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# SCIENTIFIC AND METHODOLOGICAL APPROACH TO THE CALCULATION OF INSURANCE RATE OF CASCO INSURANCE

***Statement of the problem.*** Effective performance of domestic insurance companies that provide property insurance, it is possible for constant increase of the number of concluded insurance contracts, that stipulate sufficient premium for the provisioning of the company. Today one of the most important factors that determines the amount of financial income of the insurer is the cost of insurance services - insurance rate. The value of insurance rate is more important for potential policyholders than other factors such as non-price factors. Than ensuring the correctness of the calculation of the insurance rate that corresponds to the level of risk and the efficient tariff policy should be implemented with the active using of improved methods of actuarial calculations.

**Analysis of recent research and publications.** Theoretical and practical aspects of calculating insurance rate by type of property insurance has been paid considerable attention from foreign and domestic scientists. Among the domestic and russian researchers, we should point out V. D. Bazilevich, I. O. Kovtun, O. V. Kozmenko, A. O. Boyko, T. V. Belikov, A. P. Tarutin, T. A. Yakovleva, G. I. Falin, V. A. Shcherbakov and others.

In hull insurance and in other types of property insurance in calculating insurance rate adopted consistently identify the components of net rate and insurance load. Among the methods for calculating the most common method is based on the theory of probability and mathematical statistics using time series. According to this method, the net rate should correspond to the probability of the insured event, and insurance load, determined empirically, should cover all costs associated with the provision of insurance services and take into account the profit margins of the company. The expert methods using mathematical statistics and calculate the rate of return, method of analogues and regression method, which is less popular than the previous one and using in the insurance practice too.

It should be noted that in the structure of the net rate vast majority of scientists proposes risk premium assigned by proportional to moments of the distribution function of the random loss: the mathematical expectation, standard deviation (variance) or coefficient of variation. In our opinion, it is advisable to conduct a more thorough study of the insurance fee component and set its own method of calculation.

**Problem.** The purpose of the article is to explore the features of actuarial calculations in property insurance and develop scientific and methodical approach to determining the insurance rate in hull insurance.

**The main material.** The calculation insurance rate provides a quantitative assessment of the random characteristics of insurance risks that require the use of special approaches based on the theory of probability and mathematical statistics [15]. Using of a particular method depends on the characteristics of a specific type of property insurance. The main differences lie for each type characterized by different insurance risks, their severity and probability of occurrence and the factors that affect them and provided insurance offering domestic insurers. Therefore, these circumstances should be consider when building the scientific and methodical approach that involves the following steps (Fig. 1).

