“Modeling of the optimal structure of insurance portfolio”

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Modeling of the optimal structure of insurance portfolio

Abstract

The article offers a scientific and methodical approach to the formation of the optimal structure of insurance portfolio in order to achieve its equilibrium on the basis of nonlinear programming. The proposed model has a differentiated nature and allows each company to choose the specific optimal structure of insurance portfolio that will ensure maximal profits and minimal risks.

Keywords: insurance portfolio, nonlinear programming, regression analysis, optimization of insurance portfolio.
JEL Classification: G22.

Introduction

Under conditions of the deepening global integration processes and increased competition among the insurance market's participants the issue of financial protection of insurance companies from the existing and potential threats is becoming increasingly relevant. A key element in the provision of financial stability of the insurer should be the choice of the optimal structure of insurance portfolio that will ensure profit maximization based on acceptable risk levels.

1. Analysis of the latest publications

The problems of this research were studied by the following well-known academic economists: G. Franco [6], E.O. Oyatoye [12], S. Asanga [1], A.I. Buresh [4], I.P. Gerashchenko [7], V.V. Davnis [5] O.V. Kozmenko [8, 9], A.O. Boyko [3]. However, in the scientific literature the proposed approaches to optimization of companies' portfolios and their mathematical formalization are unidirectional. Therefore, there is a need to adapt the existing models and develop new approaches to the formation of the structure of insurance portfolio.

The purpose of this article is to study the basic methodical principles of formation and management of insurance portfolio to achieve its equilibrium and ensure the financial stability of insurance companies.

2. The main results of the research

The implementation of effective tariff policy allows insurance companies to maintain a balance between insurance premiums and insurance payments, which is a key to ensuring the stability of the insurance company. Adequate calculation of tariff rates for insurance contracts can achieve the next important criterion to ensure the financial stability of insurance companies – the equilibrium of insurance portfolio of insurance companies.

In our opinion, the insurance portfolio is the amount of risks taken by insurance companies and the cost of insurers' obligations.

In the recent time considerable attention on the part of insurance companies is paid to the process of formation of insurance portfolio, because it serves as an indicator of the quality of insurance liabilities. One of the stages in the management of the company's insurance portfolio is its optimization, which leads to the reduction of risks and increase in profitability levels. To ensure the portfolio's optimization equilibrium insurance companies use a whole system of measures and methods.

In practice, classical and neoclassical approaches are used to form the optimal insurance portfolio according to specific criteria. The first approach is based on the hypothesis that the yield of a security (or a certain type of insurance) has invariable mathematical expectation and any fluctuations related to it are characterized by the same invariable value – a standard deviation. Moreover, the bigger the deviation, the greater the degree of risks associated with a particular strategy. Classical models include the following: the Markowitz model (direct and inverse); the Tobin model (direct and inverse); the Sharpe model; the model of optimization of the profitability and risk ratio; the model of optimization of the risk premium and risk ratio; the model of maximization of the expected utility.

After conducting a detailed analysis of the proposed methods, it should be noted that these approaches have certain advantages that should be used in further studies. Systematization of scientific approaches makes it possible to assert that in order to optimize the insurance portfolio it is necessary to use the Markowitz model [10]. We will proceed to its practical implementation by using the example of insurance companies in Ukraine: the joint-stock insurance company "Oranta", the joint-stock insurance company "INGO Ukraine", the joint-stock insurance company "TAS", the joint-stock insurance company "Universal", the joint-stock insurance company "European Tourist", the joint-stock

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company "AXA Insurance", the joint-stock company "European Insurance Alliance", the joint-stock company "Cardif". This model consists of five stages, which are shown in Figure 1.

