gross tariffs for $N = 100000$.

Prn=2,715$\cdot 10^7$ rubles is the amount required to cover insurance payments with reliability $P_{nad} = 0{,}975$(net premium).

$\delta = 0{,}4$ - the insurer's workload

$Tr_n = \frac{Prn}{S_{cr}N} \cdot 100 = 1{,}81\%$ - net rate

$Tr_{br} = \frac{Tr_n}{1-\delta} = 3{,}017\%$ - gross tariff

For the remaining N, the calculations of premiums and tariffs are performed similarly. The calculation results, depending on the number of tourists served, N, are shown in Figs. 4, 5.

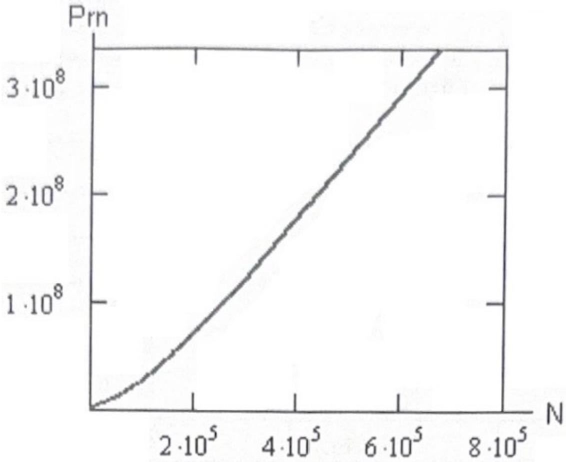

Figure 4: Estimated dependence of the net premium on the number of tourists served.

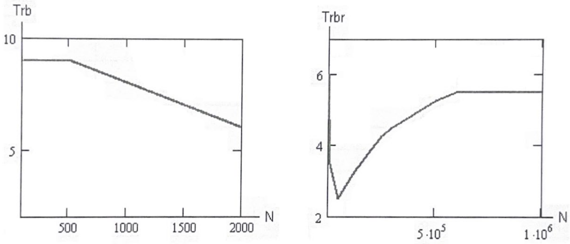

Figure 5: The regulatory dependence of the gross insurance rate on the number of tourists served

4 CONCLUSIONS

This study confirms that the creation of a liability insurance system for tour operators in the absence of reliable statistical information requires the development of specialized methodological approaches. The proposed solution is based on the consistent application of expert assessments, mathematical modeling of insurance risks and the use of an adaptive tariff setting mechanism. The key achievement of the work is the development of a methodology that makes it possible to launch an insurance product without retrospective data and carry out subsequent iterative tariff adjustments as actual loss statistics accumulate.

Special attention is paid to the principle of matching the initial array of expert data between the parties to the insurance contract, which increases the transparency of calculations and contributes to the formation of an objective risk assessment. The implementation of the proposed approach creates the basis for the sustainable functioning of the financial guarantee system in the tourism industry, ensuring a balance of interests of all market participants — from insurance companies to end users of travel services. The prospects for further research include optimizing algorithms for verifying expert assessments and developing industry standards for the transition from expert assessments to statistical model ones.

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