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HIERARCHY MODELING OF THE THREATS OF REGIONAL ECONOMIC SECURITY

Визначено основні загрози регіональній економічній безпеці в сучасних умовах господарювання. Проаналізовано зв'язки між основними загрозами економічній безпеці регіонів України. Проведено систематизацію виявлених загроз за допомогою математичного моделювання. Визначено ступінь впливу та виявлено найбільш суттєві загрози регіональній економічній безпеці. Створено ієрархічну структуру загроз регіональній економічній безпеці з метою забезпечення раннього їх запобігання та реагування на загрози.

Ключові слова: *регіон, економічна безпека, загроза, метод аналітичної ієрархії, математичне моделювання.*

Определены основные угрозы региональной экономической безопасности в современных условиях хозяйствования. Проанализированы связи между основными угрозами экономической безопасности регионов Украины. Проведена систематизация выявленных угроз при помощи математического моделирования. Определена степень влияния и выявлены наиболее существенные угрозы региональной экономической безопасности. Создана иерархическая структура угроз региональной экономической безопасности с целью обеспечения их раннего предупреждения и реагирования на угрозы.

Ключевые слова: *регион, экономическая безопасность, угроза, метод аналитической иерархии, математическое моделирование.*

Intr oduction

1. Problem statement. Under conditions of destabilization of the national economy, the issue of national economic security and regional imbalances of its provision becomes more and more relevant. This is the economic development of the regions that is the basis for provision of the economic security of the state, especially under conditions of decentralization. The necessity of creation of the effective system of the regional economic security management requires identification of the economic security threats of the regions.

2. Analysis of recent studies and publications. The following domestic and foreign scientists dealt with the problem of provision of the national economic security: A. Williams, G. Turnbull and F. Cheit (Williams, Turnbull, & Cheit, 1982) [1], E. Poirson (Poirson, 1998) [2], H. Maull (Maull, 1984) [3], K. Murdoch (Murdoch, Knorr, Trager 1977) [4], Z.S. Varnalii, D.D. Burkaltseva, A.S. Saienko [5], Z.S. Varnalii, S.V. Onyshchenko, A.A. Maslii [6].

The works of such scientists as O.M. Holovchenko [7], T. E. Voronkova [8], S.P. Stetsenko [9], G.O. Sukrusheva [10], I.V. Zablodska [11] are devoted to study of issues of economic security of the region and its threats. However, despite the sufficient interest

in the issues of economic security of the regions, the issues of impact of different threats to regional economic security remain unresolved.

3. Purpose of the article – modeling of the hierarchical structure of the threats of regional economic security in order to provide early warning and response to threats.

Results and discussion. As a result of the conducted theoretical study, we determined that some researchers characterize the economic security from perspective of the necessity to provide the resistance of the economic system to impact of threats.

The group of authors [6] draw attention to the fact that the economic security of Ukrainian economy under modern conditions is based on situational response to threats that have already arisen.

G.O. Sukrusheva determines the economic security of the region as provision of the independence from impact of internal and external factors, provision of safe operation mode of the objects of management in order to create conditions for sustainable economic growth and conditions of full life of the population [10].

In our opinion, the statement of O.M. Holovchenko about special role of meso-levels, which is that they serve as buffers, when the threats to stability of the economic system main levels are active, and serve as reserves at surplus or deficiency of the factors, resources and conditions of sustainable development [7], is expedient.

From perspective of S.P. Stetsenko, the place in the common economic space, concentration on their territories of natural raw material resources, industrial potential, transport corridors connecting the regional economy is the specific factor of emergence of threats of economic security of the regions of Ukraine [9].

At the same time the scientists determine the different types of the threats of regional economic security. Concerning the scope of threats occurrence, we can distinguish the following main groups [12]: production and technology (Endress, 2015) [13], (Heiets, 2006) [14], market (Sandri, 2014) [15], finance (Gourio, 2013) [16], social (Imrohoroglu, 2012) [17], legal and regulatory (Volker & Marion, 2010) [18], administrative and political (Chomaa, Hanocha, Gummeruma, & Hodsonb, 2013) [19], ecological (Stern, 2013) [20].

Considering the regional economic security from the perspective of provision of national security, we deem it expedient to determine the key threats of economic security of the region and the degree of their impact. Based on the results of studies of these threat groups, we suggest to determine the degree of impact on the regional economic security threats presented in table 1.

