ИНСТИТУТ ЗА ИКОНОМИЧЕСКИ ИЗСЛЕДВАНИЯ НА БЪЛГАРСКАТА АКАДЕМИЯ НА НАУКИТЕ
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INDICATORS-MARKERS FOR ASSESSMENT OF PROBABILITY OF INSURANCE COMPANIES RELATEDNESS IN IMPLEMENTATION OF RISK-ORIENTED APPROACH

The article identifies that a fundamental change in the financial monitoring system is the development of mechanisms to improve the risk-oriented approach that is applied at the national level to the reporting entities of the primary financial monitoring and aimed at carrying out risk analysis and classification. Methodical study of assessment of the probability of relatedness of insurance companies based on the use of tools of graph theory and indicators-markers for assessment of the probability of relatedness of insurance companies. The indicators-markers include: assets, equity and insurance reserves, insurance premiums and insurance premiums owed to reinsurers. For testing systems technologies (based on the use of indicators-markers) to assess the probability of relatedness of insurance companies and determining its impact on the risk of money laundering, it has been used data from the financial statements of 15 Ukrainian insurance companies for 2006-2017 years that served as the statistical base. This made it possible to identify the relatedness of insurance companies, which would improve the risk-oriented approach to insurance companies, which are the reporting entities of the initial financial monitoring. An empirical test of the use of the indicator-marker "equity" was used to determine the correlation coefficients that characterize the tightness of relatedness of the investigated insurance companies, as well as the determination of the coefficients for building the insurance companies' relatedness graphs.
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1. Introduction

The implementation of a risk-oriented approach to the system of anti-money laundering, terrorist financing and combating the financing of terrorism (hereinafter – the AML / CFT) is an urgent issue; therefore, it is important to improve the risk management process in this area, in particular by determining the level of relatedness between entities of the initial financial monitoring (hereinafter referred to as EIFM), in particular insurance companies.

In 2019 it was approved the Concept of combating terrorism in Ukraine (On the Concept of Combating Terrorism in Ukraine, 2019) based on the principles of the need to improve information, research, personnel and logistics of combating terrorism.

When conducting oversight in the field of prevention and counteraction AML / CFT, The State Financial Monitoring Service of Ukraine applies a risk-oriented approach to EIFMs.

Thus, the relevance of the study is due to the need of improvement of state regulation of financial monitoring that requires a network discovery tools aimed at AML / CFT when introducing risk-oriented approach in accordance with international standards (Vnukova, 2018).

According to the Strategy for the development of the system of prevention and counteraction to the legalization (laundering) of proceeds from crime, the financing of terrorism and the financing of the proliferation of weapons of mass destruction for the period up to 2020 (On approval of the Strategy for the development of the system of prevention and counteraction to the legalization (laundering) of proceeds from crime, terrorist financing and financing the proliferation of weapons of mass destruction for the period until 2020, 2015)key activities are consistent and effective fight against corruption and improving the forms and methods of improving risk-oriented approach to financial monitoring.

The relevance of the research is also due to the need of improvement of state regulation of financial monitoring that requires a network discovery tools aimed at AML / CFT when introducing risk-oriented approach in accordance with international standards (Vnukova, 2018; Vnukova, Hontar, Vorotyntsev, 2018).

Consequently, methodical study of assessment of the probability of insurance companies' relatedness to improve the management process risks of financial monitoring indicators through the use of markers, which will promote the use of the risk-oriented approach in ensuring AML /CFT is a particularly pressing issue that requires investigation.

2. Literature overview

Risk assessment and application of a risk-oriented approach are the first recommendations of the international standards of the Financial Action Task Force on Money Laundering (hereinafter – FATF) (FATF Recommendations, 2012).

That is why the developing and implementing AML / CFT measures using a risk-oriented approach is still in the early stages of development. Countries and institutions need to be supported to be confident to embrace international efforts on proportional regulation and not be unduly conservative (Malady, Buckley, Arner, 2014).

FATF has not defined "risk" for purposes of the risk-oriented approach. The absence of a clear definition complicates the identification of low-risk products. FATF do provide an example of a risk matrix that can be used to identify low-risk banks, but the example is based on assumptions and generalizations that are not sustainable (de Koker, 2009).

In addition, much attention is paid to systems relatedness research (Poliakova, Simarova, 2014; Chepyk, 2013).

Thus, in the article by Polyakova A. H. (Poliakova, Simarova, 2014) relatedness is seen as a property of space, which is characteristic of the control object in the course of economic policy. The work of Chepik A. E. (Chepyk, 2013) proposed to evaluate the unevenness of interregional development in different spheres of the economy using the non-uniformity index and to investigate the influence of different factors on the magnitude of these coefficients.

The legislation of Ukraine also considered the issue of relatedness of individuals. The sources (Tax Code of Ukraine, 02.12.2010; On approval of the Instruction on the procedure for regulating the activity of banks in Ukraine: Resolution of the Board of the National Bank of Ukraine, 2001; International Accounting Standard 24 Related Party Disclosures: IASB Standard 01/01/2012 5: Standart IASB, 2012; On Approval of Regulation (Standard) of Accounting 23 “Related Party Disclosures”: Ministry of Finance of Ukraine, 2012; On approval of the Regulation on determining the size of credit risk by active banking operations by banks of Ukraine: Resolution of the Board of the National Bank of Ukraine, 2016)found that under the related parties are considered legal entities belonging to the same group (parent and subsidiaries) are joint owners of substantial participation (or owners of substantial participation in each other), investors, end-beneficiaries using financial services synergies and are the only source of funding. As the definition of relatedness features out for exclusivity, economic dependence, common infrastructure, lack of transparency, the purpose of the use of funds, documentation, operational standards, debt and credit standing, internal control instruments, interest rates, fees and rates, collateral and guarantees.

However, the consideration of the relatedness of individuals in assessing the risks in the field of financial monitoring for insurance companies, which are EIFMs, has hardly been investigated. The methodological support and criteria for determining the connectedness of persons in scientific works and national legislation have not been sufficiently considered. The authors attempted to evaluate the level of relatedness of insurance companies, which are EIFMs by markers-indicators, using the graph theory toolkit.