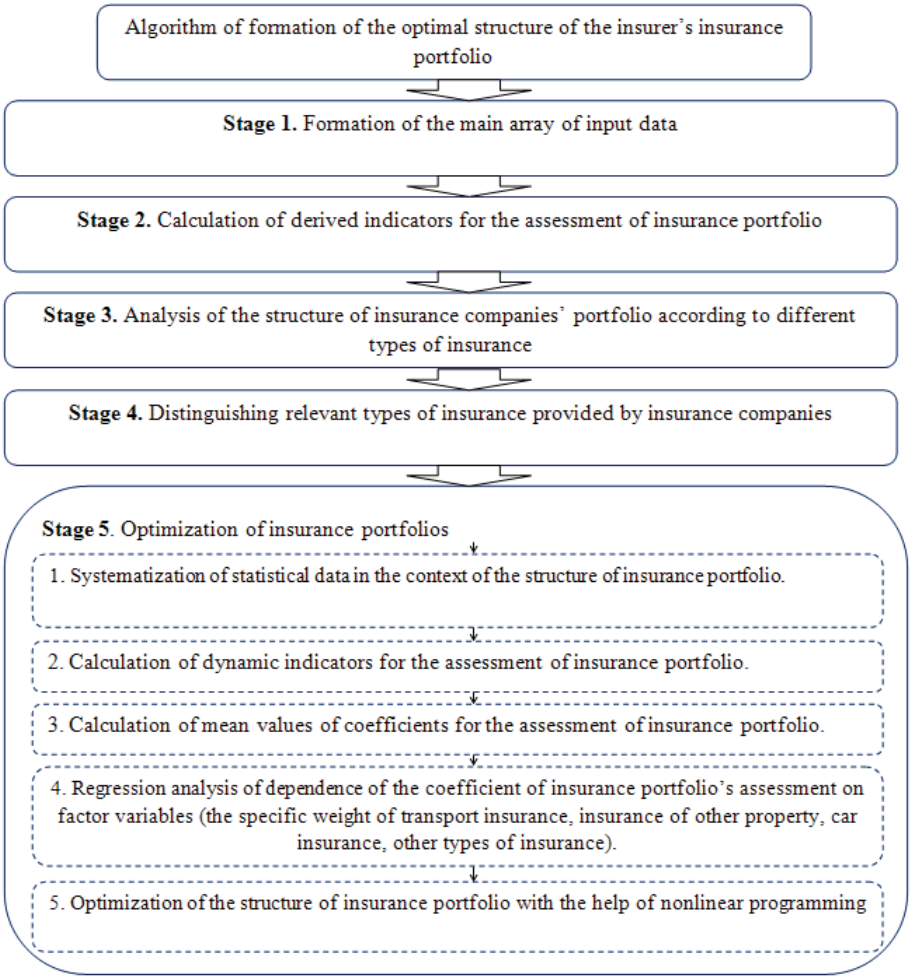

Fig. 1. Algorithm of formation of the optimal structure of the insurer's insurance portfolio

During the first stage the array of input data is formed. It should be noted that the statistical series include: insurance payments (gross), insurance payments (net), insurance payments and compensations (gross), insurance payments and compensations (net), insurance reserves (gross), net profits/losses, inwards reinsurance – payments to reinsurers, assets, equity, liabilities, current liabilities, current assets, accounts payable, costs of insurance (acquisitional, including commissions).

During the second stage the derived indicators for the assessment of insurance portfolio are calculated on the basis of input of statistical data.

Indicators for the assessment of insurance portfolio are divided into two blocks:

1. Riskiness of insurance portfolio: coefficient of risk retention; coefficient of insurance risk; coefficient of unprofitableness of insurance operations.

2. Returns on insurance portfolio, coefficient of profits on sales; coefficient of profitability of insurance services; coefficient of assets growth.

During the third stage the analysis of the structure of the following insurance companies' portfolio is performed: the joint-stock insurance company "Oranta", the joint-stock insurance company "INGO Ukraine", the joint-stock insurance company "TAS", the joint-stock insurance company "Universal", the joint-stock insurance company "European Tourist", the joint-stock company "AXA Insurance", the joint-stock company "European insurance alliance", the joint-stock company "Cardif" for different types of insurance in the period 2009-2013.

It is expedient to consider the structure of the companies' insurance portfolio in the following types of insurance: transport insurance, insurance of other property, car insurance, other types of insurance, green card; voluntary medical insurance (VMI), accident insurance, other types of insurance.

The fourth stage – *Distinguishing relevant types of insurance provided by insurance companies*.

Table 1. The structure of relevant types of insurance

Company	Type of insurance			
1. Oranta	Insurance of land transport	Insurance of other property	Car insurance	Other types of insurance
2. INGO Ukraine	Insurance of land transport	Insurance of other property	Voluntary medical insurance	Other types of insurance
3. TAS	Insurance of land transport	Insurance of other property	Car insurance	Other types of insurance
4. Universal	Insurance of land transport	Insurance of other property	Car insurance	Other types of insurance
5. European Tourist Insurance	Insurance of other property	Insurance from accidents	Other types of insurance	-
6. AXA Insurance	Insurance of land transport	Insurance of other property	Car insurance	Other types of insurance
7. European insurance alliance	Insurance of land transport	Insurance of other property	Car insurance	Other types of insurance
8. Cardif	Insurance of other property	Voluntary medical insurance	Insurance from accidents	Other types of insurance

The data of Table 1 show that the analyzed companies in their insurance portfolio have such relevant types of insurance that exist in almost every portfolio of other insurers, such as insurance of land transport, insurance of other property and car insurance. During the next (fifth) stage we conduct optimization of insurance portfolios, the implementation of which has a specific algorithm. The first step is the systematization of statistical data in the context of characteristics of the structure of insurance portfolio of the "Oranta" company.