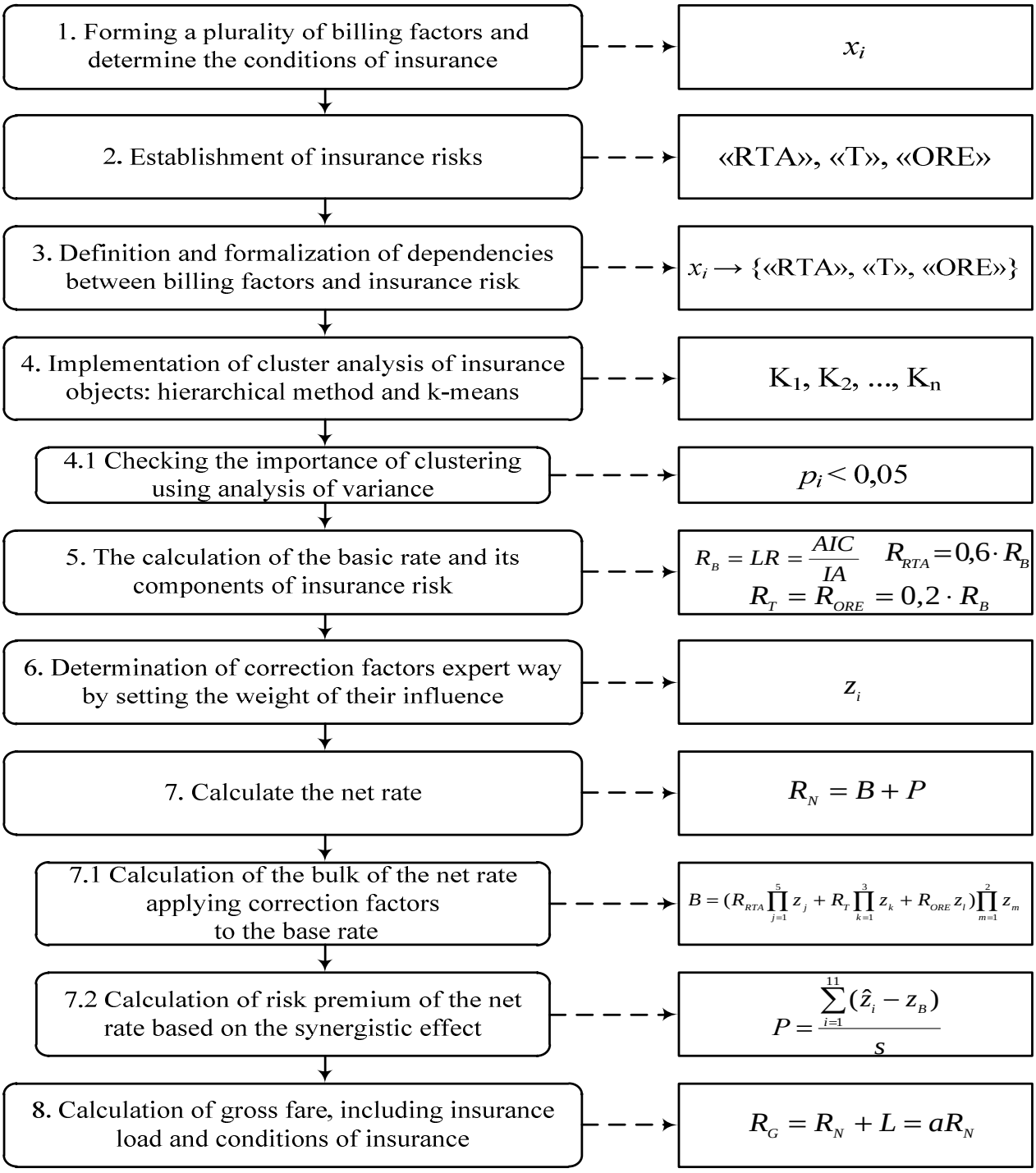


**Fig.1. Scientific and methodical approach to the calculation of the insurance rate**

*Source:* [**Ошибка! Источник ссылки не найден.**; 6; 8; **Ошибка! Источник ссылки не найден.**; 15; 16]

The first step of this approach is to form a plurality of billing factors (risk factors) and to define of common insurance terms (conditions of the insurance contract).

After knowing practical aspects regarding diversity factors used to draw a conclusion that insurance rates in hull insurance depends on a combination of factors, firstly, of the individual as a car owner, and secondly, the factors characterizing features of vehicle use, and on the characteristics of the insurance contract [4-7, 9-14, 16, 17].

Thus scientific and methodical approach to the calculation of the insurance rate will take into account the above two groups of factors and conditions of the insurance contract. The question of the significance and selection for the calculation of a factor depends on the amount of statistical data and the features of its application in practice too [8].

So, for the construction of approach was chosen following factors in terms of content, that can be quantitative and qualitative (Table 1).

*Table 1*

**General characteristics of billing's factors $x_i$ and conditions of insurance**

| Group of factors | Factors | Legend | Number of similar sets of values | Quantitative/qualitative | Compliance risk |
|---|---|---|---|---|---|
| 1. Billing factors | | | | | |
| I group (factors motorist) | Driving experience | $x_1$ | 4 | Quantitative | RTA |
| | Experience of previous accidents | $x_2$ | 2 | Qualitative | RTA |
| | Mode of operation | $x_3$ | 2 | Qualitative | RTA, T, ORE |
| The second group (factors of car) | Type of car body | $x_4$ | 6 | Qualitative | T |
| | Country of production | $x_5$ | 3 | Qualitative | T |
| | Car age | $x_6$ | 4 | Quantitative | RTA, T, ORE |
| | Territory of cars | $x_7$ | 2 | Qualitative | ORE |
| | Color of car | $x_8$ | 2 | Qualitative | RTA |
| | Displacement | $x_9$ | 4 | Quantitative | RTA |
| | Actual mileage | $x_{10}$ | 4 | Quantitative | RTA |
| | Insured amount | $x_{11}$ | 4 | Quantitative | T |
| 2. Terms of conclusion of the insurance contract | | | | | |
| Insurance terms | Insurance coverage | – | 3 | – | – |
| | Franchise by RTA | $F_{RTA}$ | 5 | – | – |
| | Franchise by T | $F_T$ | 5 | – | – |
| | Term of the policy | $t$ | 12 | – | – |

*Source:* [1; 3; 9; 17]

The analyze the possible insurance risks and statistics on losses of the company is necessary for the calculation of the insurance rate. So the next stage is connected with the study of signs of insurance risks. The main risks in hull insurance is road transport accident (RTA), natural disasters, fire and explosion, hitting foreign objects on the surface of the vehicle, kidnapping and unlawful acts of third parties (CTPs) [1, 3-6, 9, 10].