The article aims to study the composition of indicators marker for assessing the probability of relatedness of insurance companies will improve the management risks of financial monitoring on the basis of selected indicators-markers, which will promote the use of the risk-oriented approach in ensuring AML / CFT.

3. Methodology

When conducting oversight in the field of prevention and counteraction AML / CFT, The State Financial Monitoring Service of Ukraine applies a risk-oriented approach to EIFMs.

Fundamental changes in the system of financial monitoring based on development mechanisms of improving risk-oriented approach at the national level applicable to reporting entities and aimed at analyzing and classifying the risk of financial transactions.

Limited methodological support required to assess the relatedness of insurance companies that are EIFMs, significantly reduces the ability to assess and manage risks in the area of financial monitoring.

Justification of assessment of the probability of insurance companies' relatedness according to the authors should be based on the use of tools of graph theory and indicators-markers.

In Ukraine, the insurance market is in a phase of active growth and more and more citizens are using the services of insurance companies, in addition to mandatory legislation. However, legislation regulating the activities of insurance companies was changed, and the result of these changes was the imposition of more stringent requirements to the terms of insurance companies, which led to the elimination of some of them (Achkasova, 2019).

To assess the probability of relatedness of insurance companies it has been used the graph theory (Kavun, Vorotintcev, 2016; Kavun, Kalashnikov, Kalashnykova, Cherevko, 2015; Kavun, 2015), that can be applied in all areas where are the system elements and relationships between them (Rose, Kolari, 1995).

Graph theory is one of the most common and popular mathematical models in many fields of science and technology.The image in the form of a set of points on a plane and lines drawn between some of them, has become a convenient and visual form of reflection of certain processes and phenomena (Christofides, 1975).

Due to the introduction of new requirements of international standards for the implementation of risk-oriented approach to control the activity of EIFMs and the fact that it is not an arbitrary option for the state and the obligations of the entities of primary financial monitoring, the issue of scientific and methodological support for implementation the risk-oriented approach needs further development, as financial institutions are required to identify, evaluate and take effective measures to reduce the risks associated with money laundering and terrorist financing (Vnukova, Hontar, Andriichenko, 2018).

In the context of the development of the Ukrainian economy, the issue of assessing the relatedness of financial institutions is quite relevant, as there are ongoing transactions in the field of money, so the existence of dependency between financial institutions may indicate some negative consequences of their activities.

For example, schemes for money laundering, tax evasion, etc. It is important for companies operating in the financial services market to be independent, which will promote competitiveness and prevent monopolization. However, if there is some dependency between financial institutions, this can be a hint of corrupt schemes (Vorotyntsev, 2016).

Determining the level of relatedness of financial companies will promote a risk-oriented approach in providing AML / CFT (Vorotyntsev, 2016).

The relatedness of financial corporations, which are EIFMs, is an additional factor that must be considered when deciding to provide financial services. An example of financial institutions' relatedness may be the existence of joint clients that attract credit, that is, the affiliated financial companies have a common source of credit repayment, and thus have a common economic risk, or may form networks to transfer funds (Vorotyntsev, 2016).

For the study of relatedness, we propose to use graph theory, which has recently been attracting more and more attention from specialists in various fields of knowledge. The graph is one of the most common and popular mathematical models in many fields of science and technology. The image in the form of a set of points on a plane and lines drawn between some of them, has become a convenient and visual form of reflection of certain processes and phenomena(Vnukova, Hontar, Vorotyntsev, 2018).

Other theories are related to graph theory: cycle theory, which is a set of different models with some simplifications that formalize the process of economic dynamics; wave theory – mathematical theory that represents the process of development and change of society or financial markets in the form of recognizable models; theory of economic growth, which explains the long-term directions of growth of economically developed countries (Sorak, Urosevic, 2014).

Graph theory originated in 1736, whose father is a Swiss mathematician Leonhard Euler (1707-1783 years.). In his first paper on the theory of graphs published in the St. Petersburg Academy of Sciences, he has decided to a widely-known problem called "problem of Konigsberg bridges(Graph theory).

"The city of Konigsberg (now Kaliningrad) located on the banks of the river Pregel (Pregel) and two islands. Different parts of the city were connected by seven bridges. On weekends, residents carried walking city. The question was whether to take a walk in a way that came out of the house back, passing only once for each bridge? Euler introduced in every part of the land as a point, and bridges marked lines (edges) that connect these points. Thus, was obtained "graph". Euler showed, from whatever vertex they began to bypass, one cannot bypass the whole graph and go back without passing any edges twice. In order for such a bypass to exist, it is necessary that in each vertex of the graph there be as many edges entering it as there are and leaving it, that is, in each vertex of the graph there must be an even number of edges (Graph theory).

Therefore, a set consisting of a finite number of elements denoted by the letters X1, X2,…, Xn, and the set itself by the letter X is considered. Each element Xi, which belongs to X, put in line zero, one or more elements of X; then we can build, using the terminology of set theory, a "graph", marking through a D law that represents this line, we write symbolically graph G = (X, D). The graph can be represented using the drawings. This is called "graph representation using directional arcs". The graph can also be represented by a table with two inputs or a matrix. In set theory, "graph" is called any reflection of the set in itself; the symbol D is this reflection (Kofman, DeBazei, 1968).

The element of the set forming a graph is called a "vertex". Some authors also call the vertices "points". An oriented pair (Xi, Xj) of vertices Xi and Xj is called an arc. A path is a series of arched arcs that allow it to pass from one vertex to another. An outline is a path whose initial vertex coincides with the end. The loop is an arc whose beginning and end coincide. Path or contour length is the number of path or contour arcs (Kofman, DeBazei, 1968).

If the two vertices are connected by an arc that starts in any of them, then we say that between these peaks has an edge. Therefore, the concept ribs equivalent to the concept of "non-oriented" graph (Kofman, DeBazei, 1968).

The chain – a sequence of linked edges, i.e. sequence of arcs linked without regard to their orientation. Every way is obviously a chain, but the chain is always a way (Kofman, DeBazei, 1968).

Columns by type are divided into oriented and non-oriented. Oriented graph (or orgraph) called a couple of sets V and E, where V – is not empty finite set and E – the set of ordered pairs of elements of the set V. In this case, the elements of the set V are called vertices (or nodes), and a plurality of E – curves (or oriented ribs) (Kofman, DeBazei, 1968).