Table 1

List of the threats of regional economic security and their mathematical notation*

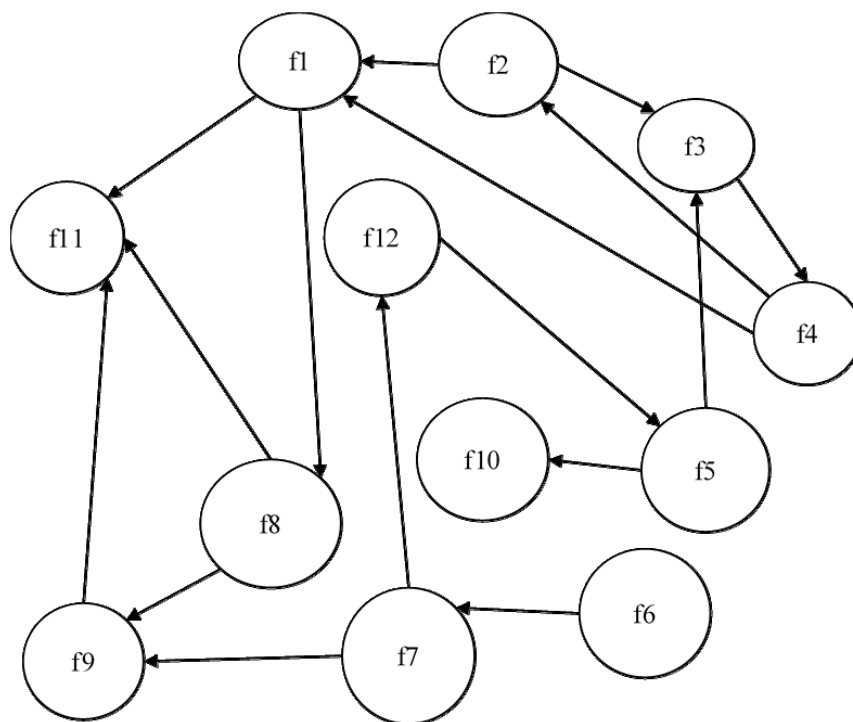
Mathematical notation	Name of the factor
f1	Industrial potential disruption
f2	Loss of sales market
f3	Loss of competitiveness and competitive advantages
f4	Decline in financial liquidity
f5	Deterioration in financial condition
f6	Migration
f7	Deterioration of living standards
f8	Increase in economic crimes
f9	Low level of legal security
f10	Changes of guarantees of economic activities
f11	Political instability
f12	Deterioration in state of the environment

*Compiled by the author.

We offer to conduct the identification of the key threats to the economic security of the region and the degree of their impact with the help of analytic hierarchy process. The analytic

hierarchy process – a hierarchical representation of the elements that define the essence of problem, was analyzed in the works of T. Saaty (Saaty, 1994) [21]. The analytic hierarchy process is an effective way for a person, who makes decisions in determining priorities. The hierarchy process takes into account both the subjective and objective aspects of the decision.

Let's suppose that a set of these threats is a subset $F1 = \{f1, f2, f3, f4, f5, f6, f7, f8, f9, f10, f11, f12\}$, that characterizes the selection of the most significant factors from the set of regional economic security threats. The subset of the selected threats and relations between them are given as an oriented graph (fig. 1), where the elements of subset F1 are placed in the vertex of graph, the arcs would connect adjacent pairs of vertices (f_i, f_j) , for which the relationship was defined.



**Fig. 1. Graph of dependency between the main threats of regional economic security
Compiled by the author.**

As a result, it was constructed the graph with 12 vertices connected by arrows that indicate the presence of dependency. The arrow is directed from factor (threat) f_i , which depends on factors f_j (end of arrow).

According to the data of constructed graph, we compile the binary matrix of dependency

$B = \{b_{ij}, i, j = \overline{1,12}\}$ for the set of vertices F1 under the following rule:

$$b_{ij} = \begin{cases} 1, & \text{if } f_i \text{ depends on } f_j \\ 0, & \text{if } f_i \text{ does not depend on } f_j \end{cases} \quad (1)$$

Thus, depending on the result of binary relation “depends on”, the matrix elements take two values 0 and 1. The results of construction of dependency matrix are presented in table 2.

Table 2

Binary matrix of dependency*

	f1	f2	f3	f4	f5	f6	f7	f8	f9	f10	f11	f12
f1								1			1	
f2	1		1									
f3				1								
f4	1	1										
f5			1							1		
f6							1					
f7									1			1
f8									1		1	
f9											1	
f10												
f11												
f12					1							

*Compiled by the author.