The proposed scientific and methodical approach will be evaluated three risks: road transport accident ("RTA"), theft ("T") and other random events ("ORE"). In particular, the risk of "ORE" take into account all the above, except for "RTA" and "T".

In the next step of this approach is defining the relationship between billing factors and insurance risk (Fig. 2).

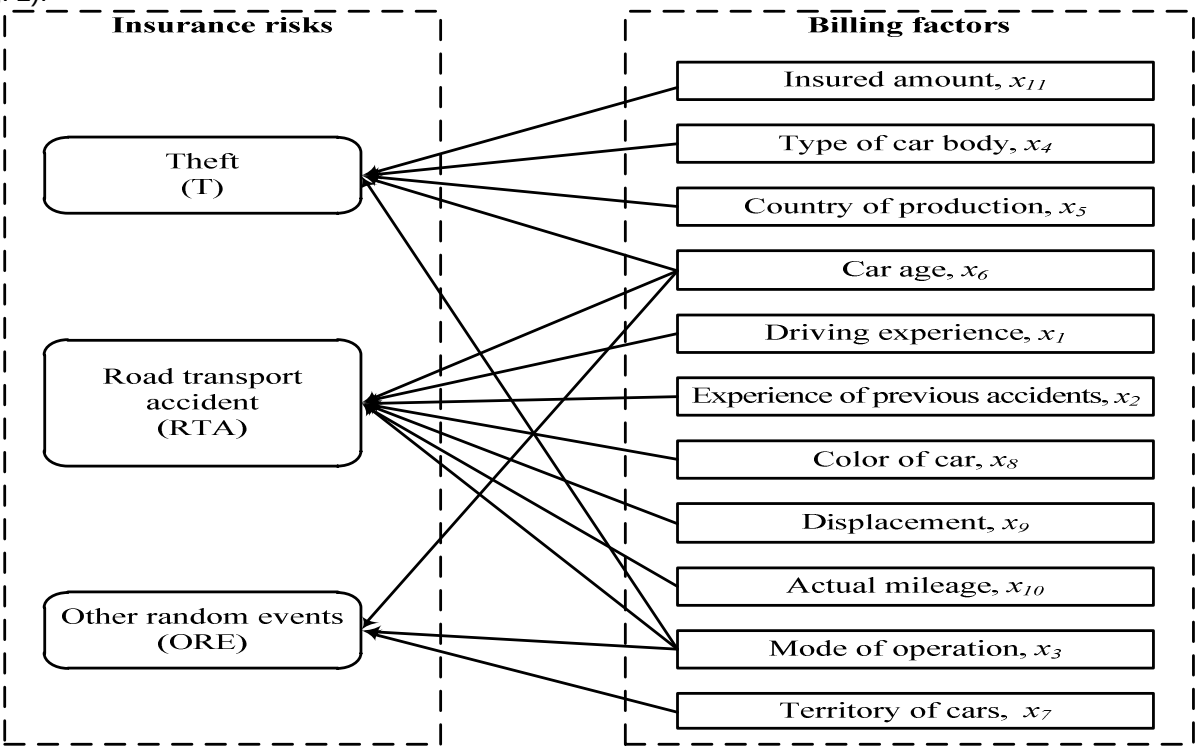


**Fig. 2. The relationship between billing factors and insurance risk**

*Source:* [3; 4; 9; 13; 17]

According to Fig. 2 we can conclude that "RTA" is the most exposed aggregate selected risk factors.

To form the billing groups we should use the cluster analysis of the program package Statistica. Also it is necessary to create a database of information loss insurance facilities. Since the basis of this analysis tasked to fall into one group insurance most similar objects, and objects of different groups differed the most, it is essential to ensure uniformity of insurance objects within a group - a necessary condition for insurance billing.

Separation of qualitative factors associated with holding scoring for homogeneous sets of values of each factor, where the specific values of the factor close riskiness get one point, and the other zero. Thus the quantitative factors for cluster analysis leave unchanged.