If a pair of vertices a and b is an arc, it denoted (a, b). The top is called a primary, and the top b – final. Doug (a, a) is called a loop. The non-oriented graph consists of three types of graphs: ultohraf (can have loops and multiple edges) ultohraf (may have multiple edges, no loops), a simple graph (without loops and multiple edges) (Bartysh, Dudzanyi, 2007).

Pseudohraf is called a pair (V, E), where V – non-empty finite set and E – family unordered pairs of elements of the set V (not necessarily distinct). The term "family" means that the elements of E (edges) are repeated. Ribs, connecting the same pair of nodes, called multiple (or parallel) edges. In some cases, view graphs, which can connect two peaks several ribs. There multyhraf concept – a pair (V, E), where V – non-empty finite set, and E – family unordered pairs of different elements of the set V. A simple graph G is called a couple of sets V and E, i.e. G = (V, E), where V – non-empty finite set and E – set of unordered pairs of different elements of the set V. The vertex a and b in a non-oriented graph is called adjacent if [a, b] is an edge. Two adjacent rib call if they have a common end. The top edge is called incident and if the top is the end of the rib. So, contiguity shows the relationship between homogeneous graph elements, and incidence – between heterogeneous elements if they have a common end (Bartysh, Dudzanyi, 2007).

One of the main properties of a graph is the ability to be connected. A graph is called connected if any pair of its vertices is connected by a simple circuit. The relationship of the vertex relatedness is an equivalence. Relationship equivalence classes are called graph relatedness components. The number of connected components is designated as k (G). G is a connected if and only k (G) = 1. Not connected graph has at least two components (Graph theory).

It is essential to structure the causal relationships between the indicators for its assessment, which allows identifying the most significant factors affecting the deviations of both individual indicators and the change of sub-indices (Kolodiziev, Chmutova, Lesik, 2018), substantiation of the composition of indicators for evaluation (Ponomarenko, Kolodiziev, Chmutova, 2017).

Analysis of the frequency of absolute indicators of relative (formed from Achkasova, 2013), characterizing the activities of insurance companies, which confirms the hypothesis about the feasibility of their use for the formation of the indicator markers to assess the probability of relatedness of insurance companies are listed in Table. 1.

Table 1

Selection of indicator markers to assess the probability of relatedness of insurance companies

Indicator	The formula for calculating	Indicators-markers, to assess the probability of relatedness of insurance companies				
		Assets	Equity	Insurance reserves	Premiums	Premiums owed to reinsurers
Factor receivables	(Accounts receivable / Capital	-	+	-	-	-
Risk assets ratio	Accounts receivable: (+ Total Premiums received indemnities from reinsurers)	-	-	-	+	-
Stock Risk Factor	The amount of investments in shares / assets	+	-	-	-	-
Reverse solvency ratio	Liabilities / Equity	-	+	-	-	-
Insurance risk factor	(Premiums – premiums owed to reinsurers) / equity	-	+	-	+	+
Loss ratio of insurance operations	Insurance indemnity / insurance premiums	-	-	-	+	-
The level of capital to total assets	Capital / Assets	+	+	-	-	-
Retention risk factor	Insurance premiums – premiums owed to reinsurers / insurance premiums	-	-	-	+	+
Adequacy of insurance reserves ratio	Net insurance reserves / average volume of insurance premiums for the last 3 years	-	-	+	+	-
Factor participation of reinsurers in insurance reserves	The share of reinsurers in insurance reserves / insurance reserves	-	-	+	-	-
The ratio of net insurance reserves to	Net insurance reserves / capital	-	+	+	-	-

Indicator	The formula for calculating	Indicators-markers, to assess the probability of relatedness of insurance companies				
		Assets	Equity	Insurance reserves	Premiums	Premiums owed to reinsurers
capital						
coefficient of independence	Shareholders' equity / debt capital	-	+	-	-	-
Solvency margin (wages fund)	Assets – Intangible assets liabilities, including insurance	+	-	-	-	-
The required solvency margin (NZP1)	(Premiums – 0,5 × premiums transferred to reinsurance) × 0,18	-	-	-	+	+
Return on assets ratio	Net profit (loss) / average annual value of assets	+	-	-	-	-
Return on equity ratio	Net profit (loss) / average annual equity value	-	+	-	-	-
Profitability Ratio insurance	Net profit (loss) / premiums	-	-	-	+	-
Return on assets ratio	Investment income / average annual value of assets	+	-	-	-	-
safety factor	Capital / Insurance reserves	-	+	+	-	-
The coefficient of financial capacity	(Insurance reserves Equity +) / (premiums – premiums owed to reinsurers)	-	+	+	+	+
The share of assets attributable to one employee	Assets / Employees	+	-	-	-	-
Stability factor management	Administrative costs / premiums	-	-	-	+	-
Change in book value of assets	The market value of assets / Balance sheet assets	+	-	-	-	-
Currency risk ratio	The net open foreign exchange position / Equity	-	+	-	-	-
The frequency of the use of indicators in terms of markers		7	10	5	9	4

Thus, as can be seen from the table 1, indicator markers that are most used in calculating the assessment of insurance companies are "equity", the frequency of use of which was 10, and "premiums" is equal to the frequency of use 9. Other 3 indicators are also significant because it is also used for the assessment of insurance companies.

Key indicators of insurance companies from the insurers' point of view are indicators of financial solvency and reliability (this is why insurance companies in Ukraine are the subject of constant supervision and control by the state regulatory activities through a specially authorized body represented by the National Commission for State Regulation of Financial Services Markets (On Amendments to the Law of Ukraine "On Insurance", 2001), because when concluding an insurance contract an insured expects to avoid losses when the insured accident occurs, and in case of stable financial conditions the insurer is able to minimize the loss of the insured.

The insurance company is considered insolvent if its assets are inadequate or unavailable at certain times for payments to the insured when the insured event occurs. The ability to cover the losses of the insured depends on the size of the adequacy of insurance reserves.

Guarantor for the solvency of insurers is formed by the insurer's insurance reserves and equity to meet obligations (Achkasova, 2013).