The reachability matrix is formed on next stage of the analytic hierarchy process of threats to regional economic safety of method, directly according to the original directed graph. The filling of matrix with binary elements is carried by row (left – right) under the rule:

$$d_{ij} = \begin{cases} 1, & \text{if from } i \text{ you can reach } j \\ 0, & \text{otherwise} \end{cases} \quad (2)$$

By applying this rule and data of basic graph we built a reachability matrix (table 3).

Table 3

Reachability matrix*

	f1	f2	f3	f4	f5	f6	f7	f8	f9	f10	f11	f12
f1	1							1	1		1	
f2	1	1	1	1				1	1		1	
f3			1	1								
f4	1	1	1	1				1	1		1	
f5	1	1	1	1	1			1		1	1	
f6			1		1	1	1		1	1	1	1
f7	1	1	1	1	1		1	1	1	1	1	1
f8								1	1		1	
f9									1		1	
f10										1		
f11											1	
f12	1	1	1	1	1					1		1

*Compiled by the author.

We identified two subsets from set F1 for each of the twelve factors: $R(f_i)$ – reachability set, $A(f_i)$ – pre-set (set of pervious vertices). The vertex is deemed reachable, if the vertex f_j can be reached from the vertex f_i , i.e. if there is a path in the graph (see fig. 1) that leads from the vertex f_i to the vertex f_j . Similarly, the vertex f_i is called previous to the vertex f_j , if it is possible to reach f_i from f_j .

The set of those vertices $A(f_i) = R(f_i) \cap A(f_i)$, for which the condition of unreachability from each vertex of remaining sets is fulfilled, can be designated as a level of hierarchy. Formed sets $R(f_i)$, $A(f_i)$ and their intersection $R(f_i) \cap A(f_i)$ are presented in table 4.

Table 4

Iteration 1*

	$R(f_i)$	$A(f_i)$	$R(f_i) \cap A(f_i)$
f1	f1, f8, f9, f11	f1, f2, f4, f5, f7	f1
f2	f1, f2, f3, f4, f8, f9, f11	f2, f4, f5, f7, f12	f2, f4
f3	f3, f4	f2, f3, f4, f5, f6, f7, f12	f3, f4
f4	f1, f2, f3, f4, f8, f9, f11	f2, f3, f4, f5, f7, f12	f2, f3, f4,
f5	f1, f2, f3, f4, f5, f8, f10, f11	f5, f6, f7, f12	f5
f6	f3, f5, f6, f7, f9, f10, f11, f12	f6	f6
f7	f1, f2, f3, f4, f5, f7, f8, f9, f10, f11, f12	f6, f7	f7
f8	f8, f9, f11	f1, f2, f4, f5, f7, f8	f8
f9	f9, f11	1, f2, f4, f6, f7, f8, f9	f9
f10	f10	f5, f6, f7, f10, f12	f10
f11	f11	1, f2, f4, f5, f6, f7, f8, f9, f11	f11
f12	f1, f2, f3, f4, f5, f10, f12	f6, f7, f12	f12

*Calculated and compiled by the author.

The vertices of graph, which satisfy the condition $A(f_i) = R(f_i) \cap A(f_i)$, form the first (lower) level of the hierarchy. These vertices can be considered as those, which are unreachable from all other vertices of the graph.

On the results of the first iteration we determined the first level (the lowest in terms of the importance of the impact on regional economic security) of threats hierarchy – f6 “Migration”. We exclude all “f6” from the data of table and perform similar calculations until there is a single object. Next eight iterations allowed to determine the next levels of hierarchy of threats to economic security of the region (fig. 2).

The obtained model of hierarchy of factors having impact on the economic security of the region allowed to get the hierarchical structure of key threats to regional economic security (fig. 3).

According to the constructed model of key threats to regional economic security we can make a conclusion on political instability as the main threat to the economic security of the region. Equally important is the low level of legal protection and growth of economic crime. These de-stimulators of economic security of the region can be attributed to a group of legal, administrative and political threats that arise during the implementation of the state regional policy.

One of the significant economic threats is the destruction of the industrial potential of the region, which under current conditions is a major source of economic development. One of the main priorities of regional policy should be to maintain and to develop the industrial potential of the region. The group of threats of 5 level is interesting in the structure of the obtained model: reducing of financial liquidity, loss of markets and a loss of competitiveness and the competitive advantages. They represent a complete cycle of relationships (see fig. 2) and are the result of the previous de-stimulators of regional economic security. The last level of the developed model of hierarchy includes such de-stimulators as deterioration of living standards and migration. But it should be noted that this does not show the insignificance of these threats, because the formal stratification of factors of threats of regional economic development leads to the fact that some of the threats should be the last.