The significance of cluster analysis examines the outcome of the analysis of variance in package Statistica, namely through the calculation of the probability $p_i$ for each billing factor. In this case, the following condition is verified. That is, if the value is less than $p_i < 0{,}05$, the differences between the clusters are significant, indicating that each cluster got close to risk insurance facilities.

Basic insurance rates $R_B$ are traditionally calculated is based on the sum insured and loss account of the three components above the threshold for risk. The study data base revealed that losses at the risk of "RTA" is about 60%, and the risk of "T" and "ORE" - 20% (1):

$$\begin{gathered} R_B = LR = \frac{AIC}{IA}, \\ R_{RTA} = 0{,}6 \cdot R_B, \\ R_T = R_{ORE} = 0{,}2 \cdot R_B, \end{gathered} \tag{1}$$

де $R_B$ – basic insurance rate;

$LR$ – loss ratio;

$AIC$ – amount of insurance claims;

$IA$ – insured amount;

$R_{RTA}$ – insurance rates for the risk «RTA»;

$R_T$ – insurance rates for the risk «T»;

$R_{ORE}$ – insurance rates for the risk «ORE».

Each group has different factors impact on the value of the insurance rate. The importance of this effect is taken into account in the method using multiplicative type of correction factors (Table 2). According to this scientific-methodological approach the value of correction factor is determined by an expert in the analysis of contemporary practice setting data values of coefficients companies that provide hull insurance. A value of correction factor for the base fare put equal to unity ( $z_B = 1$).

The next step is to calculate the net rate $R_N$, which includes the bulk of the net rate $B$ and the risk premium of the net rate $P$:

$$R_N = B + P, \tag{2}$$

where $R_N$ – net rate;

$B$ – bulk of the net rate;

$P$ – risk premium of the net rate.

The bulk of the net rate $B$ for the particular object of insurance is based on the basic insurance benefit (1) taking into account the expert determined correction factors (Table 2). The formula is used as follows (3):

$$B = (R_{RTA} z_1 z_2 z_8 z_9 z_{10} + R_T z_4 z_5 z_{11} + R_{ORE} z_7) z_3 z_6, \tag{3}$$

where $z_1, z_2, \ldots, z_{11}$ – correction factors.

Hence we have (4):

$$B = (R_{RTA} \prod_{j=1}^{5} z_j + R_T \prod_{k=1}^{3} z_k + R_{ORE} z_l) \prod_{m=1}^{2} z_m, \tag{4}$$

where $\prod_{j=1}^{5} z_j$ – product of the correction factors for risk «RTA»;

$\prod_{k=1}^{3} z_k$ – product of the correction factors for risk «T»;

$z_l$ – correction factor for risk «ORE»;

$\prod_{m=1}^{2} z_m$ – product of the correction factors for all risks.

*Table 2*

**Correction factors of thr billing factors**

| Factors | Units | Range of values | Correction factors |
|---|---|---|---|
| Driving experience | year | 0-3 | 1,3 |
| | | 4-7 | 1 |
| | | 8-15 | 1 |
| | | more than 15 | 1,1 |
| Experience of previous accidents | – | yes | 1,2 |
| | | no | 1 |
| Mode of operation | – | own goals | 1 |
| | | commercial purposes: carriage of passengers or cargo | 1,2 |
| Type of car body | – | sedan/ coupe | 1 |
| | | wagon/ combi/ hatchback/ liftback | 1,1 |
| | | SUV/ crossover/ pickup/ van/ minivan | 1,2 |
| | | convertible/ limousine | 1 |
| | | minibus | 1,1 |
| | | cargo | 1,2 |
| Country of production | – | USA/ UK/ Germany/ France/ Italy/ Japan | 1 |
| | | Czech Republic/ Romania/ Korea etc. | 1,2 |
| | | Russia/ Ukraine/ China | 1,4 |
| Car age | year | 2013 | 1 |
| | | 2011-2013 | 1,1 |
| | | 2006-2010 | 1,2 |
| | | less than 2006 | 1,4 |
| Territory of cars | – | Ukraine | 1 |
| | | foreign countries | 1,1 |
| Color of car | – | grey/ black | 1,1 |
| | | other | 1 |
| Displacement | $dm^3$ | less more 1,5 | 1 |
| | | 1,5-2,5 | 1 |
| | | 2,6-4 | 1,2 |
| | | more than 4 | 1,3 |
| Actual mileage | km | less more 10000 | 1 |
| | | 10000-39999 | 1 |
| | | 40000-100000 | 1,1 |
| | | more than 100000 | 1,3 |
| Insured amount | UAH | less more 100000 | 1 |
| | | 100000-249999 | 1 |
| | | 250000-450000 | 1,1 |
| | | more than 450000 | 1,1 |

* – correction factors basic insurance rate of the hull insurance;
– correction factors of the most riskiness performance factors used to determine the risk premium in view of the synergistic effect.

