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METHODOLOGICAL PRINCIPLES AND FORMALIZATION OF THE STABILITY ACHIEVEMENT PROCESS AT THE REINSURANCE MARKET

Abstract. *Introduction.* The global economic system demands effective mechanisms to prevent and minimize various risks. So, the progressive international tendencies of national economics lead to the consideration of the mechanism, which allows, not disrupting the entrepreneurship market, neutralizing the negative consequences of adverse events with the means of reinsurance market. Therefore, *the purpose* of the article is to research methodological and formalization aspects of the stability achievement process at the reinsurance market. *Methods.* Methodological basis of the study are fundamental tendencies of the finance and insurance theory, modern insurance management concepts.

Results. The article is devoted to the essential characteristics and mathematical formalization of reinsurance market stability as a dynamic process of the stable distribution formation between two sets of subjects at this market: the subjects who transfer risk for reinsurance, and the subjects who take risk for reinsurance. The practical implementation of the proposed approach is carried out with the usage of Gale-Shapley algorithm («pending approval algorithm»), adjusted to the peculiarities of reinsurance market functioning on the sample of four insurance companies (Munich Reinsurance Co., Swiss Reinsurance Co., Berkshire Hathaway Re., Hannover Rueckversicherung AG), to the share of which 55.51% of the global reinsurance market assets fall. Stable distribution determines conclusion and compliance with the conditions of reinsurance contracts between the subjects pairs at the reinsurance market, which is the conclusion of agreements, which can provide: cover of losses in full; implementation of insurance payments or the obligations execution within permissible limits; optimizing the profitability of insurers and reinsurers due to the compromise solution in the context of tariff rate and insurance reserves. On the basis of calculations, stable distribution of the subjects in the reinsurance market for the period 2010-2012 provides for companies Munich Reinsurance Co. and Berkshire Hathaway Re. reinsurance their risks in 2010 in Berkshire Hathaway Re and Munich Reinsurance Co., respectively, and change reinsurance company on Hannover Rueckversicherung AG (respectively, on Swiss Reinsurance Co.) in the next two years. For companies Swiss Reinsurance Co. and Hannover Rueckversicherung AG the stable distribution is possible at a variation of the reinsurer in 2010 on Hannover Rueckversicherung AG (respectively, Swiss Reinsurance Co.), in 2011 – on Munich Reinsurance Co. (respectively, Berkshire Hathaway Re.), in 2012 – on Berkshire Hathaway Re. (respectively, Munich Reinsurance Co).

Conclusion. Methodological principles and formalization of the stability achievement process at the reinsurance market allowed defining the stability of the reinsurance market, exploring its stable distribution on the basis of Gale-Shapley algorithm («pending approval algorithm»), identify the main principles of its formation, and realize its practical implementation on the Sample of four insurance companies (Munich Reinsurance Co., Swiss Reinsurance Co., Berkshire Hathaway Re., Hannover Rueckversicherung AG). The stable distribution provides the following key aspects: full covering of losses, making insurance payments or performance of obligations within permissible limits; optimizing the profitability of insurers and reinsurers due to the compromise decision.

Keywords: reinsurance market; market stability; stable distribution.
JEL Classification: B41, C61, C62, G22

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МЕТОДОЛОГИЧЕСКИЕ ПРИНЦИПЫ И ФОРМАЛИЗАЦИЯ ПРОЦЕССА ДОСТИЖЕНИЯ СТАБИЛЬНОСТИ РЫНКА ПЕРЕСТРАХОВАНИЯ

Аннотация. В статье рассматриваются основные характеристики и математическая формализация стабильности рынка перестрахования как динамического процесса формирования устойчивого распределения между двумя множествами субъектов этого рынка: субъектами, которые передают риски на перестрахование, и субъектами, принимающими риски на перестрахование. Практическая реализация предлагаемого подхода осуществляется на глобальном рынке перестрахования с использованием алгоритма Гейла-Шепли («алгоритм отложенного согласования») и учетом особенностей функционирования рынка перестрахования.