Assets characterize the amount of money the insurance company that invested in securities, real estate, accounts and deposits with banks, other assets and rights and other requirements (Financial information of the TAS insurance group).

Equity is the own source of an insurance company, contributed by its founders and participants to the property of the insurer, or left by the insurer for net profit earned during its business. The main source is the equity share capital, which shows the level of interest in the owner of the insurer. Premiums characterize the amount of funds received by the insurer under contracts of insurance and reinsurance and reflect the insurer to ensure future payments of insurance compensation (Financial information of the TAS insurance group).

The development of the insurance market of Ukraine is closely associated with the instruments that use domestic insurers to manage low capitalization, including coinsurance and reinsurance services. Reinsurance helps insurance companies to take very large and expensive risks (Pukala, Vnukova, Achkasova, Smoliak, 2017).

Insurance reserves characterize the insurer's future payment of insurance indemnity and determine the degree of placement of funds at the expense of which the insurance company's liabilities are covered, in investment assets and funds (Financial information of the TAS insurance group).

Evaluation of relatedness of insurance companies and the influence of these circumstances, the risk of money laundering invited to perform in the following stages: forming information database study (this phase involved the selection and formation of a plurality of insurance companies for the study). After forming the research information base, that is, selecting and forming a plurality of insurance companies, the close relationship of the investigated financial institutions was determined, which included the calculation of the correlation coefficient, as well as the correlation coefficient in the constructed connectedness graph of the insurance companies.

The correlation coefficient is a measure of the relative connection between the two factors. Therefore, the correlation coefficient always ranges from -1 to +1. A positive correlation coefficient indicates a direct link between performance and negative – about reverse connections (Karaeva, Varava, 2016).

After calculating the correlation coefficients, a matrix of their values was constructed using the one-to-one principle.

Also, based on the properties of the matrix, it is found that the secondary diagonal of the matrix always contains a value of "1", since each financial institution is independent of itself. The correlation matrix is symmetric with respect to the minor diagonal, according to which the correlation coefficient is always 1, because the correlation is calculated across all institutions (Karaeva, Varava, 2016). In this way, such a matrix can be regarded as diagonal (Kavun, Mykhalchuk, Kalashnykova, Zyma, 2012).

Selection of closely related insurance companies based on the construction of a two-dimensional binary matrix. At this stage, closely related insurance companies (Chaddock scale) for which the correlation coefficient module exceeds 0.7 and weakly related insurance companies for which the correlation coefficient module is less than 0.7 are identified for further investigation.

The proposed method of identifying the relationship of insurance companies allows considering both direct and inverse relationships between insurance companies based on a dedicated bipartite graph (divided into two subsets).

Performance evaluation of relatedness insurers calculated as:

$$X_1 = \frac{1}{j}\sum_{i=1}^{n}\{p_{ij} \,|\, p_{ij} > 0.7\},\ p_{ij} \in \{B\},\ i,j = \overline{1,21}, \qquad (1)$$

where n – the number of insurance companies, n = 15;

pij – item correlation matrix density;

$$X_2 = \frac{1}{j}\sum_{i=1}^{n}\{p_{ij} \,|\, p_{ij} \leq 0.7\},\ p_{ij} \in \{B_{ij}\},\ i,j = \overline{1,21}, \qquad (2)$$

$$X_3 = X_1 - X_2, \qquad (3)$$

$$X_4 = \frac{1}{j}\sum_{j=1}^{n}\frac{x_{1j}}{x_{1j}+x_{2j}}(\%),\ X_{1j} \in \{X_1\},\ X_{2j} \in \{X_2\},\ i,j = \overline{1,21}, \qquad (4)$$

$$X_5 = \frac{1}{j}\sum_{j=1}^{n}\frac{x_{2j}}{x_{1j}+x_{2j}}(\%),\ X_{1j} \in \{X_1\},\ X_{2j} \in \{X_2\},\ i,j = \overline{1,21}, \qquad (5)$$

$$X_6 = \sum_{j=1}^{m}\sum_{i=1}^{n}\left\{p_{ij} \,|\, p_{ij} > \frac{1}{n\cdot m}\sum_{i=1}^{n}\sum_{j=1}^{m}p_{ij}\right\}, \qquad (6)$$

$$X_7 = \frac{X_{62}}{X_{61}+X_{62}},\ p_{ij} \subset \{B\},\ i,j = \overline{1,21}. \qquad (7)$$

Further, there is a problem with the calculation of indicators, characterizing the relatedness sets for financial institutions insurance companies with direct and inverse relationships, that is presented in empirical results.

4. Empirical results

Thus, it has been selected five indicators-markers (assets, equity, insurance premiums owed to reinsurers, insurance premiums, and insurance reserves) that characterize the financial stability and reliability of the insurance company to reflect its growth and dynamic development, so they describe the best the status and activities of insurance companies.

Empirical testing of the use of marker indicators involved determining the correlation coefficients that characterize the tightness of the links of the investigated insurance companies, as well as determining the coefficients of relatedness in the constructed graphs of the relatedness of insurance companies. Selection is closely connected insurance companies held on the basis of building a two-dimensional binary matrix. At this stage for the further research, there have been highlighted the closely connected insurance companies, for which the module correlation coefficient greater than 0.7, and loosely connected insurance companies, which module of the correlation coefficient is less than 0.7. The next step defines the importance of relatedness for the insurer's indicator marker. To investigate the relatedness, the graph theory has been used. The graphs construction was carried out using a Graphoanalizer program, which is an environment for the visualization of graphs and provides the ability to create and manipulate graphs to visually display the results of the algorithms. The environment supports the work with oriented and simple graphs, loaded and unloaded.

To assess the probability of relatedness of the insurance companies it has been chosen 15 insurance companies which occupy leading positions in the rankings of insurance companies in Ukraine for 2006-2017 years, formed from source (Forinsure) and performed calculations using formulas 1-7.

The approbation of marker-indicators have the following results:

The insurer indicator 'the insurer's assets" concludes that the studied insurance companies are mostly connected in the volume of their sets, since the average share of insurance companies with direct ties with high connection is 60% and the coefficient of inconsistency for them is 40%. Much smaller is the value of this indicator for backhaul insurance companies – 6.67%, that is, in the study group of insurance companies, direct relationships prevail.