*Source:* [3; 5; 6; 8; 9; 13; 17]

Determination of net risk premium rate $R_P$ will be based on the following considerations. Insurance items per tariff have been used the least value correction factors for one or another factor, respectively is less flawed than those characterized by high values of correction factors. Therefore, according to the

scientific and methodological approach to calculate risk premium is required, since these objects are characterized by the lowest degree of risk. Risk premium for the insurance will be determined only objects with a high loss ratio, as shown in table 2. Most risk billing factors mentioned contain the highest values of correction factors $\hat{z}_i = \max_g \{z_{ig}\}$.

We believe that including this component, and consequently a certain increase of insurance rates, stipulate to the occurrence of negative synergistic effect among the most unprofitable risk characteristics of the case for a particular insured facility. The occurrence of synergistic effect observed in coincidence of two or more major values of correction factors for all billing factors. The formula for calculating the risk premium is as follows:

$$P = \frac{\sum_{i=1}^{11} (\hat{z}_i - z_B)}{s}, \quad (5)$$

де $P$ – risk premium of the net rate;

$z_B$ – correction factor of the base rate ( $z_B = 1$);

$\hat{z}_i$ – correction factors for the most important factor in risk, which causes the synergistic effect;

$s$ – number of correction factors of the values of risky factors ( $s = 2 \div 11$).

Thus the net rate in expanded form is equals:

$$R_N = B + P = (R_{RTA} \prod_{j=1}^{5} z_j + R_T \prod_{k=1}^{3} z_k + R_{ORE} z_l) \prod_{m=1}^{2} z_m + \frac{\sum_{i=1}^{11} (\hat{z}_i - z_B)}{s}. \quad (6)$$

The last step is to calculate the gross rate $R_G$. Since the insurance burden is often set as a percentage of net rate that is about 15%, so we introduce a coefficient *a* (*a* = 1.15) and satisfy it in the following formula (7):

$$R_G = R_N + L = aR_N = a((R_{RTA} \prod_{j=1}^{5} z_j + R_T \prod_{k=1}^{3} z_k + R_{ORE} z_l) \prod_{m=1}^{2} z_m + \frac{\sum_{i=1}^{11} (\hat{z}_i - z_B)}{s}). \quad (7)$$

As noted above, the value of the insurance rate is also influenced by the conditions of insurance. At first consider the amount of coverage that may be complete (full insurance) or partial (economy hull insurance). Since the full insurance covered all the risks discussed above, the equation will be charging the same form as (7).

The economy hull insurance is not for everyone, but only for one or more risks. Then, for example, equalization charging of risks "RTA", "T" and "RTA+T" will have the form (8) - (10):

$$R_{G(RTA)} = a(R_{RTA} \prod_{j=1}^{5} z_j \prod_{m=1}^{2} z_m + \frac{\sum_{i=1}^{11} (\hat{z}_i - z_B)}{s}), \quad (8)$$

$$R_{G(T)} = a(R_T \prod_{k=1}^{3} z_k \prod_{m=1}^{2} z_m + \frac{\sum_{i=1}^{11} (\hat{z}_i - z_B)}{s}), \quad (9)$$

$$R_{G(RTA+T)} = a((R_{RTA} \prod_{j=1}^{5} z_j + T_B \prod_{k=1}^{3} z_k) \prod_{m=1}^{2} z_m + \frac{\sum_{i=1}^{11} (\hat{z}_i - z_B)}{s}). \quad (10)$$

Typical condition insurance is the ability to use the franchise value to the insurance rate. The most common size of franchises for risk "RTA" ($F_{RTA}$: 0%, 0,5%, 1%, 2% and 5%) and "T" ($F_T$: 0%, 3%, 5%, 10% and 15%). Then the formula for calculating the gross rate considering the franchise will have the following form (11):

$$R_{G[F]} = aR_N(1-F) = a((R_{RTA} \prod_{j=1}^{5} z_j + R_T \prod_{k=1}^{3} z_k + R_{ORE} z_l) \prod_{m=1}^{2} z_m + \frac{\sum_{i=1}^{11} (\hat{z}_i - z_B)}{s})(1-F). \quad (11)$$

The most common term for the insurance contract in hull insurance is one year. However, such a contract can be concluded for a period of several months or even days. Establishes the correspondence between the amount of insurance rate and insurance periods under 1 year, under which the amount of insurance rate changes disproportionately change the period of insurance, but it violates the principle of equivalence of calculating the rate. Therefore, according to the scientific and methodical approach gross rate will vary in proportion to the period of insurance (Table 3).