Ключевые слова: рынок перестрахования, стабильность рынка, устойчивое распределение.

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МЕТОДОЛОГІЧНІ ЗАСАДИ ТА ФОРМАЛІЗАЦІЯ ПРОЦЕСУ ДОСЯГНЕННЯ СТАБІЛЬНОСТІ РИНКУ ПЕРЕСТРАХУВАННЯ

Анотація. У статті розглядаються основні характеристики та математична формалізація стабільності ринку перестрахування як динамічного процесу формування стійкого розподілу між двома множинами суб'єктів цього ринку: суб'єктами, що передають ризики у перестрахування, і суб'єктами, що приймають ризики на перестрахування. Практична реалізація запропонованого підходу здійснюється автором на основі даних функціонування глобального ринку перестрахування із використанням алгоритму Гейла-Шеплі («алгоритм відкладеного узгодження») та урахуванням особливостей функціонування ринку перестрахування.

Ключові слова: ринок перестрахування, стабільність ринку, стійкий розподіл.

Introduction. Under current conditions of the world economy development the destructive effect of external and internal factors on the activities of economic entities in the financial and real sectors leads to the systemic crises, the consequences liquidation of which requires significant financial and time expenses. Therefore, it may be noted that the functioning of the global economic system demands forming the effective mechanism to prevent and minimize various risks. So, the progressive international tendencies of national economics lead to the consideration of the mechanism, which allows, not disrupting the entrepreneurship market, neutralizing the negative consequences of adverse events.

The existing architecture of the global financial system allows considering the reinsurance market in the capacity of this mechanism. In this article we are investigating the insurance market possibilities because mostly it is the catalyst of negative consequences at the national level and the assignor for the reinsurance market. At the same time, it may be noted that this market can be characterized by the certain instability as any dynamic system. Therefore, it is reasonable to consider the relationships among the subjects of reinsurance market as the basic stability principles of this market. The aim of each member is to reach its own benefit and priorities, while not breaking the general equilibrium of the market. In addition, all participants of reinsurance relations must meet their own needs in the reinsurance protection.

Brief Literature Review. Significant contribution to the study of the general features of reinsurance market functioning and development in the crisis period and approaches to its stabilization were made by the following scientists-economists: Andrews D. (1993) [1], Gale D. (1962) [2], Ravindran M. (2011) [3], Shapley L. (1962) [2; 3] and other Among domestic theoretical and practical aspects of formalization of the achieving stability process in the reinsurance market, we should highlight publications of: Baholdyn A. [4], Boyko A. [5], Merenkova O. [6], Onishchenko Y. I. and Pshenychna A. A. [7] et al. Despite this, further development are required directions related to the formation and realization of stable distribution the subjects of this market, that is the conclusion of such agreements, which will allow to provide: implementation of insurance payments, or obligations within acceptable limits; optimization the return of insurers and reinsurers through the adoption of a compromise solution in the context of wage rates and within the volume of the formed insurance reserves.

Purpose. The article is aimed at the methodological principles research to formalize the stability achievement process of the reinsurance market.

Results. The term «stability of the reinsurance market» is proposed to consider as the dynamic process which includes the stable distribution (correspondence) between two sets of subjects of the market: subjects that transfer risk for reinsurance (insurers (assignors), reinsurers, reinsurance pools) and subjects that take risks for reinsurance (reinsurers (assignors, assigns), reinsurance pools).

On the other side, it may be remarked that the stable distribution determines the conclusion and compliance with the conditions of reinsurance contracts between the subjects pairs at the reinsurance market, that is the conclusion of agreements, which can provide: cover of losses in full; implementation of insurance payments or the obligations execution within permissible limits; optimizing the profitability of insurers and reinsurers due to the compromise solution in the context of the tariff rate and the insurance reserves. In addition, the necessary condition for the stable distribution is the following: for every insurance company among two stable matching sets it is not profitably to terminate the reinsurance contracts with «stable» counterparty for the purpose of transfer a part of insurance premiums (on its own responsibility) to other reinsurers or insurance pools.