1. The next step is to calculate dynamic indicators for assessing the insurance portfolio.

Table 2. The dynamics of insurance portfolio coefficients

Year	Riskiness of insurance portfolio			Profitability of insurance portfolio		
	Coefficient of risk retention	Coefficient of risk insurance	Coefficient of unprofitableness of insurance operations	Coefficient of profits on sales	Coefficient of profitability of insurance services	Coefficient of assets growth
	p1	p2	p3	д1	д2	д3
2009	0.72	0.68	0.48	-0.33	-0.49	-0.42
2010	0.90	0.25	0.45	0.01	0.02	1.27
2011	0.92	0.19	0.34	0.00	0.00	-0.02
2012	0.91	0.18	0.39	0.00	0.00	0.06
2013	0.95	0.30	0.49	-0.31	-0.51	-0.34

1. This step is characterized by the calculation of mean values of the insurance portfolio coefficients.

2. We should proceed to the regression analysis of the dependence of insurance portfolio's assessment coefficient (effective indicator Y) on factor variable x1, x2, x3, x4 (specific weight of land transport insurance, insurance of other property, car insurance, other types of insurance).

As a result of statistical analysis of the dependence of risk insurance coefficient (effective indicator Y) on factor variables x1, x2, x3, x4 we have obtained the following regression equation:

$$Y = 15.24 - 0.15x1 - 0.13x2 - 0.20x3, \quad (1)$$

where Y – coefficient of risk insurance; $x1$ – specific weight of land transport insurance; $x2$ – specific weight of insurance of other property; $x3$ – specific weight of car insurance; $x4$ – specific weight of other types of insurance.

These data suggest that an increase in the specific weight of land transport insurance by 1% leads to a decrease of risk insurance coefficient by 0.15; an increase in the specific weight of other property insurance by 1% leads to a decrease of the risk retention coefficient by 0.13; an increase in the specific weight of car insurance by 1% leads to a decrease of car insurance coefficient by 0.20.

After the statistical analysis of the dependence of risk retention coefficient (effective indicator Y) on factor variables $x1$, $x2$, $x3$, $x4$ we have obtained the following regression equation:

$$Y = -3.7 + 0.04x + 0.05x + 0.06x3, \quad (2)$$

where Y is risk retention coefficient.

These data suggest that an increase in the specific weight of land transport insurance by 1% leads to an increase of the risk retention coefficient by 0.04; an increase in the specific weight of other property insurance by 1% leads to an increase of the risk retention coefficient by 0.05; while an increase in the specific weight of car insurance by 1% leads to an increase of the coefficient by 0.06.

After the statistical analysis of the dependence of the coefficient of unprofitableness of insurance operations (effective indicator Y) on factor variables $x1$, $x2$, $x3$, $x4$ we have obtained the following regression equation:

$$Y = -6.09 - 0.07x1 - 0.01x2 - 0.09x3, \quad (3)$$

where *Y* is the coefficient of unprofitableness of insurance operations.

These data suggest that an increase in the specific weight of land transport insurance by 1% leads to a decrease in the coefficient of unprofitableness of insurance operations by 0.07; an increase in specific weight of other property insurance by 1% leads to a decrease in the coefficient of unprofitableness of insurance operations by 0.01; an increase in the specific weight of car insurance by 1% leads to a decrease of the coefficient by 0.09.

After the statistical analysis of the dependence of the coefficient of profits on sales (effective indicator *Y*) on factor variables *x*1, *x*2, *x*3, *x*4 we have obtained the following regression equation:

$$Y = -17.78 + 0.19x + 0.13x + 0.24x3, \quad (4)$$

where *Y* is the coefficient of profits on sales.

These data suggest that an increase in the specific weight of land transport insurance by 1% leads to an increase in the coefficient of profits on sales by 0.19; an increase in the specific weight of other property insurance by 1% leads to an increase in the coefficient of profits on sales by 0.13; an increase in the specific weight of car insurance by 1% leads to an increase of the coefficient by 0.24.

After the statistical analysis of the dependence of coefficient of insurance services profitability (effective indicator Y) on factor variables *x*1, *x*2, *x*3, *x*4 we have obtained the following regression equation:

$$Y = -27.85 + 0.30x + 0.19x + 0.38x3, \quad (5)$$

where *Y* is the coefficient of insurance services profitability.