*Table 3*

**Compliance gross rate and term insurance**

| Term of the policy | The share of the value of gross fare | |
|---|---|---|
| | Used value | Proposed value |
| 1 month | 20-30% | 8,33% |
| 2 months | 30-40% | 16,67% |
| 3 months | 40-50% | 25,00% |
| 4 months | 50-60% | 33,33% |
| 5 months | 60-65% | 41,67% |
| 6 months | 70% | 50,00% |
| 7 months | 75% | 58,33% |
| 8 months | 80% | 66,67% |
| 9 months | 85% | 75,00% |
| 10 months | 90% | 83,33% |
| 11 months | 95% | 91,67% |

$$R_{G[F]} = aR_N(1-F)t = at((R_{RTA}\prod_{j=1}^{5} z_j + R_T\prod_{k=1}^{3} z_k + R_{ORE}z_l)\prod_{m=1}^{2} z_m + \frac{\sum_{i=1}^{11}(\hat{z}_i - z_B)}{s})(1-F). \quad (12)$$

As a result of scientific and methodical approach we obtained formula (12) to calculate insurance rate in hull insurance, which takes into account the time of conclusion of the insurance contract in accordance with the principle of equivalence insurance obligations between the insurer and the insured.

**Conclusions.** Thus, for the construction of scientific and methodical approach of calculating insurance rate in hull insurance is investigated and selected the most influential factors and conditions for the conclusion of an insurance contract, built billing groups (clusters) of objects in terms of insurance risk, the composition of the insurance rate. The formula for calculating the risk premium in view of the synergistic effect for most unprofitable insurance facilities. Features of this approach make it possible to apply it to calculate the insurance rate for other types of property insurance. But of course, such approaches will differ billing factors, insurance risk and correlation, significance factor, expressed as a correction factor, the number and volume of billing groups (clusters), conditions of the insurance contract and others.

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**Oliinyk V.M., Ruban S.O. SCIENTIFIC AND METHODOLOGICAL APPROACH TO THE CALCULATION OF INSURANCE RATE OF CASCO INSURANCE**

**Purpose.** The purpose of the article is to investigate the features of actuarial calculations in property insurance and develop scientific and methodical approach to determining the insurance rate of CASCO insurance.

**Methodology of research**. The basis of the scientific and methodical approach to the calculation of the insurance rate of CASCO insurance is the most common method based on probability theory and mathematical statistics.

The cluster analysis has been used in constructing billing groups, namely hierarchical clustering – to establish the number of groups and k-means – to determine the composition of the clusters. These methods provide uniformity of billing groups which are built. The significance of the cluster analysis is investigated as a result of analysis of variance in the package Statistica, namely the calculation of $p_i$ indicators probability for each billing factor.

**Findings**. Formulas for calculating the main part of the risk premium, net rate and loading insurance have been obtained. The formulas take into account the standard terms and conditions of the insurance CASCO offered by domestic insurers, that is insurance coverage (offered risks by insurance), the presence or absence of a franchise risk an accident or theft, as well as the validity of the insurance contract from one month to one year.

Calculation of the main part of the net fare is traditionally based of the loss ratio of the insured sum; it is proposed to carry out for each billing group. The formula of risk premium takes into account the synergistic effect of most risk meanings of billing factors. And insurance loading is treated as a constant of the magnitude of the net fare.

**Originality**. In the paper proposed to carry out the calculation in the risk premium of the insurance tariff structure based on synergies among the most risky factors billing values for a particular object insurance CASCO insurance in accordance with the level of risk.

**Practical value**. New scientific and methodical approach allows domestic insurance companies determine insurance rates by CASCO insurance, as well as other mass property insurance on the basis of statistic characteristics and loss of insurance objects.

**Key words:** insurance rate, structure of the insurance rate, risk premium, cluster analysis, hull insurance.