The conceptual problem formulation of attainment and assurance of reinsurance market stability can be submitted in the following way. Two sets should be studied: M1 – subjects that transfer risk for reinsurance (insurers (assignors), reinsurers, reinsurance pools) and M2 – subjects that take risks for reinsurance (reinsurers (assignors, assigns), reinsurance pools). Each element of M1 subjects is characterized by the following principle: the elements of the second set M2 are arranged according to the clearly defined ranking. It means that in the context of each set component, it has been well established which elements of the other set are preferred to each other. The priority of the insurers and reinsurers of the first set is defined from the point of view of each subject in the second set similarly to the above-mentioned one.

Therefore, formalization process of the reinsurance market stability presupposes the need for division of the subjects (which carry out active and passive reinsurance) in pairs taking into account that for couple formation only one element from each set M1 and M2 is selected. Distribution, obtained in the described way, is called the stable distribution [1; 3], because the basic principles of this approach give possibility to provide the refunding expenses in full, the execution of claim statements within the permissible limits, the formation of an adequate insurance reserves level, the establishment of insurance risk price complying to the market requirements.

Thus, summarizing the above-mentioned features of stability achievement of the reinsurance market and basing on literary sources, devoted to the analysis of «the stable distribution theory and market structure practice», it is offered to consider stability as a general concept of the game theory, which is interpreted in this research as the absence of pairs (m1, m2) and (m1*, m2*) characterized by the implementation of the following feature: for m1 element m2* is more preferable than m2, while for m2* item m1 is more preferable than m1*.

The practical implementation of proposed approach to understanding the reinsurance market stability is suggested to carry out on the basis of Gale-Shapley algorithm («pending approval algorithm»), adapted to the specific features of research object.

Going directly to the practical realization of the proposed approach in the context of stable infrastructure research of the reinsurance market, first of all, the need arises to create an adequate information base for performing further calculations. The reason of this fact is that one of the most important factors, which ensure the stable distribution and following the «pending approval algorithm», is identification of the statistic data that characterizes the reinsurance market as a stable one. So, it is required to specify companies by country and research the dynamic variances of the main indicators of the reinsurance market stability as time series, because insurance, reinsurance companies and insurance, reinsurance pools are the subjects of the studied market, which can be represented in the various countries in the context of reinsurance operations.

The existing statistical base analysis of characteristics and quantitative estimation of the components of the global reinsurance market stability provides an opportunity to determine six relevant indicators: technical provisions and claims paid, net reinsurance premiums and net profit, gross premiums and assets (Table 1). It is suggested to consider the features and development tendencies of each time-series set of initial data more detailed.

The next stage (based at the input data) is a practical implementation of the proposed approach from the angle of reinsurance market stable arrangement. On this stage we have to adjust the collected statistical data carrying out its normalization with the usage of the natural method.

Depending on the priority of the characteristics indicators impact of the reinsurance market subjects on their rating in modern scientific works, in particular [2], the approach is presented on the basis of Fishbern formula, which allows taking into account the ratio between both weights of various indicators and general relationship regularities between them.

So, the array of information support for modeling the stability of the reinsurance market on the basis of a stable distribution according to Gale-Sheply algorithm, adjusting the evaluation indicators of insurance companies to the comparable form, ranking and calculated values of the specific weight of the respective indicators are the basis for carrying out the next stage of the methodological approach to formalization of the

reinsurance market trends – the determination of the generalized rating of the studied companies. Therefore, the ratings calculation of each subject in the reinsurance market is offered on the basis of reduction of the characteristics indicators of its stability, normalized by the natural approach and calculated by the Fishbern formula that is the following ratio:

$$RO_{ij} = \sum_{k=1}^{K} \widetilde{x}_{kij} w_k , \qquad (1)$$

where RO_{ij} – the generalized rating estimation of the i-th company (country) for the j-th year of the considered period of time; $\widetilde{x}_{kij}$ – the normalized value of the k-th characteristics indicator of the k-th company (country) for the j-th year of the considered period of time; w_k – the specific weight of the k-th characteristics indicator of the reinsurance market subjects operation.