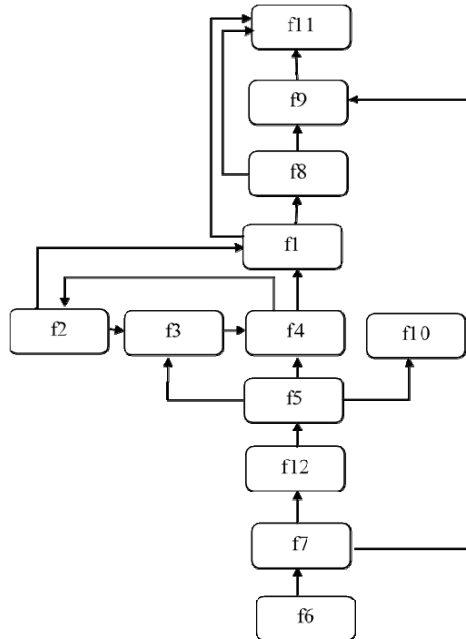


Fig. 2. Model of hierarchy of factors having impact on the economic security of the region
Compiled by the author.

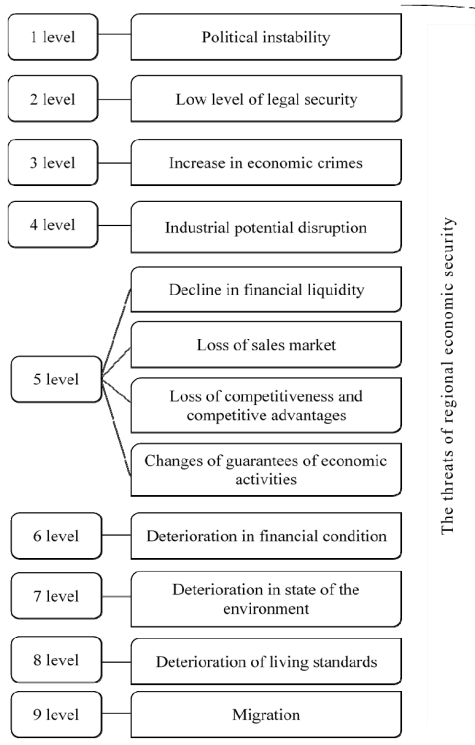


Fig. 3. Model of hierarchy of the key threats to the economic security of the region
Compiled by the author.

It should be noted that the classification of threats to a particular hierarchical level is made objectively, the reliability of the obtained results is provided by the application of methods of system analysis and mathematical modeling. The model can be modified by changing the relations between the threats in the first stage of modeling – at the construction of oriented graph.

Conclusions. The hierarchical model contains the key threats to the economic security of the region, which are placed according to their relevance and significance for ensuring of regional economic security. The presented model of structure of regional economic security threats allows to develop an early prevention and response system as part of preventive governance. The objectivity and reliability of the model is confirmed using the methods of system analysis.

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The purpose of the research is modeling of the hierarchical structure of the threats to the regional economic security. The economic security is analyzed as the part of the social-economic system of the particular region demonstrating the ability to prevent the destabilizing impact of the threats of different types and guarantee the necessary economic independence.

The main threats to the regional economic security in the modern economic conditions have been defined. The connections between the main threats to the regional economic security of Ukraine have been analyzed. The mathematical modeling method has been applied for the systematization of the detected threats. The degrees of impact, as well as the most significant threats to the regional economic security have been identified.

The hierarchical structure of the threats to the regional economic security has been made to provide the timely prevention and response to the threats.

The methods of theoretical generalization, the system analysis methods to prove the objectivity and reliability of the given model have been applied for the studying and systematization of the key threats to the regional economic security. The hierarchical structure of the given threats to the regional economic security with the help of the hierarchy analysis method has been developed according to the impact and significance for the regional economic security.

The interdependence between the threats has been defined. The relationship between the threats has been demonstrated on the graph. The importance of the group of the legislative and administrative political threats that can appear while implementing the state regional policy has been indicated as a result of research based on the given hierarchical structure. The most important threats include: loss

of the markets, population migration, competitiveness of the region, protection and rational use of the natural resources, political instability. The destroying of the regional industrial potential which can become one of the most important leverage to the state economic development has been indicated as the main threat. It has been proved that the support and development of the regional industrial potential can be one of the main priorities of the regional policy.

The developed structural model of the threats to the regional economic security allows develop the system of timely prevention and response to the threats as a part of the preliminary control.

The peculiarity of the given model is its possibility to be modified by changing the relationship between the threats on the first stage of the modeling process while making the preliminary graph. The applied model can be the basis for defining the impact of the threats for the regional economic security and measuring the possibility of the regions to prevent the identified threats.

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