According to the "Insurance reserves" indicator, insurance companies are largely unaffiliated, since the average proportion of high-closure direct-to-link insurance companies is 40% and their non-affiliation ratio is 60%. Much higher is the value of this indicator for backhaul insurance companies – 53.33%, that is, in the studied group of insurance companies, the reverse relationship prevails.

According indicator marker "Insurance premiums, reinsurers adequate" insurance companies are mostly incoherent, as the average share of insurance companies with direct connections with high connection tightness is 40% and unrelatedness factor for them is 60%. Much less is this value for insurance companies with the reverse connections – 13.33%, i.e. the research group of insurance companies dominate the direct relationships.

According to the indicator "Premiums owed to reinsurer", insurance companies are largely unrelated, since the average proportion of high-bonded direct-link insurance companies is 40% and the non-affiliation ratio for them is 60%. Much less is the value of this indicator for backhaul insurance companies – 13.33%, that is, in the study group of insurance companies, direct relationships prevail.

An example of a detailed validation of a technology system (based on the use of a designated equity indicator) to assess the reliability of insurance companies' relatedness was to determine rank using the Microsoft Excel^{TM} rank, as shown in Table 2.

Table 2

The calculated average for the sets of insurance companies

The set of insurance companies	The average proportion of organizations with a strong correlation (> ± 0,7) – X1%	The average proportion of institutions with weak correlation (<± 0,7) – X2%	The difference between tightly and loosely connected- X3%	The coefficient of relatedness – X4	No relatedness factor – H5	The average proportion of institutions with more average correlation – X6%	The average proportion of establishments with less correlation average – X7%
Insurance companies with direct connections	33.33	66,67	-33.34	0.33	0.67	53.33	46.67
Insurance companies with reverse connections	12.89	87.11	-74.22	0.13	0.87	40	60

As seen in Table 2, the results show that the insurance companies are connected and independent according to the equity indicator. These insurance companies are mostly connected, since the average share of insurance companies with direct connections with high tightness due amounted to 53.33% and the rate for them unrelatedness is 46.67%. Lower the value of this index for the insurance companies of the reverse connections – 40%, i.e. the research group of insurance companies dominate the direct relationships.

The data on the ranks of the ratio of insurance companies and the number of relationships of insurance companies are presented in Table 3.

Table 3

Ranks relatedness ratios for insurance companies and the number of connections of the insurance companies

Serial number of the insurance company	A plurality of direct connections		In the set of reverse connections	
	Rank insurance company	Number of the connections insurance company	Rank insurance company	Number of the connections insurance company
1	8	5	1	0
2	4	7	9	1
3	1	8	10	1
4	2	8	13	1
5	9	4	11	1
6	5	7	1	0
7	10	0	1	0
8	10	0	1	0
9	6	7	12	1
10	10	0	1	0
11	10	0	15	7
12	10	0	1	0
13	7	6	8	1
14	3	8	14	1
15	10	0	1	0
The average weight of relatedness	4		0.93	

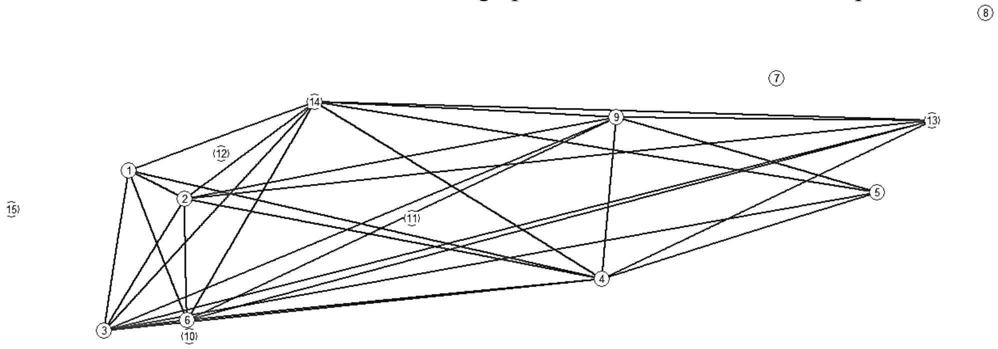
As seen from Table 3, to avoid affecting the image of the insurance companies, the authors decided to impersonate data, replacing the names of insurance companies on the numbers.

Data giving in Table 3 shows, that the average weight of relatedness is 4 insurance companies in the set of straight bonds and 0.93 plural of reverse connections. The average weight of the insurance company's relatedness shows the average number of other insurance companies, among which is the connection for the performance indicators set among all insurance companies.

That is, each insurance company on average has a direct connection with 4 other insurance companies and an inverse relationship with one insurance company. Based on the binary matrix, it was built a relationship's graph for insurance companies (Fig. 1). Construction was carried out graphs using the program Graphoanalizer (Graphoanalizer, 2019), which is an environment for visualization of graphs and provides the ability to create and manipulate graphs to visually display the results of the algorithms. The environment supports oriented and simple graphs loaded and unloaded.

Figure 1

General view of a non-orientated link graph for direct-link insurance companies



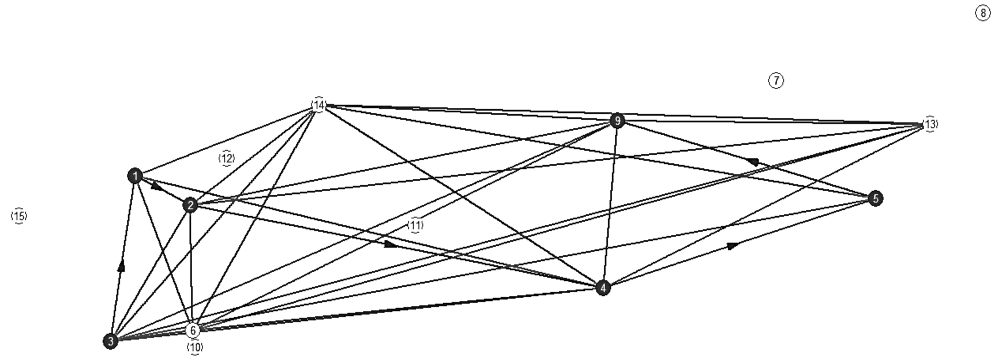
According to the graph's connections (Fig. 1) for insurance companies concluded that, for example, insurance companies number 1, 3, 4, 5, 13, 14 and others have many links with the others (graphical form provided opportunity to view all available links), it is possible to assume that these insurance companies may have common customers.