The performed calculations results of the generalized rating estimation of the reinsurance market subjects in terms of the sample population (four insurance companies, to the share of which 55.51% of the global reinsurance market assets fall) can be represented in the form of Table 2.

On the assumption of the data in the table 3 showing the iterative procedure results of stable distribution formalization of the reinsurance market subjects in the context of the sample population (four companies in Germany, Switzerland, and the United States) for the period from 2010 to 2012, the main stages of the «pending approval algorithm» should be considered in more details.

The year 2010. Iteration 1. The first stage. The insurance company Munich Reinsurance Co. selects the priority reinsurer among the companies according to their rating – the company Berkshire Hathaway Re., in which it is planned to reinsure the part of the insurance risk commitment. The contractor agrees to perform reinsurance operations, because the insurer has the highest rating estimation from the Berkshire Hathaway Re. point of view.

The second stage. The next insurance company Swiss Reinsurance Co., trying to maximize the level of financial security, offers the Munich Reinsurance Co. to conclude the reinsurance contract. The reinsurer supports the proposal for cooperation, because it hasn't more any favourable offer at the moment.

The third stage. Similarly to the previous stage the company Berkshire Hathaway Re. selects the most preferred reinsurance company Munich Reinsurance Co. For the Munich Reinsurance Co. this offer is more advantageous than the previous one, proposed earlier by Swiss Reinsurance Co., therefore, the reinsurer accepts the current proposal declining the previous one. As a

result, the company Swiss Reinsurance Co. should look for another counterparty.

The fourth stage. In the rating list of the insurance company Hannover Rueckversicherung AG Munich Reinsurance Co.

Tab. 1: Input data for the model construction of reinsurance market stability in the context of technical provisions and claims paid during 2010-2012							
Company	**Country**	**2010**	**2011**	**2012**	**2010**	**2011**	**2012**
		Technical provisions			Claims paid		
Munich Reinsurance Co.	Germany	5219.4	5698.7	4844.1	302.0	3843.1	1871.1
Swiss Reinsurance Co.	Switzerland	4399.0	2436.0	3642.0	4376.0	5717.0	6610.0
Berkshire Hathaway Re.	USA	6196.0	6119.0	7693.0	2735.0	2953.0	2925.0
Hannover Rueckversicherung AG	Germany	9302.4	11183.3	11382.7	605.9	621.6	902.8
		Net Reinsurance Premiums			Net profit		
Munich Reinsurance Co.	Germany	29269.1	33719.2	30854.6	1805.2	1463.7	3072.8
Swiss Reinsurance Co.	Switzerland	19652	22868.0	27190.0	674.0	1010.0	1247.0
Berkshire Hathaway Re.	USA	14669	15350.0	-	12967.0	10254.0	14824.0
Hannover Rueckversicherung AG	Germany	13562.2	14279.2	15787.4	1102.9	942.6	1200.5
		Gross premiums			Assets		
Munich Reinsurance Co.	Germany	27091.9	32457.0	32838.0	103322.2	107969.5	103510.4
Swiss Reinsurance Co.	Switzerland	19433.0	26792.0	30769.0	228403.0	225899.0	215785.0
Berkshire Hathaway Re.	USA	30749.0	32075.0	34545.0	34767.0	33513.0	42358.0
Hannover Rueckversicherung AG	Germany	15170.3	16846.3	17709.4	62022.5	69449.8	70471.2

Source: The author's calculations based at [8; 9; 10]

Tab. 2: Ratings of the reinsurance market subjects in the context of the sample							
Company	**Country**	**M1**			**M2**		
		2010	2011	2012	2010	2011	2012
Munich Reinsurance Co.	Germany	1	2	3	2	1	2
Swiss Reinsurance Co.	Switzerland	4	4	4	3	2	1
Berkshire Hathaway Re.	USA	2	3	1	1	3	3
Hannover Rueckversicherung AG	Germany	3	1	2	4	4	4

Source: The author's calculations

Tab. 2: **Conventional representation of the iterative procedure for the stable distribution of the reinsurance market subjects in the context of the sample from 2010 to 2012**

Note: M – Munich Reinsurance Co.; S – Swiss Reinsurance Co.; B – Berkshire Hathaway Re.; H – Hannover Rueckversicherung AG;

legend for the reinsurance market subjects in the context of the sample;

legend for the reinsurance market subjects which take a decision concerning the conclusion of reinsurance operations in the context of the sample;

legend for the reinsurance market subjects which take a decision concerning the unreasonableness of reinsurance operations risks in the context of the sample.