These data suggest that an increase in the specific weight of land transport insurance by 1% leads to an increase of the coefficient of insurance services profitability by 0.30; an increase in the specific weight of insurance of other property by 1% leads to an increase of the coefficient of insurance services profitability by 0.19; an increase in the specific weight of car insurance by 1% leads to an increase of the coefficient by 0.38.

After the statistical analysis of the dependence of the assets growth coefficient (effective indicator *Y*) on factor variables *x*1, *x*2, *x*3, *x*4 we have obtained the following regression equation:

$$Y = -58.09 + 0.55x + 0.76x + 0.69\ x3, \quad (6)$$

where *Y* is the coefficient of assets growth.

These data suggest that an increase in the specific weight of land transport insurance by 1% leads to an increase of assets growth coefficient by 0.55; an increase of the specific weight of other property insurance by 1% leads to an increase of assets growth coefficient by 0.76; an increase in the specific weight of car insurance by 1% leads to an increase of the coefficient by 0.69.

1. The next step is to optimize the structure of insurance portfolio of the "Oranta" company by using nonlinear programming.

With the available data we can use the option "Solver". With the help of "Solver" we should get the quotients, at which the risks would be minimal ($p2 \rightarrow \min$).

It should be noted that the necessary prerequisite is the imposition of restrictions so that the sum of qoutients equals 1, the coefficients of risk retention (p1) and unprofitableness of insurance operations (p3) are «≤» according to their mean values over the studied period, while the coefficients of profits on sales (д1), profitability of insurance services (д2), growth of assets (д3) are «≥» according to their mean values. The results of the analysis are shown in Table 3.

Table 3. Optimization of the structure of insurance portfolio of the "Oranta" company

Variables				
Specific weight of certain types of insurance,%	x1	x2	x3	x4
	66.05	0	33.95	0
Objective function	-1.28		($p2 \rightarrow \min$)	
Restrictions				
p1	0.88	<=		0.88
p3	-1.30	<=		0.37
д1	2.93	>=		-0.01
д2	4.74	>=		-0.01
д3	1.55	>=		0.19
Σx_i	100	=		100

In the end we have the following result: the optimal portfolio of the insurance company "Oranta" will consist of 66.05% of land transport insurance, of 33.95% of car insurance while other types of insurance should be minimized.

It should be noted that this approach is differentiated, as for each insurance company it is necessary to select a specific optimal structure of insurance portfolio that will ensure maximal profitability and minimal risks.

Based on the results of regression analysis of each insurance company we conducted the systematization of the data (see Table 4).

The above-mentioned structure shows that almost all insurance companies must increase two main types of

insurance services in their portfolios, while the other two companies have to minimize them: insurance company "Oranta" (66.05% – insurance of land transport, 33.95% – car insurance) and the joint-stock company "INGO Ukraine" (77.59% – insurance of other property, 22.41% – voluntary medical insurance).

Table 4. Optimal structure of insurance portfolios

Insurance company	Specific weight of certain types of insurance, %			
	x1	x2	x3	x4
1. Oranta	66.05	0.00	33.95	0.00
2. INGO Ukraine	0.00	77.59	22.41	0.00
3. TAS	100.00	0.00	0.00	0.00
4. Universal	0.00	83.56	16.44	0.00
5. European Tourist Insurance	0.91	82.40	16.69	0.00
6. AXA Insurance	99.03	0.00	0.97	0.00
7. European insurance alliance	0.00	66.74	0.00	33.26
8. Cardif	0.00	88.47	0.00	11.53

Joint-stock company "Universal" (83.56% – insurance of other property, 16.44% – car insurance), joint-stock company "AXA Insurance" (99.03% – insurance of land transport, 0.97% – car insurance), joint-stock company "European insurance alliance" (66.74% – insurance of other property, 33.26% – other types of insurance), joint-stock insurance company "Cardif" (88.47% – voluntary medical insurance, 11.53% – other types of insurance). However, the joint-stock insurance company TAS must minimize all types of insurance services with the exception of land transport insurance – 100% while the joint-stock company "European Tourist Insurance" should ensure the following structure of its insurance portfolio: insurance of other property – 0.91%, insurance of accidents – 82.40%, other types of insurance – 16.69%.

Conclusions and prospects for further research

The proposed scientific and methodical approach to building and managing an insurance portfolio in order to achieve its equilibrium based on nonlinear programming has a differentiated character. For each company this model chooses an optimal structure of insurance portfolio that ensures maximal profits and minimal risks. Thus, to choose a model for the optimal structure of insurance portfolio it is important to consider a number of factors. In transition economies, in which financial markets are still in the process of development and reorganization, it is expedient to choose differentiated approaches that could provide more adequate assessment of research.

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