Meanwhile, insurance companies № 7, 8, 11, 12, 15 have no affiliation with other insurance companies analyzed.

The next step in the study of the obtained set of graphs is to establish, by known algorithms, graph theory of paths of achievement from one vertex to another in a graph (Fig. 2).

Figure 2

Highlighting the path of achievement from top № 3 to top № 9

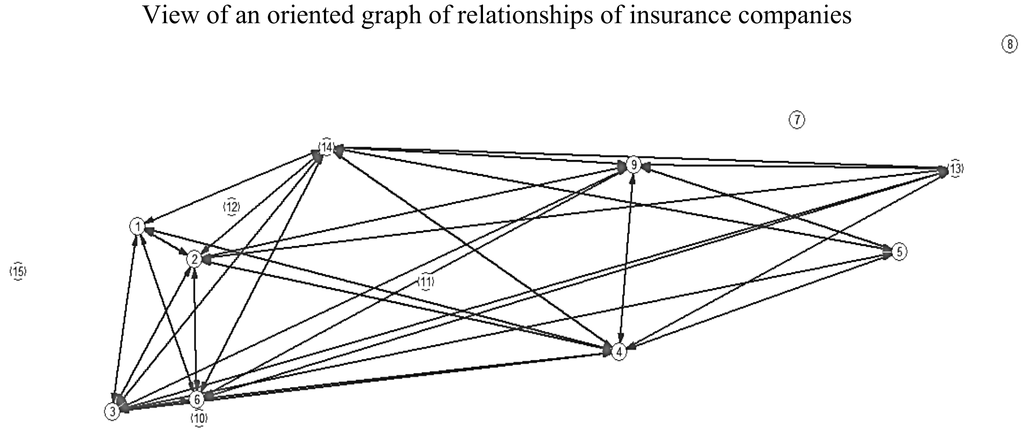


As shown in Fig. 2, the resulting graph can contain some areas of achievement, as shown for example, from the top to the top №3 №9. That is, considering the top insurance companies, suggests the presence of hidden communication insurers number 1, 2, 3, 4, 5 and 9.

The next step is the transformation of non-oriented graph to approximate, as shown in Fig. 3.

Figure 3

View of an oriented graph of relationships of insurance companies

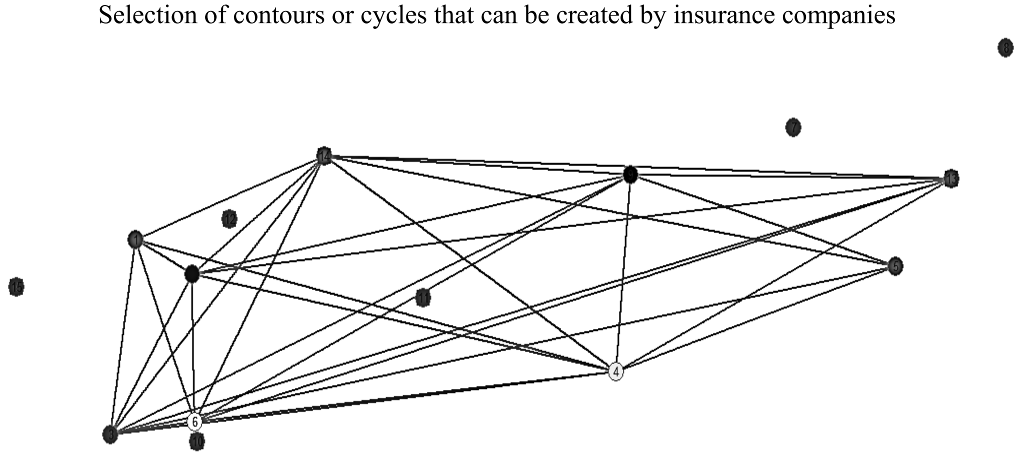


The type of oriented graph (Fig. 3) provided an opportunity to identify and demonstrate all possible directions of relations between the studied insurance companies. All of them are directly subject to further risk assessment of AML / CFT.

The new stage of the analysis given set of graphs calculated the chromatic number of the graph (Fig. 4), which in this case, is 7.

Figure 4

Selection of contours or cycles that can be created by insurance companies

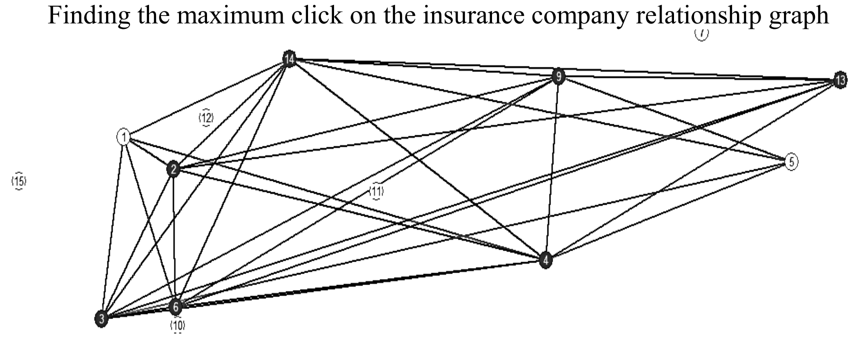


In this case, the interpretation of the insurance company may indicate that there are a sufficient number (7) of insurance companies affiliated with each other in the insurance market but established by different beneficiaries.

The next step in analyzing the resulting set of graphs is to calculate all clicks on the graph. The maximum click – a (14, 13, 9, 6, 4, 3, 2), that is not contained in any other click (Fig. 5).

Figure 5

Finding the maximum click on the insurance company relationship graph



From the calculated example (Fig. 5) it is apparent that the largest conglomerate of many insurance companies contains 7 (click number) of them. The total number of clicks received in the column confirms the existence of links between insurance companies, which can be used for further verification to identify the links.