Source: The author's calculations

has the highest rating estimation, which rejects the proposal for cooperation, as in previous case, because the agreement with the preferred reinsurer – Berkshire Hathaway Re. has been already concluded.

Iteration 2. Two companies Swiss Reinsurance Co., and Hannover Rueckversicherung AG faced with the need in looking for a reinsurer. These companies, in the set of the highest rating advantages among the subjects of the reinsurance market, which are able to reinsure risks, not found the most advantageous counterparty for cooperation and choose the company Berkshire Hathaway Re. In its turn, the mentioned reinsurer rejects both proposals, because he has already concluded a contract of reinsurance with the company Munich Reinsurance Co. in the first iteration, which has the highest rating.

Iteration 3. The first stage. In the set of benefits the insurance company Swiss Reinsurance Co. determined Hannover Rueckversicherung AG as the reinsurer with the third rating. Proceeding from the fact that the reinsurance market subjects with the highest ratings denied this partner's proposal to cooperate, Swiss Reinsurance Co. forwards the proposal to the company Hannover Rueckversicherung AG, which not having received any proposals beforehand, agrees to reinsure a part of the risks.

The second stage. Analogically to the described situation on the 1-st stage of the III-th iteration, the insurance company Hannover Rueckversicherung AG offers a part of its risks to Swiss Reinsurance Co. for reinsurance, which in its turn agrees to cooperate.

Thus, based at the algorithm results, it should be noted that the stable distribution of the reinsurance market subjects in dynamics provides the reinsurance operations implementation, presented in Table 4.

Tab. 4: **Dynamics of the reinsurance market subjects stable distribution**		
Year	**The insurer**	**The reinsurer**
2010	Munich Reinsurance Co.	Berkshire Hathaway Re.
	Swiss Reinsurance Co.	Hannover Rueckversicherung AG
	Berkshire Hathaway Re.	Munich Reinsurance Co.
	Hannover Rueckversicherung AG	Swiss Reinsurance Co.
2011	Munich Reinsurance Co.	Hannover Rueckversicherung AG
	Swiss Reinsurance Co.	Munich Reinsurance Co.
	Berkshire Hathaway Re.	Swiss Reinsurance Co.
	Hannover Rueckversicherung AG	Berkshire Hathaway Re.
2012	Munich Reinsurance Co.	Hannover Rueckversicherung AG
	Swiss Reinsurance Co.	Berkshire Hathaway Re.
	Berkshire Hathaway Re.	Swiss Reinsurance Co.
	Hannover Rueckversicherung AG	Munich Reinsurance Co.

Source: The author's calculations

In the context of six indicators selected for the research, the sample companies have the highest share of gross premiums (from 45.47% to 63.18%) and profits (from 30.38% to 63.65%) in comparison to the other market participants. As indicated above, the assets of the selected insurance companies occupy 55.51% of the total assets of all companies, which perform reinsurance operations that confirms the representativeness of the sample.

Almost the same values in the global reinsurance market characteristics are found in the context of technical provisions and net reinsurance premiums, accounting for about 40%. Besides these indicators, the lowest level of representativeness of the sample population has payments amounting 30.61%.

Conclusion. Thus, Methodological principles and formalization of the stability achievement process at the reinsurance market allowed defining the stability of the reinsurance market, explore its stable distribution on the basis of Gale-Shapley algorithm («algorithm pending approval»), identify the main principles of its formation, realize its practical implementation on the Sample of four insurance companies (Munich Reinsurance Co., Swiss Reinsurance Co., Berkshire Hathaway Re., Hannover Rueckversicherung AG).

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