It can also be noted that the resulting graph is perfect because its chromatic number is equal to the click number (Kavun, 2016).

One of the variants of analysis of the obtained set of graphs is the task of finding the minimum spanning tree. A minimum spanning tree for a non-orientational graph is a spanning tree that has the minimum possible weight as the sum of the weights of the edges that belong to it. For the insurance companies surveyed, the minimum spanning tree was not detected. The volume of insurance services can serve as the weight of the rib.

The general view of the non-orientated link graph for backlink insurance companies is shown in Fig. 6.

According to the obtained graphs of links for insurance companies (Fig. 6), it is concluded that, for example, insurance companies number 11 has a large number of relationships with others (the graphical form made it possible to visually see all available links), that is, we can assume that these insurance companies may have joint clients, reinsurance, etc.

Meanwhile, insurance companies № 6, 7, 8, 10, 12, 15 have no affiliation with other insurance companies analyzed.

The next step in the study of the obtained set of graphs is to establish, by known algorithms, graph theory of paths of achievement from one vertex to another in the graph (Fig. 7).

Figure 6
General view of the non-orientated link graph for backlink insurance companies

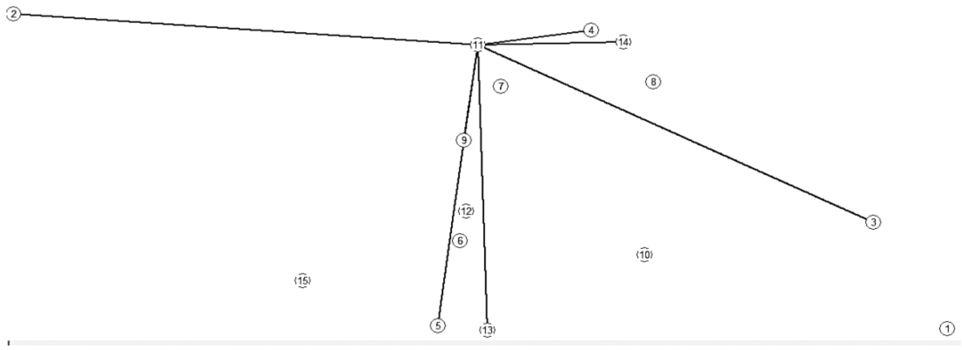
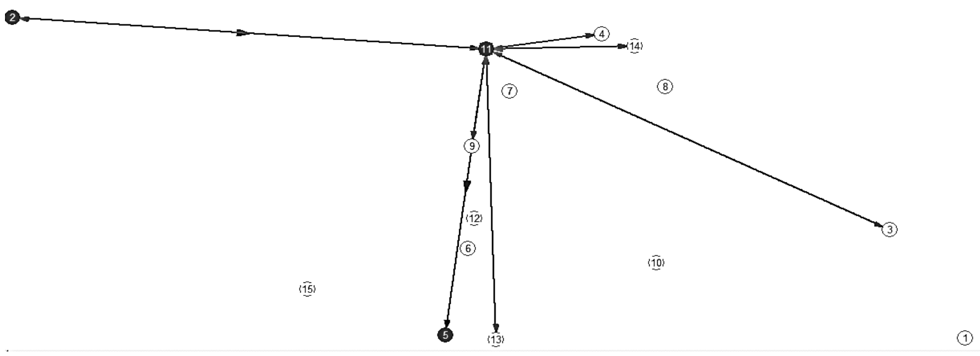


Figure 7
Highlighting the path of achievement from top №2 to top №5, which are insurance companies (2) and (5)



As can be seen from Fig. 7, the resulting graph may contain some directions of achievement, as given for example, from vertex № 2 to vertex № 5. That is, considering the tops as insurance companies, we can assume that there is a hidden connection of insurance companies №2, 5, 11. Similarly, all possible connections are calculated for the purpose of their careful checking for risk assessment.

The next step is to convert the graph from non-orientable to approximate, as shown in Fig. 8.

The type of an oriented graph (Fig. 8) made it possible to identify and clearly demonstrate all possible directions of relations between the studied financial institutions. All of them are subject to further review to determine the risk of money laundering, terrorist financing and the financing of the proliferation of weapons of mass destruction in the presence of hidden links.

At the new stage of analysis of the obtained set of graphs, the chromatic number of the graph (Fig. 9) is calculated, which in this case is 2.

Figure 8

Type of an oriented graph of relationships of insurance companies

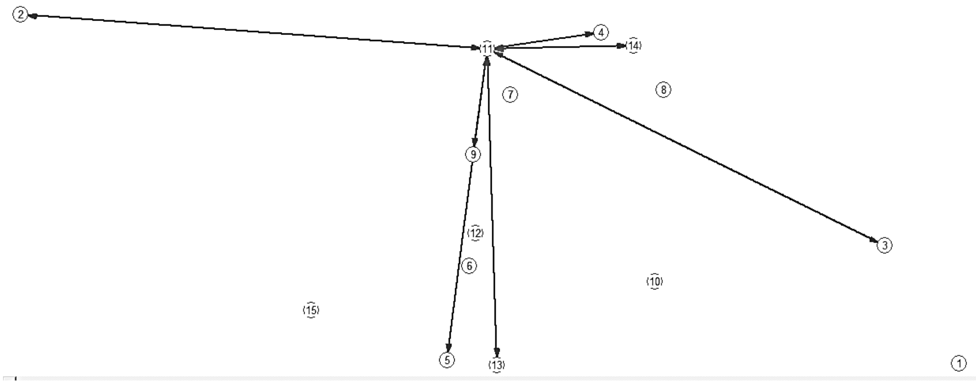
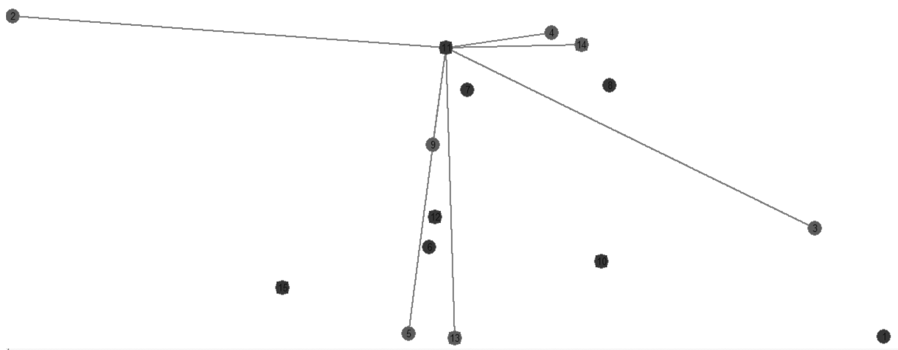


Figure 9

Selection of contours or cycles that can be created by insurance companies

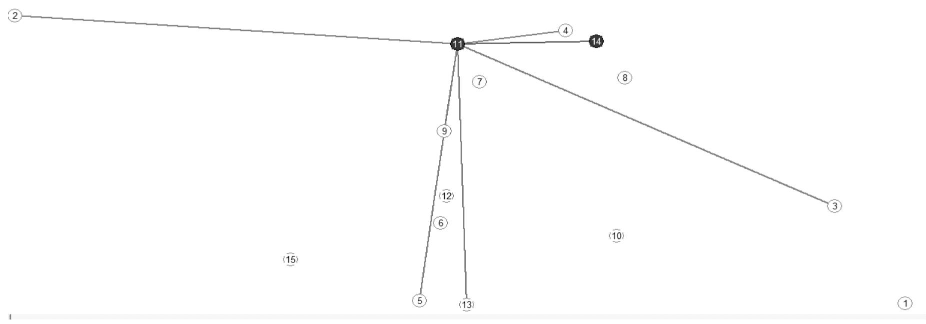


In this case (Fig. 9), the interpretation regarding the insurance company may indicate that there is a sufficient number (2) of related, but based on, different beneficiaries of insurance companies in the studied insurance market. The next step in analyzing the resulting set of graphs is to calculate all clicks on the graph. The maximum click is (14, 11); that is, it is not contained in any other click (Fig. 10).

The calculated example shows that the largest conglomerate of many insurance companies contains 2 (click number) of them. The total number of clicks received in the column confirms the existence of links between insurance companies, which can be used for further verification to identify the links. It can also be noted that the obtained graph is perfect because its chromatic number is equal to the click number.One of the variants of the analysis of the obtained set of graphs is the task of finding the minimum spanning tree, which for a non-orientated graph has the minimum possible weight as the sum of the weights of the edges that belong to it. For the insurance companies surveyed, the minimum spanning tree was not detected. The volume of insurance services can serve as the weight of the rib.

Figure 10

Finding maximum count clicks



The final analysis of the obtained data to confirm the hypotheses regarding the connection between the insurance companies was performed based on the calculation of the coefficients of connection of the insurance companies, presented in Table 4.

Table 4

The final analysis of the data relatedness for insurer's indicator-marker "equity"

The set of insurance companies	The level of relatedness, %	Level of no relatedness, %
Insurance companies with direct connections	33.33	66.67
Insurance companies with reverse connections	12.89	87.11

Thus (Table 4), the level of relatedness of insurance companies is one third, which requires the development and improvement of measures to assess the risk of "money laundering" by those insurance companies that fall into their list of affiliated insurance companies. Therefore, the proposed tool for managing money laundering risks based on determining the level of relatedness of insurance companies is promising and can be used to improve the risk-oriented approach to EIFMs.

5. Concluding remarks

It is determined that the fundamental changes in the system of financial monitoring are the development of mechanisms for improving the risk-oriented approach applied to report entities of the primary financial monitoring and aimed at carrying out risk analysis and classification. The offered methodical study of assessment of the probability of relatedness of insurance companies based on the use of tools of graph theory and indicators-markers for assessment of the probability of markers relatedness of insurance companies (assets, equity and insurance reserves, insurance premiums and insurance premiums owed to reinsurers).

For testing systems technologies (based on the use of indicators-markers) to assess the probability of relatedness of insurance companies and determining its impact on the risk of money laundering, it has been used data from the financial statements of 15 Ukrainian insurance companies for 2006-2017 years that served as the statistical base. This made it possible to identify the relatedness of insurance companies, which would improve the risk-oriented approach to insurance companies, which are the reporting entities of the initial financial monitoring.

An empirical test of the use of the indicator-marker “equity” was used to determine the correlation coefficients that characterize the tightness of relatedness of the investigated insurance companies, as well as the determination of the coefficients for building the insurance companies' relatedness graphs. Selection is of closely connected insurance companies was held based on building a two-dimensional binary matrix. At this stage for the further research, there have been highlighted the closely connected insurance companies, for which the module correlation coefficient greater than 0.7, and loosely connected insurance companies, which module of the correlation coefficient is less than 0.7. The next step defines the importance of relatedness for the insurer’s indicator marker. To investigate the relatedness the graph theory has been used. The graphs construction was carried out using a Graphoanalizer program, which is an environment for the visualization of graphs and provides the ability to create and manipulate graphs to visually display the results of the algorithms. The environment supports the work with oriented and simple graphs, loaded and unloaded. As a result,it has been determined that for indicator-marker "equity" the level of relatedness is one third that needs to develop and improve measures for risk assessment "laundering" of funds by the insurance companies which get to their list of connected insurance companies. The average share of insurance companies with direct connections with high connection tightness is 53.33%, while the incoherent coefficient is 46.67%. The lower value for this indicator is for the insurance companies with the reverse connections are 40%, i.e.in the research group of insurance companies with direct relationships are dominant.

Thus, to establish entities with a common economic risk to be involved in money laundering, the necessity of determining the level of relatedness between insurance companies was justified. The proposed tool will enable to improve the risk assessment of possible involvement by insurance companies in money laundering in the financial services market, to provide a plurality of independent insurers, to prove the influence of one insurance company to another that will facilitate prevention of the risk of connected financial institutions’ impact on the ability to create a network for money laundering.

Hence, the results of the evaluation of insurance companies’ relatedness recommended to be used as an element of a methodological approach to assess the potential risk of money laundering based on the definition of insurance companies’ relatedness. The issue of improvement of state regulation of financial monitoring that requires a network discovery tools aimed at AML / CFT based on the offered indicators-markers is the subject of further research.

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